AN INTEGRATED APPROACH WITH SEM, FUZZY-QFD, AND MLP FOR SUPPLY CHAIN MANAGEMENT STRATEGY DEVELOPMENT: A CASE STUDY IN VIETNAMESE FOOD INDUSTRY

BY

TRAN THI THAM

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING (LOGISTICS AND SUPPLY CHAIN SYSTEMS ENGINEERING)

SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY
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Abstract

AN INTEGRATED APPROACH WITH SEM, FUZZY-QFD, AND MLP FOR SUPPLY CHAIN MANAGEMENT STRATEGY DEVELOPMENT: A CASE STUDY IN VIETNAMESE FOOD INDUSTRY

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The Vietnamese food industry is a rapid growing industry and can dominate several food export sectors with sustainable competitive advantages in the world. However, growing in the competitive environment, organizations need to improve their business performance by increasing their competitiveness through suitable Supply Chain Management (SCM) strategies and actions. The aim of this study is to propose an approach to determine the most suitable SCM strategies for the Vietnamese food industry, based on the combination of Structural Equation Modeling (SEM), Fuzzy-QFD, and Multi-Objective Linear Programming model (MLP). A case study from the Vietnamese food industry is given to illustrate the proposed methodology. The outcome of the study reveals that companies should pay more attention to supply chain capabilities for SCM strategy development, which can help to gain improvement of their competitiveness and business performance.

Keywords: Supply chain management strategy; Structural Equation Modeling (SEM); Fuzzy-QFD approach; Multi-objective Linear Programming model (MLP); Vietnamese food industry

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Chapter 1
Introduction

This study focuses supply chain's strategy development based on the case study of food industry in Vietnam. By investigating factors that have impact on business performance, a useful methodology for strategy development is developed. Problem statement, research objectives, and overview of the study are included in this chapter.

1.1 Problem statement

Today's dynamic business environment is driving a new competitive concept, in which organizations compete globally and comprehensively on different aspects of products and services that they provide, such as price, quality, service satisfaction, etc. For a business to be successful, business owners need to ensure that their business is operating as effectively as possible, by searching for creative solutions to improve quality, reduce costs, improve customer service, manage risk, and increase efficiency. This also requires an understanding of the key drivers within and across a company of its supply chain, and a practical approach to implement processes that will optimize these key drivers. In other words, it requires that a company effectively manages capabilities across the supply chain to enable increasing sustainable competitive advantages and business performance. From this perspective, supply chain capabilities and competitive advantages have become key success factors for effective competing and business improvement.

Recent works have shown a clear interest in investigating the impact of supply chain management capabilities on business performances. Rosenzweig et al. (2003), Özdemir and Aslan (2011), and Hatani et al. (2013) evaluated the role of Supply Chain Integration (SCI), while Becker and Gerhart (1996), Youndt et al. (1996), and Ahmad and Schroeder (2003) investigated the importance of Human Resource Management (HRM) on competitive advantages and business performance. Nonetheless, in a supply chain, all functions need to be integrated together to achieve company goals. This study focuses on three functions of supply chain capability, namely, Supply Chain Integration

(SCI), Supply Chain Operation (SCO), and Human Resource Management (HRM), in relationships with competitive advantages, towards business performance. Such relationships allow companies to get clear understanding about how supply chain capability factors can help improve the business performance. So, based on such relationships, a company can develop and implement appropriate strategies and actions to improve the supply chain capabilities, in order to increase sustainable competitive advantages towards meeting customer satisfaction for their products or services.

Among different techniques, Quality Function Deployment (QFD) is a well-known technique that is used for identifying business strategy. However, due to the uncertain nature of this field, it is more difficult to assess the performance of the process with accurate quantitative value. The use of fuzzy logic has been introduced to incorporate the uncertainty, vagueness, and imprecision (Ayağ et al., 2013). Many researches have used fuzzy-QFD as a systematic tool for developing Supply Chain Management (SCM) strategies such as Bottani and Rizzi (2006), Issam and Wafa (2006), Zarei et al. (2011), Jia and Bai (2011), and Ayağ et al. (2013). Despite the success of these studies on strategy development, not much research has recognized the relationships between SCM strategy with supply chain capabilities and a company's competitive advantage, even though these factors are the root cause of success in the business performance. When companies lack an understanding about their supply chain and fail to recognize the importance of relationships, their operations may become expensive, time consuming, and ineffective. Based on above discussion, business strategy needs to be developed and considered comprehensively in relation to supply chain capabilities and competitive advantages, which can affect business performance.

This research aims at examining the relationships between supply chain capabilities and competitive advantages towards business performance in Vietnamese food industry by using Structural Equation Modeling (SEM). In addition, a methodology is developed for business strategy formulation and implementation based on the above mentioned relationships. In the methodology, Structural Equation Modeling (SEM), Fuzzy-QFD, and Multi-objective Linear Programming Model (MLP) are chosen as systematic tools to transform the requirements of business improvement into specific SCM strategies and actions under given constraints. Case studies of both small sized and large sized companies of the food industry in Vietnam have been chosen to demonstrate the methodology developed.

1.2 Research objectives

The main objectives of this study are:

(1) To examine the relationships between supply chain capabilities and competitive advantages towards business performance in Vietnamese food industry.

(2) To compare the above mentioned relationships between small sized and large sized companies.

(3) To propose an effective methodology for selecting SCM strategies based on the combination of methods between SEM, Fuzzy-QFD, and MLP model.

(4) To propose an alternative weight/score assignment of QFD by using the standardized coefficients of significant paths given by SEM.

(5) To recommend suitable SCM strategies and actions for small sized and large size companies in Vietnamese food industry.

1.3 Overview of the study

This thesis is divided into 6 chapters as following:

Chapter 1: Introduction includes problem statement and research objectives

Chapter 2: Literature review includes related knowledge, related literatures, and background of the food industry in Vietnam.

Chapter 3: Methodology shows the description of method approach, hypotheses, and mathematical model.

Chapter 4: SEM results indicate significant relationships between supply chain capabilities, competitive advantages, and business performance.

Chapter 5: Integrated SEM, Fuzzy-QFD, and MLP results suggest suitable strategies and actions through a case study in the Vietnamese food industry.

Chapter 6: Conclusion concludes all experiment knowledge and gives recommendations for further studies.

Chapter 2
Literature Review

The literature review is divided into two parts. The first part addresses related knowledge, which defines the terms of “Supply chain management”, “Supply chain integration”, “Human resource management”, “Competitive advantage”, “Cumulative model”, “Structural equation modeling”, “Quality function deployment”, “Fuzzy set”, and “Multi-objective linear programming model”. The second part reviews previous studies, which are related to topics, related to the proposed methodology as well as the Vietnamese food industry.

2.1 Related knowledge

2.1.1 Supply chain management

According to the Council of Supply Chain Management Professional, Supply Chain (SC) is a system of organizations, people, technology, activities, information, and resources involved in moving a product or service from suppliers to customer. The supply chain concludes not only the manufacture and suppliers, but also transporters, warehouses, retailers, and even customer themselves. With each organization, the supply chain includes all functions involved in receiving and filling a customer request. Supply chain activities transform natural resources, raw materials, and components into a finished product that is delivered to the end customers.

Supply Chain Management (SCM) has received attention since the early 1980s. According to the Council of Supply Chain Management Professional, SCM is the planning and management of all activities related to procurement process, conversion, logistics management, and also partners’ coordination in a chain. Success of SCM depends on whether a company can develop and manage specific capabilities and competitiveness in order to provide products and services that fulfill customer requirements. In other words, it depends on how well the coordination between a company and other partners throughout the supply chain can be established, how well they manage their resources and staff to run business effectively, and how well they operate and control their production to produce the best value for customers.

2.1.2 Supply Chain Integration (SCI)

Numerous studies have explored the concept of Supply Chain Integration (SCI) in terms of flow of material as well as information and knowledge shared. Pagell (2004) defined SCI as the coordination in which different processes, such as manufacturing, purchasing, and logistics work together within and across companies to improve outcome performance. According to Storey et al. (2006), high level of coordination among partners in a supply chain can help reduce the challenge of uncorrected knowledge and information. With a high degree of SCI, manufacturers can react more quickly to individual customer demands, decreasing delivery times, and reducing inventories. All of which can make the supply chain more efficient. In contrast, lacking an integration leads to increasing demand at upstream of the supply chain, known as the "bullwhip effect" with resulting alternations between excess inventory and stock-outs (Lee and Billington, 1992). As such, SCI plays an important role in improving organizational performance. Companies, which can combine the internal processes with the suppliers and customers in supply chains, are able to gain important competitive advantages (Hatani et al., 2013). Kim (2006) also argued that SCI is one key to achieve high success in supply chain management.

2.1.3 Human Resource Management (HRM)

Human Resource Management (HRM) is a function in organizations designed to maximize employee performance in service of their employer's strategic objectives. HRM focuses on different activities related to people such as recruitment, management, and providing direction for staff, who work in the organization. HRM activities are important strategies since they are central to create the organizational capability, to enact the firm's strategic goals. Effective HRM enables employees to contribute productively in the process of obtaining the companies' targets (Barney and Wright, 1998). The importance of HRM has been recognized by many studies that the effective management of human resources helps organizations achieve sustained competitive advantages (e.g., Barney and Wright, 1998; Swink and Hegarty, 1998; Youndt et al., 1996).

Lobanova and Ozolina-Ozola (2014) stated 18 significant practices, which can help improve HRM in their study. They are realistic job previews, use of psychometric tests for selection, well-developed induction training, provision of extensive training for experienced employees, regular appraisals, regular feedback on performance from many sources, individual performance-related pay, profit-related bonuses, flexible job descriptions, multi-skilling, presence of work-improvement teams, presence of problem-solving groups, information provided on firm's business plan and firm's performance targets, no compulsory redundancies, avoidance of voluntary redundancies, commitment to single status, and harmonized holiday entitlement.

2.1.4 Competitive advantage

According to Porter (1985), competitive advantage is the extent to which a company can obtain a prior position over its competitors in the marketplace. A company is considered to have competitive advantages if it creates value, which helps differentiate itself among competitors, to achieve customer's satisfaction and market performance (Barney, 1991; Li et al., 2006; Tracey et al., 1999). For example, a company can achieve a cost advantage when the company operates at a lower cost, then, offers a compatible price of product compared to its competitors.

Four important dimensions of a competitive advantage were constructed including quality, cost, delivery, and flexibility (Amoako-Gyampah and Boye, 2001; Badri et al., 2000; Rosenzweig et al., 2003; Ward et al., 1995). In addition, Li et al. (2006) described a research framework in which five dimensions of competitive advantages were defined: cost, quality, delivery dependability, product innovation, and time-to-market.

2.1.4.1 Quality

Quality is a perceptual, which may be understood differently by different people. According to Tracey et al. (1999), quality is defined as fitness for use and is a key element to satisfy a customer's expectations. Quality performance includes the value of reliability and durability. Vickery et al. (1997) view product quality as the ability to manufacture a product, whose operating characteristics meet performance standards. Customers may compare product quality among different competitive brands in the marketplace, so quality can affect product's sales (Tracey et al., 1999).

Kannan and Tan (2005) examined the relationships between Just-In-Time (JIT), Supply Chain Management, Quality Management, and business performance. Results demonstrate that an understanding of supply chain dynamics and a commitment to quality have the greatest effect on business performance. Zehir et al. (2012) investigated the relationships between Total Quality Management (TQM) practices with innovative performance and quality performance. Data were collected through a survey in Marmara Region. The results show that management leadership, process management, supplier management, and system approach to management effect quality performance significantly. While management leadership, continuous improvement, and customer focus are positive factors, contributing to innovative performance.

2.1.4.2 Delivery

The definition of delivery is found in the study of Noble (1997). It is defined as company competition based on speed and reliability of the delivery process. Delivery reliability refers to the ability that a company can offer on-time service and accurate delivery amount for supply chain entities (Wacker, 1996). When considering the dimensions of delivery performance, Li (2000) defined delivery as a time issue. It is considered in three aspects such as how quickly a product is delivered, how reliably the products are developed and brought to the market, and the rate at which improvements in products and processes are made.

To improve delivery performance, rather than considering the performance at a single company, activities throughout the supply chain need to be managed. By investigating the impact of supply chain complexity on delivery performance, Vachon and Klassen (2002) reported that management initiatives to improve delivery performance are best focused on improving informational flows within the supply chain and leveraging new process technologies that offer flexibility to respond to uncertainty.

2.1.4.3 Flexibility

Flexibility is described as the adjusted ability of a manufacturing system to deal with uncertainties in the business environment as well as customer demand (Barad and Sipper, 1988; Sethi and Sethi, 1990). There are different aspects of flexibility can be outlined, such as functional aspects (flexibility in operations, marketing, logistics), hierarchical aspects (flexibility at shop, plant or company level), measurement aspects (focused on global flexibility measures, context specific ones), strategic aspects (central on the strategic relevance of flexibility), time horizon aspects (long-term, short-term flexibility), and object of change (flexibility of product, mix, volume) (Sánchez and Pérez, 2005).

Arawati (2011) examined the relationship between SCM, supply chain flexibility, and business performance by using Pearson’s correlation and Structural Equation Modeling (SEM). The overall result suggests that SCM has significant impact on supply chain flexibility and business performance. Rudd et al. (2008) investigated the mediating effects of flexibility on the strategic planning and performance relationship. In their study, flexibility is divided into four main types, namely operational flexibility, financial flexibility, structural flexibility, and technological flexibility. The empirical results show that both operational and financial flexibility mediate the influence of strategic planning on financial performance, while structural and technological flexibility mediate its influence on nonfinancial performance.

2.1.4.4 Cost

Competing in the dynamic marketplace requires low-cost production as a basic approach. In order to keep manufacturing costs competitive, managers must address materials cost, labor cost, overhead cost, and other costs (Li, 2000). Specifically, inventories have been the focus of cost reduction for manufacturers and are one of the justifications for the Just-In-Time (JIT) system. Thus, cost capability focuses on reducing production costs, controlling inventory level, and increasing equipment and capacity utilization in a company (Noble, 1997; Ward and Duray, 2000).

Boon (2009) examined the effect of information technology and supply chain integration on production cost performance in Thai automotive industry. Analysis of Variance (ANOVA) was used to analyze the data. The results indicate that the adoption of an information technology for supply chain integration can improve production cost.

2.1.5 Cumulative model (Sand cone model)

Cumulative capability modeling is defined as a concept in which an improvement process with predetermined and sequential paths is implemented, in order to improve not only internal performance, but also competitive advantages (Sarmiento et al., 2010). Nakane (1986) suggested a cumulative model in which quality improvement is the basis of all other improvements, followed by dependability. Flexibility priority can be obtained when they achieve prior improvement of quality, dependability, and cost.

Ferdows and De Meyer (1990) proposed a cumulative model called the "sand cone model" in which a typical sequence recommended focuses on quality, delivery, flexibility, and cost efficiency (see Figure 2.1). Quality is a precondition for all lasting improvements in manufacturing. While the efforts to improve the quality continue to expand, some efforts should be focused on making the production process more dependable, and improvement of speed should be added next. Cost is the last improvement in the sequence; ultimately the company will be able to enjoy improved performance in quality, delivery, flexibility, and cost efficiency, simultaneously.

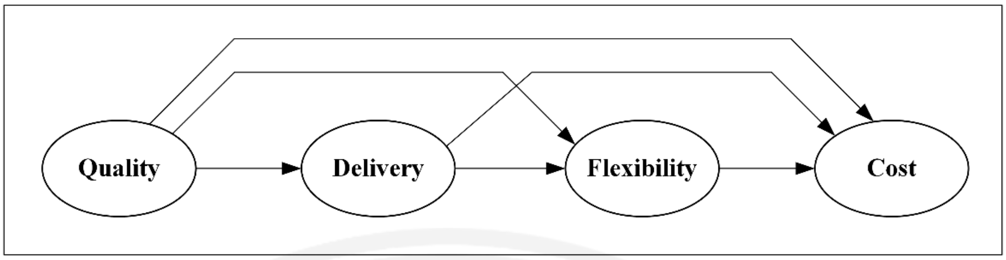

Figure 2.1: Cumulative model

2.1.6 Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM) has become one of the most widely used multivariate statistical tools in various areas, such as psychology, education, and behavioral sciences. It has been used to describe a large number of statistical models used to evaluate the validity of substantive theories with empirical data. Statistically, it represents an extension of General Linear Modeling (GLM) procedures and multiple regression analysis (Lei and Wu, 2007).

The goal of SEM is to determine whether a hypothesized theoretical model is consistent with the data collected, to reflect the theory. SEM is performed by using a two-step procedure, called measurement and structural models. In the first step, the measurement model is developed to measure relationships between factors and their indicators by using Confirmatory Factor Analysis (CFA). In the second step, the structural model is developed and tested, to examine relationships between latent variables themselves.

Advantages of SEM include more flexible assumption, use of confirmatory factor analysis to reduce measurement error by having multiple indicators per latent variable, the attraction of the graphical modeling interface, desirability of testing models overall rather than coefficients individually, ability to model error term, and ability to handle incomplete data. The most importance is that SEM can be used to model mediating variable and test the relationships among latent constructs that are indicated by multiple measures.

2.1.7 Quality Function Deployment (QFD)

Quality Function Deployment (QFD) was originally developed and implemented in Japan in the early 1970s (Hauser and Clausing, 1988). QFD has been used as an important part of the product development process. It is a systematic and analytical technique for translating customer requirements (voice of the customer) into a final product through the stages of product planning, engineering, and manufacturing (Akao, 1990). Specifically, this method begins by analyzing market and customer needs for a product. Then, it translates the desires of customers into technical characteristics, and subsequently into parts characteristics, process plans, and production requirements using four Houses of Quality (HOQ) (Partovi, 2006). Companies can achieve various benefits using QFD such as reducing customer complaints, improving design reliability and customer satisfaction, and reducing product development cycle time (Moskowitz and Kim, 1997). Due to its usefulness, in the review of QFD theory and applications, Chan and Wu (2002) reported that QFD has been applied successfully in various fields, from determining customer needs (Stratton,1989), developing priorities (Han et al., 2001), manufacturing strategies (Crowe and Cheng, 1996), to logistics and SCM (Bevilacqua et al., 2006; Bottani and Rizzi, 2006).

The procedures of the traditional QFD approach are described in these following steps:

Step 1: Identifying the customer requirements “WHATs”.

Step 2: Identifying the technical characteristics “HOWs”.

Step 3: Determining the relative importance of the “WHATs”.

Step 4: Determining the “WHATs”–“HOWs” correlation scores.

Step 5: Determining the weight of the “HOWs”.

Step 6: Determining the correlation between “HOWs”.

The customer requirements (WHATs) are represented on the left side of the House of Quality (HOQ). Identifying the relative importance of “WHATs” plays an important role in recognizing critical requirements and prioritizing design effort. Technical characteristics “HOWs” are represented on the upper side of the HOQ. The relationships between the “WHATs” and “HOWs”, which are presented in the main body of the HOQ, can be in symbol or numerical form. The weight of the “HOWs” can be calculated using the relative importance of customer requirements and the correlation scores assigned to the relationships between "WHATs" and "HOWs". The correlations between "HOWs" are typically assessed by the design team in a subjective manner (Kim et al., 2000). A typical HOQ is shown in Figure 2.2.

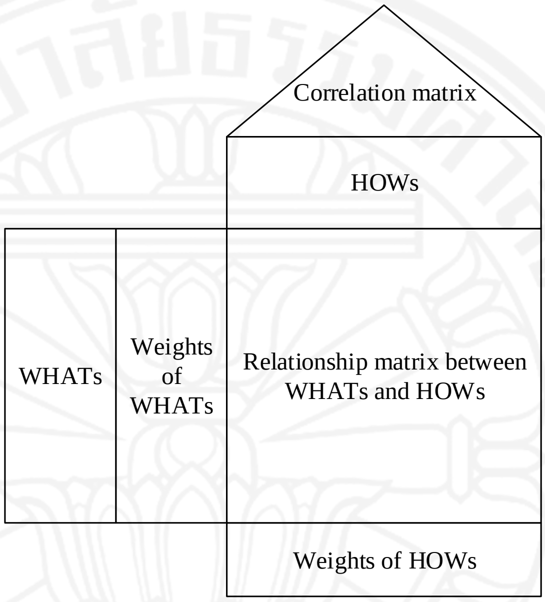

Figure 2.2: Typical House of Quality

2.1.8 Fuzzy set

The fuzzy set theory was originally introduced by Zadeh (1965), to deal with uncertainty and inaccuracy in an experiment. A fuzzy set is characterized by a membership function, which assigns a grade of membership, ranging between 0 and 1 to each object (Kahraman et al., 2006; Zadeh, 1965). The use of fuzzy numbers is important in decision-making problems, where linguistic scales are adopted and a panel of decision makers is involved in the judgment process. Decision makers are often faced with doubts, uncertainties, and inaccuracies. To deal with this problem, fuzzy logic takes into account different meanings that may be given to the same linguistic expression. As a matter of fact, the fuzzy approach has been widely adopted in different research fields (Bottani and Rizzi, 2006).

There are various types of fuzzy numbers, each of which may be more suitable than others for analyzing a given ambiguous structure. The use of triangular fitness functions is fairly common in the literature because triangular fuzzy numbers are easy to manage from a computational point of view (Karsak, 2004; Chan and Wu, 2005).

2.1.9 Multi-Objective Linear Programing Model (MLP)

Many planning problems contain a hierarchical decision structure, each with independent, and often conflicting objectives (Baky, 2010). These types of problems can be modeled using a Multi-objective Linear Programming Model (MLP). MLP is concerned with mathematical optimization problems involving more than one objective function to be optimized simultaneously (Wilamowsky et al., 1990). Specifically, the main aim of a MLP model is to optimize "k" different linear objective functions, subject to a set of linear constraints, where $k \geq 2$ (Pandian and Jayalakshmi, 2013). Such models have the advantage of accurately representing the real multi-criteria nature of certain situations (Benayoun et al., 1971). So, MLP has been applied in many fields of science, including engineering, economics, and logistics. Consider the mathematical formulation of a MLP problem:

$$Max\ z = w_1 \sum_{j=1}^{N} C_j * X_j - w_2 \sum_{j=1}^{N} R_j * X_j \qquad (1)$$

Constraints:

$$\sum_{j=1}^{N} R_j * X_j \leq a \qquad (2)$$

$$w_y \geq 0, \qquad y = 1, 2 \qquad (3)$$

$$\sum_{y=1}^{4} w_y = 1 \qquad (4)$$

$$X_j\ is\ binary\ \forall\ j \qquad (5)$$

where:

C_j is the first criterion, its objective aimed to maximize

R_j is the second criterion, its objective aimed to minimize

X_j is a decision variable

N is the number of subjects that are considered

a is the constraint limited value

w_y is the weight of criterion y

In the MLP problem, optimizing all objective functions at the same time is not possible because of the conflicting nature of the objectives (Pandian and Jayalakshmi, 2013), so that optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives. In this case, prioritizing different criteria becomes important. There are different methods for weighting criteria in the objective function such as Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Sensitivity Analysis, etc.

2.2 Related literature

2.2.1 Literature carried out in the food industry

Okello and Were (2014) examined the influence of supply chain practices on the performance of food manufacturing companies in Nairobi Kenya. In this study, both correlation and regression, and Analysis of Variance (ANOVA) were used to analyze data. The results show that product development process, inventory management, lead time, technology, and innovation have a significant influence on the performance of food manufacturing company in Kenya.

Tariq et al. (2013) investigated the factors effect to firm's financial performance in textile sector and food sector in Pakistan by using the one-way fixed effect regression model. The findings in the case of food sector indicate that long term leverage, size, risk, tangibility, and non-debt tax shield are the important and significant determinants of firm's performance of Pakistan. While in the case of textile sector, firm's performance is significantly affected by short term leverage, size, risk, tax and non-debt tax shield.

The impact of information technology to the business performance in small and medium food companies was investigated by Sugiharto et al. (2010). Path analysis was used in this study to analyze data. Independent variables include perceived internet usefulness, perceived ease of internet use, internet self-efficacy, and internet anxiety. Two dependent variables are internet adoption and business performance. The findings indicate that internet adoption is significantly affected by perceived usefulness, perceived ease of use, internet self-efficacy, and internet anxiety. However, business performance is not affected by internet technology adoption.

Among many methods, Johnson et al. (2009) used Structural Equation Modeling (SEM) to examine the links between incorporates market orientation theory (competitor orientation, customer orientation, and inter functional coordination), firm innovativeness, and firm financial performance. While they found no evidence of direct impacts on performance via three elements of market orientation, their results reveal a positive influence on performance through firm innovativeness. In addition, the more successful firms are more internally focused (inter functional coordination and innovativeness) than externally focused (competitor and customer orientation).

Chegini et al. (2013) tested the relationship between business intelligence and the performance of food industry companies in Rasht industrial city. They developed seven hypotheses, which comprise a main hypothesis and six subsidiary hypotheses. These hypotheses represent the influence of efficient flow of information, employee's capability of learning, policies of continuous improvement, investment in Information Technology (IT), technology and IT infrastructure, and organizational learning on the performance. The result shows that organizational learning has the strongest effect on the performance of company, and policies of continuous improvement are the second strong one.

Chiadamrong and Sophonsaritsook (2015) used SEM to analyze the relationships between supply chain capabilities, competitive advantages, and business performance. Data were collected from 236 food manufacturing companies in Thailand. The results provide that supply chain capabilities (supply chain integration, supply chain operation, and human resource management) affect business performance through competitive advantages (quality, delivery, flexibility, and cost). In addition, except flexibility, other factors of competitive advantages have positive and significant effects to business performance.

2.2.2 Literature related to SEM

Zulkiffli and Perera (2011) investigated the significant levels of Supply Chain Integration (SCI) on the relationships between corporate competitive capabilities and business performance. Data were collected from 135 small and medium manufacturing companies in Malaysian and was tested by using confirmatory factor analysis, cluster analysis, and multi-group SEM analysis. The findings show that SCI significantly moderate the relationships between competitive capabilities and business performance.

Hult et al. (2004) developed eight hypotheses to propose that market orientation, entrepreneurial orientation, and learning orientation affect business performance through innovativeness. All hypotheses were tested via Structural Equations Modeling (SEM). Except learning orientation, three elements namely market orientation, entrepreneurial orientation, and innovativeness are the drivers of performance. The empirical findings also confirm innovativeness as an important determinant of business performance, partially mediate the relationships between market orientation and entrepreneurial orientation to business performance.

Farhanghi et al. (2013) investigated how information technology affect to organizational structure and firm performance. Three hypotheses were developed to determine the cause-and-effect relationships among these constructs, and SEM was used to analysis data. All these hypotheses are strongly supported by the data, providing that information technology affect positively on organizational structure, and has a direct and indirect impact on firm performance. Organizational structure is found to have a positive and significant effect on firm performance.

The relationships between Lean manufacturing management, competitive skills, and business performance were tested by Moori et al. (2013). Data were collected from a survey of 68 Brazilian companies that use lean manufacturing, and were analyzed by using SEM. The empirical results reveal that Lean manufacturing affect positively on business performance with competitive skills as mediating variable.

Sohn et al. (2007) used SEM to analyze the relationships between technology evaluation factors and the financial performances by developing Financial Performance Index (FPI). They categorized technology evaluation factors into five factors, namely knowledge and experience of manager, operation ability of manager, level of technology, marketability of technology, and technology profitability. The empirical results show that the operation ability of manager has the highest direct effect on the FPI, while the level of technology has the highest indirect effect on the FPI. In addition, other factors such as knowledge and experience of manager, and marketing of technology have positive effect on the FPI.

Sarwoko et al. (2013) used SEM to examine the influence of entrepreneurial characteristics and competencies on business performance in Small and Medium Enterprises (SMEs). Entrepreneurial characteristics comprise factors of psychology, experience, and the influence of the family. Business performance measures consist of three indicators, such as sales growth, profit growth, and capital growth. The results provide evidences to support that the entrepreneurial characteristics and entrepreneurial competencies have a significant influence on business performance, with entrepreneurial competencies as mediating factor. It means the more powerful entrepreneurial characteristics will lead to an increase in the competence of the SMEs owner, which will ultimately have an effect on business performance.

Meutia and Ismail (2012) investigated the impact of entrepreneurship social competence to business network, competitive advantage, and business performance of Small and Medium Enterprises (SMEs). Data were analyzed through SEM. The empirical results show that entrepreneurial social competence has positive and significant effect to the business network and competitive advantage. Business network positively affects competitive advantage, and in return competitive advantage directly and significantly affects the business performance.

Santos et al. (2014) studied the relationships between innovation and firm performance in Brazilian companies using SEM. Innovation factor is measured by innovation effort, relational capital, and human capital. Results indicate that variables, associating with investments in innovation do not explain financial performance significantly.

2.2.3 Literature related to QFD and Fuzzy-QFD

Bevilacqua et al. (2006) developed a fuzzy-QFD methodology for supplier selection. The methodology starts by identifying the features of purchased product that can satisfy the company's needs. Then, the relevant supplier assessment criteria are identified. Linguistic variables and fuzzy numbers allow the company to define the relative importance of the "WHATs", the "HOWs"–"WHATs" relationships, the resulting weights of the "HOWs", and the impact of each potential supplier.

Bottani and Rizzi (2006) proposed a fuzzy-QFD approach to select suitable strategic actions for improving logistics performance. This leads to increased customer satisfaction and market shares. The proposed methodology was applied to an Italian company operating in the mechanical industry. Issam and Wafa (2006) recommended a QFD matrix to develop manufacturing strategies for improving the efficiency and effectiveness of companies. The proposed model consists of six stages, starting from the business strategy formulation, functional strategy formulation, manufacturing priorities formulation, the generation of action plans and the suggestions of the detailed tasks of each action plan, and ending up with the evaluation of the developed strategy. Developed model was applied to a small size Jordanian pharmaceutical companies.

An integrated fuzzy-QFD approach, for identifying the most appropriate Lean enablers, was introduced by Zarei et al. (2011), in order to increase the leanness of the food supply chain. The multi-dimensional approach focuses on cost reduction. Fuzzy logic was used to deal with linguistic judgments expressing relationships and correlations required in QFD. A case study in the canning industry was used to illustrate the practical implications of the methodology.

Jia and Bai (2011) suggested a methodology for manufacturing strategy development based on fuzzy set and QFD. QFD was used as a transforming device to link competitive factors with manufacturing decision categories, including structural decision categories and infrastructural categories. This study also integrates fuzzy set theory and QFD to provide a structural tool, to deal with the inherent imprecision and vagueness of decision-relevant inputs.

Partovi (2004) introduced a methodology for the facility location problem. There are four steps in their process, starting from market segments to build competitive priorities, then, critical processes, location attributes, and finally build various locations. In the methodology, AHP was used to determine the relationships between the row and column variables of each matrix. ANP was used to determine the intensity of the effects among column variables.

Ayağ et al. (2013) developed crucial logistics requirements and SCM strategies for the dairy industry by using an Analytic Hierarchy Process (AHP) approach, fuzzy-QFD, and Multi-objective Linear Programming Model (MLP). Qualitative information was converted into quantitative parameters. Then, the data were combined with other quantitative data to parameterize two MLP models. In the first model, the most important logistic requirements for the company were determined based on technical importance, cost, feasibility, and value increment. In the second model, based on these criteria, appropriate SCM strategies were determined. A case study from the Turkish dairy industry was given to illustrate the proposed methodology.

2.2.4 Research on the food industry in Vietnam

The food industry can be defined as the transformation of agricultural product to be a part of final product or the final product, which is served for human consumption (Minot, 1998). After performing *"Đổi mới"*-*"renovation"* in 1986, the Vietnamese food industry has become an essential industry in the economy. In 1989, Vietnam became one of the three largest rice exporters in the world, a position it has maintained ever since (Minot, 1998). The food industry in Vietnam is not only a major consumer of agricultural products, but also a large sector, which generates employment opportunities for the rural communities, where most poor people are found. In addition, this sector produces food for Vietnam's growing population, and is an important source of export revenue, particularly from rice, coffee, and seafood (Canh et al., 2013).

Due to the country's vast population (nearly 90 million Vietnamese consumers), Vietnam has the fastest growing market in Asia. The industrial production index of food manufacturing rose steadily, together with the rise of the consumption index during the period, 2008-2012. The amount of food products accounted for over 1,378 thousand tons, including rice (40 million tons), sugar (1,526 thousand tons), canned vegetable and fruit (110 thousand tons), and other products (General statistics office)[1]. In 2013, Vietnam's food and beverage market was worth over USD 60.1 billion, accounting for 40.5% of the total consumption of the country. Domestic consumption reached 42.8 billion, occupying approximately 71% of the total food industry value (VP Bank Securities, Financial Institute)[2].

Moreover, becoming members of ASEAN in 1995 and of the WTO in 2007 has been the best opportunity for Vietnam to participate in a huge export market. In 2009, Vietnam dominated a number of food export sectors, ranking second in the world for rice, following Thailand. According to the Corporate Banking and Financial Institutions' report[3], Vietnamese food products have reached more than 120 countries and territories on five continents, including the United States, Japan, and European nations as the three main export markets. The most important Vietnamese food products are processed foods (rice, coffee, and instant noodles), processed seafood, alcoholic beverages, dairy products, and vegetable oil. Main food industry exports have accounted for a substantial amount of the total export value of approximately USD 17.3 billion in 2013. This amount comprises canned, frozen, and processed fishery products (nearly USD 6.73 billion), rice (USD 2.99 billion), canned and processed coffee (USD 2.69 billion), and other products. Fishery products have become Vietnam's second largest resource-based export.

Vietnam's food industry is a rapidly growing sector in recent years, playing a vital role in economic development, and can create a strong base for later development. However, growing in the dynamic environment with many potential competitors has spurred organizations to find ways to improve their performance even better. They seek for competitive capabilities that enable them to exceed customers' expectations and enhance business performance. One of the key successes is that of understanding supply chains and how they should be implemented. They enable increasing sustainable

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[1] General statistics office, available at http://www.gso.gov.vn/Default.aspx?tabid=217 (accessed on 9 January 2015)
[2] 'Vietnam food and beverage industry', VP Bank Securities, Financial Institute, available at http://www.vpbs.com.vn/Handlers/DownloadReport.ashx?ReportID=2231 (accessed on 10 January 2015)
[3] 'Vietnam's food sector prospects and financing solutions', Corporate Banking and Financial Institutions, available at http://www.iesingapore.gov.sg/~/media/IE%20Singapore/Files/Events/iAdvisory%20Series/Vietnam/6_Overview_of_Vietnams_Food_Sector_Prospects_and_Financing_Solutions.pdf (accessed on 14 January 2015)

competitive advantages, in order to have the best strategy for getting the best position in a competitive business environment.

Minot (1998) examined the competitiveness of the food processing sector, including rice milling, coffee processing, seafood processing, and fruits and vegetables. In each subsector, production, marketing, processing, domestic demand, and export demand are described. It was found that the competitiveness of food processing industry depends largely on quality and the cost of production of the raw material. The competitiveness of food processing in international markets is subject to rapid change. In Viet Nam, state-owned enterprises (SOEs) play a dominant but declining role in the food processing sector. The main reason for the decline in the share of food processing is lack of flexibility, slow decision-making, and higher costs.

Le and Harvie (2010) evaluated firm performance, measured by technical efficiency of Small and Medium Enterprises (SMEs) in Vietnam. An econometric approach was used to analyze the data, conducted from three surveys in 2002, 2005, and 2007. The results reveal that manufacturing SMEs in Vietnam have relatively high technical efficiency. In addition, it was found that firm age, size, location, ownership, cooperation with a foreign partner, subcontracting, product innovation, competition, and government are all significant factors, effecting technical efficiency.

Canh et al. (2013) analyzed the impact of various policy reforms on the competitiveness of the food processing industry in Vietnam. Data come from a survey of 350 manufacturing firms, conducted in 2000. Profitability analysis was used to predict the evolution of the competitiveness, and to simulate the impact of a wide variety of government policies on this sector. The results show that among the different scenarios, devaluation and efficiency gains have the strongest and most positive impact on profitability. Reduction in material input and service costs are also positive factors, contributing to improved profitability. In contrast, smaller tariff reductions, and a rise in social and health insurance costs for workers have negative impacts on profitability.

From the above literature review, it was found that there are a few areas that are still missing. Firstly, even though many works have been done to evaluate the business performance in Food industry, there are not many studies examines the relationships between supply chain capabilities, competitive advantages, and business performance in the Vietnamese food industry. Secondly, there are not much research considers the above mentioned relationships in business strategy development. Also, the combination of SEM, Fuzzy-QFD, and MLP has not been studied and applied in the literature. The above findings lead to the main idea and objectives of this study.

Chapter 3
Research Methodology

This chapter describes a proposed methodology, used to determine the most suitable SCM strategies, based on the combination of Structural Equation Modeling (SEM), Fuzzy-QFD, and Multi-Objective Linear Programming model (MLP).

3.1 Proposed methodology

Based on the analysis of the existing methodologies related to the supply chain strategy development, a methodology is proposed, which is based on the transformation of QFD principles from product development to supply chain strategy development. The characteristics of the methodology are illustrated in Figure 3.1.

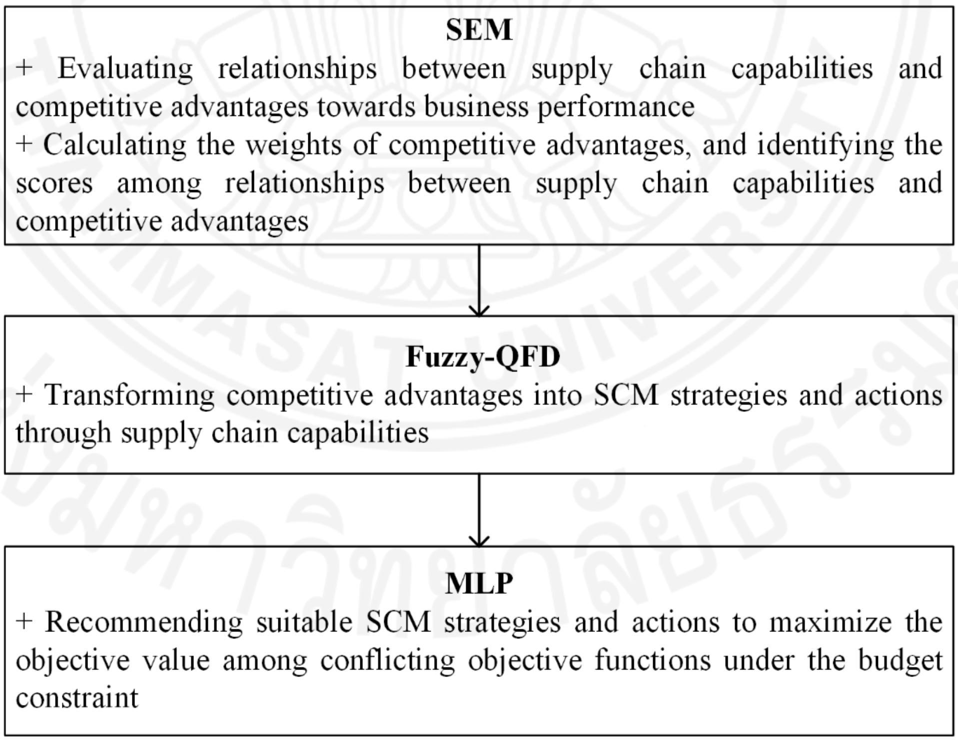


Figure 3.1: Proposed methodology

In this study, SEM is used to analyze the relationships between supply chain capabilities and competitive advantages towards business performance. The result from SEM is used for weighting competitive advantages, based on significant relationships between these factors and business performance. This result is also used to input the relationship scores between competitive advantages and supply chain capabilities into Quality Function Deployment (QFD).

Then, two QFD matrixes are built to transform supply chain requirements into SCM strategies and actions. The first QFD matrix is used to transform competitive advantages into supply chain capabilities. The second QFD matrix is used to transform supply chain capabilities into specific SCM strategies. Relationships between supply chain capabilities and SCM strategies are given by academic experts. They express their opinions by linguistic terms such as "very high relationship", "high relationship", "medium relationship", "low relationship", or "very low relationship", which are imprecise. Linguistic variables expressed in fuzzy numbers seem to be more appropriate for describing these relationships in QFD, as the levels of these relationships are not defined in exact numbers. So, triangular fuzzy numbers are used to quantify linguistic data, in terms of the levels of these relationships in a Fuzzy-QFD matrix in the second QFD matrix.

Finally, MLP is used to select suitable strategies to be implemented, to maximize the value among four conflicting objectives under a limited investment budget. Sensitivity analysis on the weight is used to build various scenarios on the weighting sets among four conflicting criteria, aiming to maximizing the value of the objective function.

3.2 Relationships between supply chain capabilities and competitive advantages towards business performance

In the first step of the proposed methodology, relationships between supply chain capabilities, competitive advantages, and business performance are tested using Structural Equation Modeling (SEM).

3.2.1 Two-step approach to path analysis with latent variable

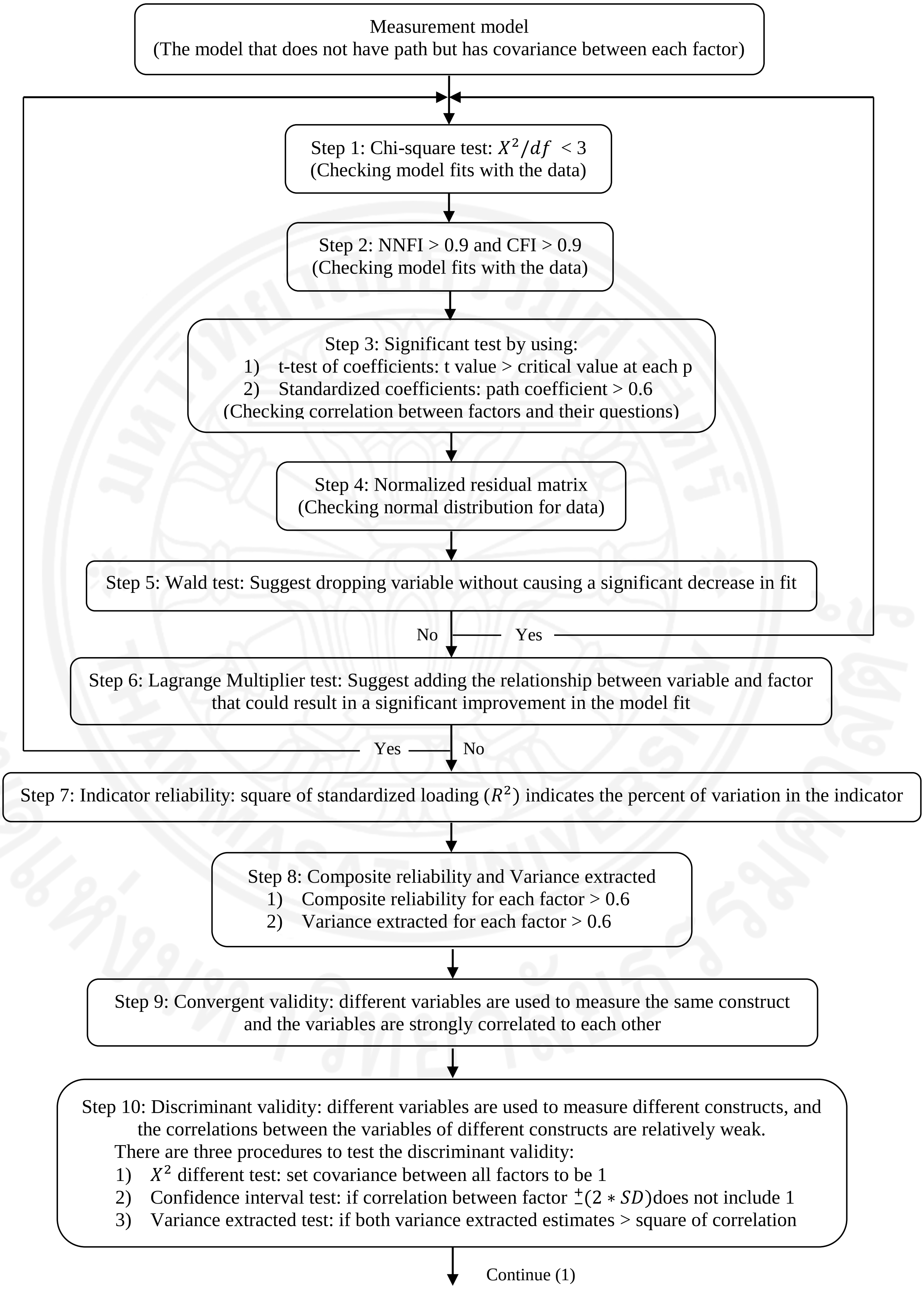
The study use Structural Equation Modeling (SEM) with SAS program to test the null and research hypotheses. SEM performed by using a two-step procedure that allows the simultaneous analysis of both measurement and structural models. In a first step, the measurement model is developed with the objective to set an observed variable. In a second step, the structural model is developed and tested, including the relationships between latent variables themselves.

The first step of this process involves using confirmatory factor analysis to develop an acceptable measurement model. A measurement model is a factor-analytic model for identifying the latent construct. In this model, any casual relationships between the latent constructs are not specified themselves. Instead, each latent construct is allowed to correlate with every other latent constructs.

Once a measurement model that displays an acceptable fit has been developed, the second step recommend by Anderson and Gerbing (1998) can be done. In this phase, the measurement model is modified, so that it now specifies casual relationships between some of the latent variables. The modifications are made so that the model comes to represent the theoretical casual model that we want to test. The resulting theoretical model is a combined model that actually consists of two components:

- A measurement model (that specifies casual relationships between the latent constructs that their indicator variable)
- A structural model (that specifies casual relationships between the latent constructs themselves)

When the path analysis with latent variable is performed, a simultaneous test that determines whether this combined model, as a whole, provides an acceptable fit to the data will be performed. If it does, then the theoretical model has survived and an attempt at disconfirmation, and to obtain some support for its predictions can be obtained. The two-step of approach is presented in Figure 3.2.



Measurement model
(The model that does not have path but has covariance between each factor)
Step 1: Chi-square test: X^2/df < 3
(Checking model fits with the data)
Step 2: NNFI > 0.9 and CFI > 0.9
(Checking model fits with the data)
Step 3: Significant test by using:
1) t-test of coefficients: t value > critical value at each p
2) Standardized coefficients: path coefficient > 0.6
(Checking correlation between factors and their questions)
Step 4: Normalized residual matrix
(Checking normal distribution for data)
Step 5: Wald test: Suggest dropping variable without causing a significant decrease in fit
No
Yes
Step 6: Lagrange Multiplier test: Suggest adding the relationship between variable and factor that could result in a significant improvement in the model fit
Yes
No
Step 7: Indicator reliability: square of standardized loading (R^2) indicates the percent of variation in the indicator
Step 8: Composite reliability and Variance extracted
1) Composite reliability for each factor > 0.6
2) Variance extracted for each factor > 0.6
Step 9: Convergent validity: different variables are used to measure the same construct and the variables are strongly correlated to each other
Step 10: Discriminant validity: different variables are used to measure different constructs, and the correlations between the variables of different constructs are relatively weak.
There are three procedures to test the discriminant validity:
1) X^2 different test: set covariance between all factors to be 1
2) Confidence interval test: if correlation between factor $\pm(2 * SD)$does not include 1
3) Variance extracted test: if both variance extracted estimates > square of correlation
Continue (1)

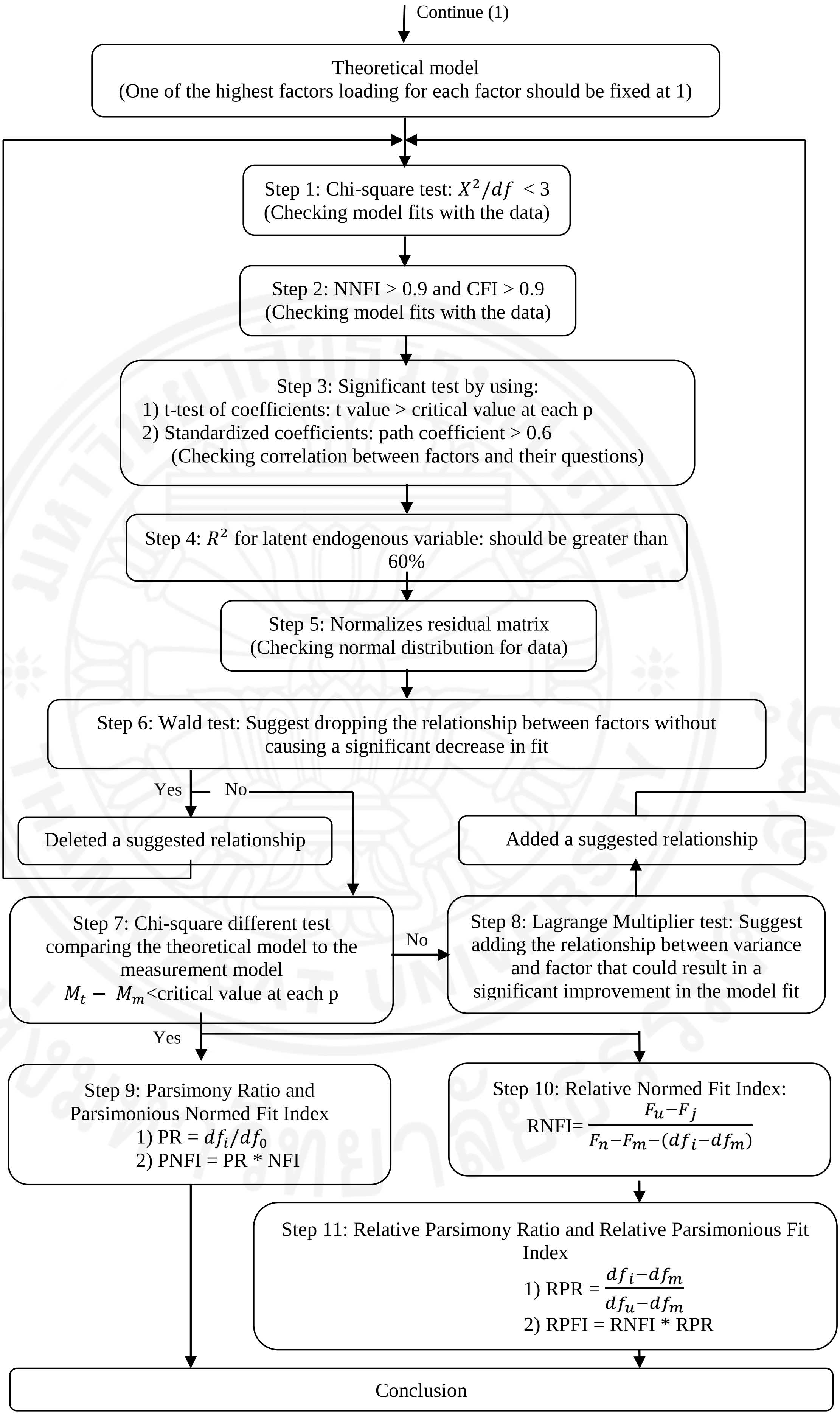


Figure 3.2: Flow chart of the two-step approach

3.2.2 Testing the fit of the measurement model

Step 1: Reviewing the chi-square test

The chi-square test provides a statistic test of the null hypothesis that the model fit the data. (H_0: Model fits with the data and H_1: Model does not fit with the data). If the model provides a good fit, the chi-square value will be relative small and the corresponding *p* value will be relatively large. In the case of accepting fit, the chi-square ratio (X^2/df) should be less than 3.

Step 2: Reviewing the Non-Normed Fit Index and the Comparative Fit Index

The Non-Normed Fit Index, or NNFI (Bentler and Bonett, 1980), and the Comparative Fit Index, or CFI (Bentler, 1989), are the identification about overall goodness of fit indices. Value over 0.9 on the NNFI and CFI indicate an acceptable fit.

Step 3: Reviewing the significance tests for factor loading

The factor loadings are equivalent to path coefficients from latent factors to their indicator variables. Therefore, an insignificant factor loading means that the involved indicator variable is not doing a good job for measuring the underlying factor, and should be reassigned or dropped. The *t*-value explains about the significance of path coefficients from latent factors to their indicator variables. The factor loadings are significant when *t*-values are greater than 1.96 at $p < 0.05$, 2.576 at $p < 0.01$, or 3.291 at $p < 0.001$.

Step 4: Normalized residual matrix

The model provides a good fit to the data when the distribution of normalized residual is centered on zero, symmetrical, and contains no or few large residuals.

Step 5: The Wald test

The Wald test estimates the change in model chi-square that would result from fixing a given parameter at zero. The first parameter listed is the one that will result in the least change in chi-square if deleted. The second parameter will result in the second-least change, and so forth. The result from *t*-value and covariance related to the Wald test about the parameter that is suggested to be deleted.

Step 6: The Lagrange multiplier test

The Lagrange multiplier test estimates the reduction in model chi-square that results from freeing a fixed parameter and allowing it to be estimated. In other words, the Lagrange multiplier estimates the degree to which chi-square would improve if a new factor loading or covariance is added to model.

The first modification index is the Wald test, which identifies parameters that should possibly be dropped from the model. The second modification index is the Lagrange multiplier, which identifies parameters that should possibly be added. It is generally safer to drop existing parameters than to add new ones. For this reason, the Wald test will be consulted first.

Step 7: Indicator reliability

The reliability of an indicator variable is defined as the square of the correlation between a latent factor and that indicator. In other words, the reliability indicates the percentage of variation in the indicator that is explained by the factor that it is supposed to measure (Long, 1983).

Step 8: Composite reliability and variance extracted

The composite reliability identifies the indicators measuring a given factor while the variance extracted identifies the amount of variance that is captured by factor in relation to the amount of variance due to measurement error. The minimal acceptable level of composite reliability and variance extracted are 0.6 and 0.5, respectively.

Step 9: Convergent validity

Convergent validity is used to measure the similarity or convergence between the indicators measuring the same construct. Convergent validity is demonstrated when the correlations between these indicators are statistically significant (greater than twice their standard errors).

Step 10: Discriminant validity

Discriminant validity is demonstrated when the correlations between different indicators measuring different constructs are relatively weak. There are three possible methods to test the discriminant validity.

Chi-square difference test: This measurement model can be analyzed by the amount of change of the chi-square value when setting the covariance between each pair of latent variables to be 1. If chi-square difference between the measurement model and the discriminant model is significant, the model is supported to give the discriminant validity.

Confidence interval test: If the range between the factors plus and minus twice its standard deviation does not include 1, there is a discriminant validity.

Variance extracted test: If the variance extracted estimates of both factors have the strongest correlation pair exceeding the square of correlation, there is discriminant validity.

3.2.3 Testing the fit of the structural model

Step 1: Reviewing the chi-square test

The chi-square test provides a statistic test of the null hypothesis that the model fit the data. (H_0: Model fits with the data and H_1: Model does not fit with the data). If the model provides a good fit, the chi-square value will be relative small and the corresponding *p* value will be relatively large. In the case of accepting fit, the chi-square ratio (X^2/df) should be less than 3.

Step 2: Reviewing the Non-Normed Fit Index and the Comparative Fit Index

The Non-Normed Fit Index, or NNFI, and the Comparative Fit Index, or CFI are the identification about overall goodness of fit indices. Value over 0.9 on the NNFI and CFI indicate an acceptable fit.

Step 3: Reviewing the significance tests for factor loading

The factor loadings are equivalent to path coefficients from latent factors to other latent factors. Therefore, an insignificant factor loading means that the relationship between these factors is relatively slow, and should possibly be dropped. The *t*-values explain about the significance of path coefficients from latent factors to other latent factors. The factor loadings are significant when *t*-values are greater than 1.96 at $p < 0.05$, 2.576 at $p < 0.01$, or 3.291 at $p < 0.001$.

Step 4: Reviewing R^2 values for the latent endogenous variables

Of particular interest is the R^2 values for the structural model's latent endogenous variables F1 (Financial Firm Performance), F2 (Operational Firm Performance) and F3 (Supply Chain Capabilities). The result shows that the independence F variables accounted for percentage of the variance in F1 (FFP), a percentage of the variance in F2 (OFP), and percentage of the variance in F3 (SCC).

Step 5: Normalized residual matrix

The model provides a good fit to the data when distribution of normalized residual is centered on zero, symmetrical, and contains no or few large residuals.

Step 6: The Wald test

The Wald test estimates the change in model chi-square that would result from fixing a given parameter at zero or eliminating a specific path or covariance from the model. The first parameter listed is the one that will result in the least change in chi-square if deleted. The second parameter will result in the second-least change, and so forth. The result from *t*-value and covariance related to the Wald test about the parameter that is suggested to be deleted.

Step 7: Chi-square difference test

The critical test of the validity of the theoretical approach is the chi-square test, comparing the theoretical model (M_t) to the measurement model (M_m). A significant difference between these two models suggests that the theoretical model does not account for relationships between the latent factors that constitute the structural portion of the model.

Step 8: The Lagrange multiplier test

The Lagrange multiplier test estimates the reduction in model chi-square that results from freeing a fixed parameter and allowing it to be estimated. In other words, the Lagrange multiplier estimates the degree to which chi-square would improve if a new factor loading or covariance is added to model.

The first modification index is the Wald test, which identifies parameters that should possibly be dropped from the model. The second modification index is the Lagrange multiplier, which identifies parameters that should possibly be added. It is generally safer to drop existing parameters than to add new ones. For this reason, the Wald test will be consulted first.

Step 9: Parsimony Ratio (PR) and Parsimonious Normed Fit Index (PNFI)

The principle of parsimony states that, when several theoretical explanations are equally satisfactory in accounting for some phenomenon, the preferred explanation is the one that is least complicated or the one that makes the fewest assumptions. With other factors geld constant, the most desirable theoretical model is the most parsimonious mode. Parsimony Ratio (PR) is calculated by the ratio of the studied model's degree of freedom based on the null model that predicts no relationship between any of the study's variables. Parsimonious Normed Fit Index (PNFI) is another index that reflects the parsimony of the model. PNFI can help in selecting the best model when more than one provides an acceptable fit to the data.

Step 10: Relative Normed-Fit Index (RNFI)

Normally, a measurement model describes the relationships between the latent variables and their indicators, and a structural model describes the causal relationships between the latent variables themselves. Relative Normed-Fit Index (RNFI) reflects the fit in just the structural portion of the model, and is not influenced by the fit of the measurement model.

Step 11: Relative Parsimony Ratio (RPR) and the Relative Parsimonious Fit Index (RPFI)

Relative Parsimony Ratio (RPR) can be computed to determine the parsimony of the structural portion of the model. Relative Parsimonious Fit Index (RPFI) combines RNFI and RPR in which RNFI provides the information about the fit in just the structural portion of the model, and RPR provides information about the parsimony of that part of the model. For this reason, RPFI can reflect both the fit and the parsimony in the structural portion of the model. RPFI can be helpful in choosing the model that simultaneously maximizes both fit and parsimony in the structural portion of the model.

3.2.4 Theoretical framework and hypotheses

There are three tiers in the research framework as shown in Figure 3.3. The first tier is supply chain capabilities, which are the sources of capabilities, including tangible and intangible factors such as physical assets, human capital, and intra-inter organizational routines and procedures that could affect competitive advantages (Menor et al., 2001; Roth and Menor, 2003). In this study, supply chain capabilities include:

1. Supply Chain Integration (SCI): a group of capabilities that help to increase the coordination between partners in the supply chain.

2. Supply Chain Operation Management (SCO): a group of capabilities that help to increase the efficiency of manufacturing and distribution systems.

3. Human Resource Management (HRM): a group of capabilities that help to strengthen the human resource ability in a company.

In the second tier, the competitive advantages include four competitive priorities, namely, quality, delivery, flexibility, and cost. Quality is measured by the degree that companies emphasize on activities to reduce defect rates, prevent mistakes or defect in manufacturing products, improve product performance, or activities related to achieving an international quality standard for companies' products. Delivery performance measures focus on activities intended to increase either delivery reliability or delivery speed as to improve the desired level of delivery service. Flexibility measures focus on reducing manufacturing and procurement lead time, reducing set-up time in the manufacturing process, and producing various products. If a company chooses lower cost as a priority, it is indicated by the emphasis placed on reducing production costs, inventory costs, transportation cost, or waste.

The last tier comprises a company's performances used to measure how well an organization achieves its financial goals as well as market performance during the last 5 years. These performances include market share, sale revenue, production capacity, return on investment, and profit as a percentage of sales. These financial and market variables have been used to evaluate organization's performance in previous studies (e.g., Chiadamrong and Suppakitjarak, 2008, 2010; Özdemir and Aslan, 2011). The combination of financial, company growth, and market variables helps to measure the overall business performance effectively and comprehensively.

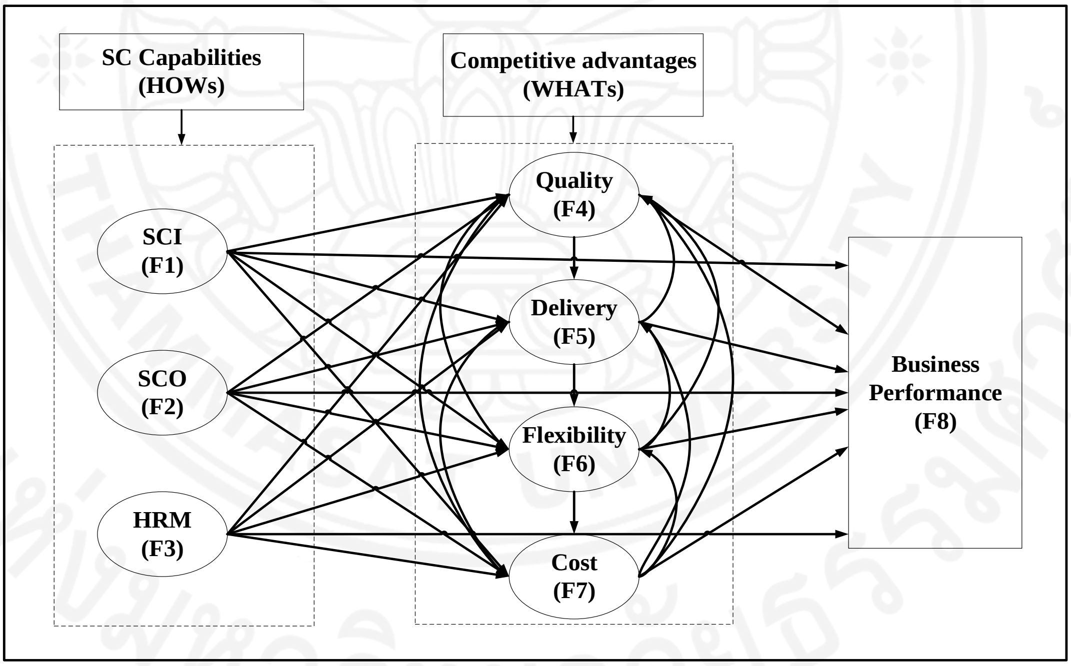


Figure 3.3: Theoretical framework

3.2.4.1 SCM capabilities in relation to competitive advantage and business performance

Hypotheses 1a-1o (Figure 3.4) propose that each of the supply chain capabilities has a positive impact on each of the competitive advantages and business performance. These hypotheses are based on the findings from previous studies, which reported such relationships. Liao and Kuo (2014) stated that supply chain capabilities play a critical role as the building blocks for the supply chain strategy and a source of competitive advantages for company success in the market. Companies, which can combine the internal processes with the suppliers and customers in supply chains, are able to gain important competitive advantages (Hatani et al., 2013). Several studies also examined the relationships between SCI, competitive advantages, and business performance. The results provide empirical evidence that SCI has a positive effect on competition capabilities, and leads directly or indirectly to improved business performance (Rosenzweig et al., 2003; Kim, 2006; Özdemir and Aslan, 2011).

Law and Pujawan (2009) stated that operational activities such as production planning, or system scheduling, etc. have an effect on stability and service level. Indeed, a poor operation management can cause the imbalance of product flow and bottlenecks, reducing throughput of distribution. This leads to erratic output, high inventory, long cycle times, and reduced customer service. So, when a better internal operation is built, a better operational performance and competitiveness can be obtained.

The importance of HRM has been recognized by many studies that the effective management of human resources helps organizations achieve sustained competitive advantages (e.g., Barney and Wright, 1998; Swink and Hegarty, 1998; Youndt et al., 1996). From this perspective, the following hypotheses are proposed:

- H1a: Supply chain integration has a positive impact on quality.
- H1b: Supply chain integration has a positive impact on delivery.
- H1c: Supply chain integration has a positive impact on flexibility.
- H1d: Supply chain integration has a positive impact on cost.
- H1e: Supply chain operation has a positive impact on quality.
- H1f: Supply chain operation has a positive impact on delivery.
- H1g: Supply chain operation has a positive impact on flexibility.

- H1h: Supply chain operation has a positive impact on cost.

- H1i: Human resource management has a positive impact on quality.

- H1j: Human resource management has a positive impact on delivery.

- H1k: Human resource management has a positive impact on flexibility.

- H1l: Human resource management has a positive impact on cost.

- H1m: Supply chain integration has a positive impact on business performance.

- H1n: Supply chain operation has a positive impact on business performance.

- H1o: Human resource management has a positive impact on business performance.

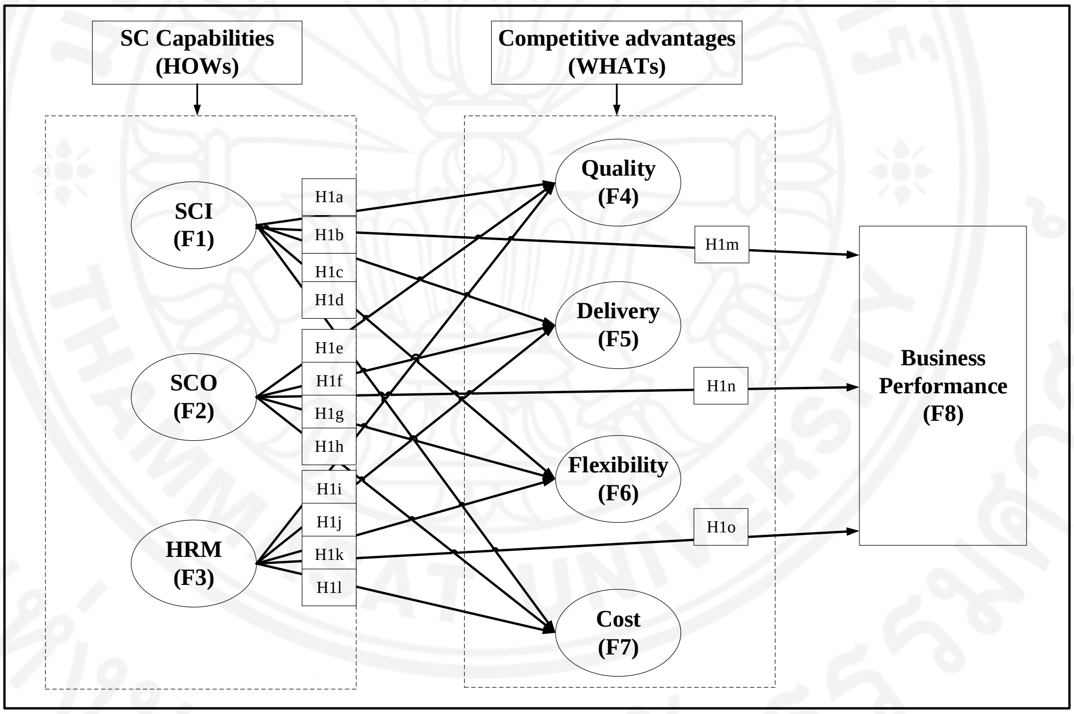


Figure 3.4: Hypotheses H1a-H1o

3.2.4.2 Competitive advantages in relation to business performance

Four important dimensions of competitive advantages are constructed in this study, i.e., quality, delivery, flexibility, and cost. Numerous studies found that competitive advantages lead directly to enhanced business performance (e.g., Özdemir and Aslan, 2011; Rosenzweig et al., 2003; Ward and Duray, 2000). Focusing on quality improvement and the understanding of supply chain relationships, are key factors to enhance business performance (Kannan and Tan, 2005). Flexibility can also be an important source of competitive advantages and strongly affects business performance (Arawati, 2011). Hence, the following hypotheses are suggested (Figure 3.5):

- H2a: Quality has a significant influence on business performance.
- H2b: Delivery has a significant influence on business performance.
- H2c: Flexibility has a significant influence on business performance.
- H2d: Cost has a significant influence on business performance.

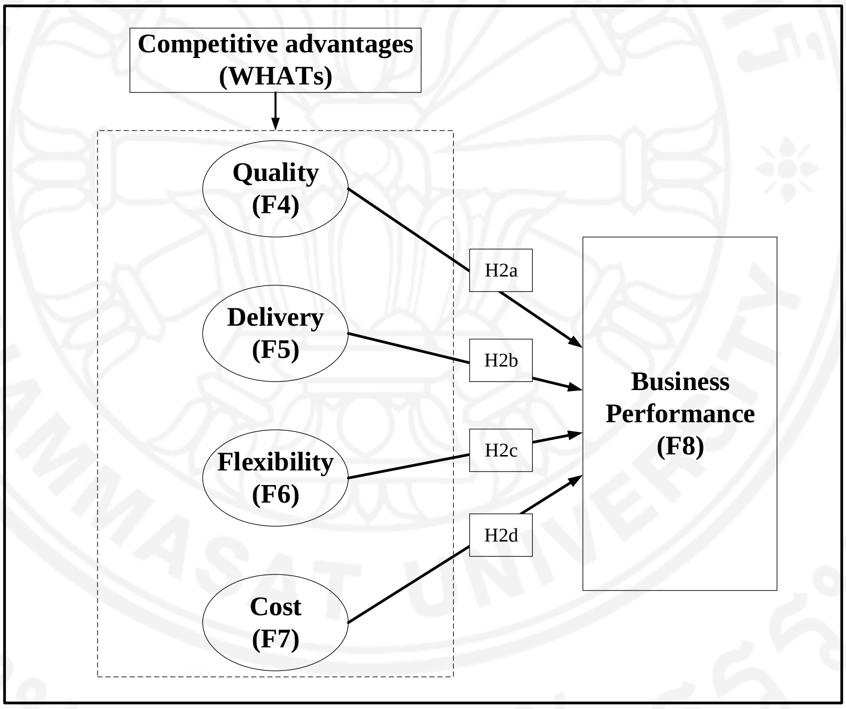


Figure 3.5: Hypotheses H2a-H2d

3.2.4.3 Relationships among competitive advantages

Several conceptual models have been suggested to depict the development and improvement of competitive advantages. Among different models, the sand cone model suggested by Ferdows and De Meyer (1990) has received much attention in literature.

Using a sand cone, Ferdows and De Meyer (1990) suggested a sequence of improvement four priorities, starting from quality as basic for other manufacturing improvement. Then, delivery, flexibility, and cost are improved simultaneously with the continuously effort on the quality improvement. They addressed that these priorities have been cumulative, and not the result of compromises and tradeoffs.

On the other hand, some research has reported that there are several differences between these relationships by changing country locations. Flynn and Flynn (2004) used the data from Germany, Italy, US, England, and Japan to test the cumulative model. It was found that the sequence of capability development was different among these countries. Amoako-Gyampah and Meredith (2007) studied data from Ghanaian companies, and found that while cumulative capabilities existed, the sequence of development was different from that in the study of Ferdows and De Meyer (1990). Sum et al. (2012) tested relationships in the cumulative model in five countries (Australia, Korea, Hong Kong, Singapore, and Taiwan). The findings support that relationships in the hypothesized cumulative model are affected by the country location of the companies.

Based on this theory, twelve hypotheses (H3a–H3l, see Figure 3.6) are suggested, to test the relationships among competitive advantages:

- H3a: Improvement in quality has a direct positive impact on delivery.
- H3b: Improvement in quality has a direct positive impact on flexibility.
- H3c: Improvement in quality has a direct positive impact on cost.
- H3d: Improvement in delivery has a direct positive impact on quality.
- H3e: Improvement in delivery has a direct positive impact on flexibility.
- H3f: Improvement in delivery has a direct positive impact on cost.
- H3g: Improvement in flexibility has a direct positive impact on quality.
- H3h: Improvement in flexibility has a direct positive impact on delivery.
- H3i: Improvement in flexibility has a direct positive impact on cost.
- H3j: Improvement in cost has a direct positive impact on quality.
- H3k: Improvement in cost has a direct positive impact on delivery.
- H3l: Improvement in cost has a direct positive impact on flexibility.

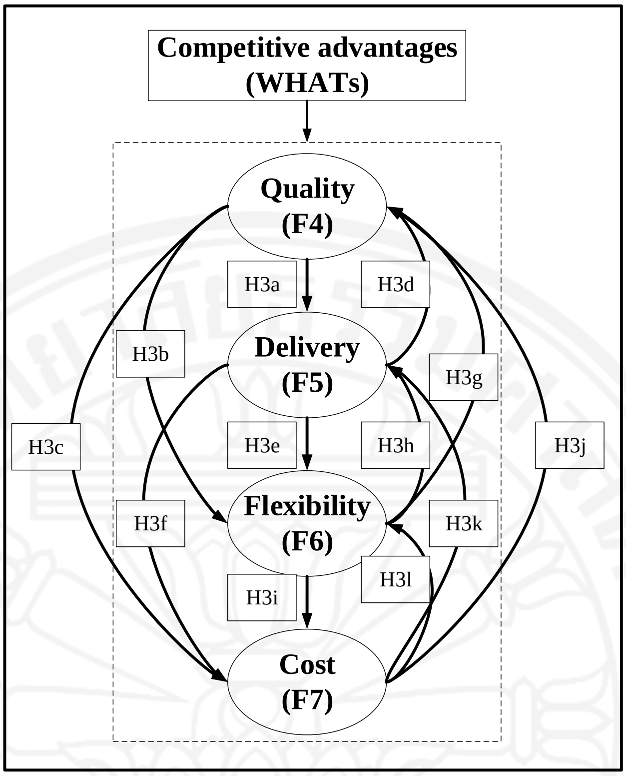


Figure 3.6: Hypotheses H3a-H3l

The measures underlying the constructs are given in Table 3.1.

Table 3.1: Measures underlying the constructs

Construct and measurement items
F1: Supply Chain Integration (SCI)
V1: Your firm has a policy to build long-term relationships with key suppliers without changing them too often.
V2: Your firm has close and frequent communication with suppliers.
V3: Your firm has a computer network linking information with suppliers so that the information can be updated constantly.
V4: There is an exchange of important information, such as production details, production level, and customer demand between the firm and its suppliers.
V5: Your firm and your suppliers always opt for an improvement and find a way to collaborate in problem solving.
F2: Supply Chain Operation (SCO)
V6: The firm has employed effective methods, tools, or systems to manage and control its inventory level/warehouse as the real customer demand can be accurately forecasted.
V7: Your firm is currently utilizing effective production planning and control systems such as Material Requirements Planning (MRP) System, Application and Products in Data Processing (SAP), and Enterprise Resource Planning (ERP) so the production control can be done effectively.
V8: Your firm has suitable methods and tools to manage the transportation routes to minimize the transportation costs under the required delivery time window (deadline).
V9: Your firm always uses the concept of Just-In-Time (JIT) and Lean Manufacturing System to produce the products, as the customer demand is used to drive raw material ordering and production processes.
V10: Your firm has employed an effective system to evaluate the strengths and weakness of each supplier so that the firm can select the suppliers for every material suitably.
F3: Human Resource Management (HRM)
V11: Your firm has a capability to recruit and completely fill new staff positions as required by each division.
V12: Your firm can continuously maintain suitable training programs to improve the capability of the staff.
V13: Your firm can maintain capable staff, as the incentives and benefits provided by the firm are fair and attractive.
V14: Your firm has an open mind and always listens to staff opinions, so a corporative and friendly working environment can be achieved.
V15: Every division of the firm contributes and takes part in all activities to strengthen the collaboration among divisions.
F4: Competitive Advantages-Quality (QU)
V16: Your firm has made the product quality to be the first priority.

Construct and measurement items
V17: Products manufactured from your firm have received certified national or international standards.
V18: Your firm has never received complaints from the customers about the quality of products during the past six months.
V19: Products of your firm have never been returned from the customers as defective units during the past six month.
V20: Your firm has been increasingly recognized for the quality of products from the customers.
F5: Competitive Advantages-Delivery (DE)
V21: Your firm is capable of forecasting and planning for its transportation resources effectively, such as always managing for suitable number of trucks, delivery staff, etc.
V22: Your firm always delivers its products to customers within the due-date.
V23: Your firm has the ability to ship its products to customers accurately according to the purchasing orders.
V24: Your firm has never had to pay compensation due to the damage caused by the delivery.
V25: Your firm has a systematic system to issue complete and suitable delivered documents with each delivery so that the post-evaluation can be done readily and effectively.
F6: Competitive Advantages-Flexibility (FL)
V26: Production lot/batch sizes can be continuously reduced.
V27: Process set-up or change over time can be gradually reduced.
V28: Process cycle time can be continuously reduced.
V29: Your firm has the ability to quickly adjust its production plan according to urgent customer requirements.
V30: Your firm is capable of adjusting its production system to produce a variety of products.
F7: Competitive Advantages-Cost (CO)
V31: Production cost of your firm can be continuously reduced.
V32: Transportation costs of your firm can be continuously reduced.
V33: Your firm can reduce its waste continuously.
V34: The firm’s inventory level can be continuously reduced.
V35: Your firm always utilizes its staffs effectively so there is no redundant staff.
F8: Firm performance during past 5 years (BP)
V36: Market share
V37: Sale revenue
V38: Production capacity
V39: Return on investment
V40: Profit as a percentage of sales

3.2.5 Estimating the model

Five estimated models were built to test hypotheses:

$$F4 = \beta_{41}F1 + \beta_{42}F2 + \beta_{43}F3 + \beta_{45}F5 + \beta_{46}F6 + \beta_{47}F7 + \varepsilon_1 \quad (6)$$

$$F5 = \beta_{51}F1 + \beta_{52}F2 + \beta_{53}F3 + \beta_{54}F4 + \beta_{56}F6 + \beta_{57}F7 + \varepsilon_2 \quad (7)$$

$$F6 = \beta_{61}F1 + \beta_{62}F2 + \beta_{63}F3 + \beta_{64}F4 + \beta_{65}F5 + \beta_{67}F7 + \varepsilon_3 \quad (8)$$

$$F7 = \beta_{71}F1 + \beta_{72}F2 + \beta_{73}F3 + \beta_{74}F4 + \beta_{75}F5 + \beta_{76}F6 + \varepsilon_4 \quad (9)$$

$$F8 = \beta_{81}F1 + \beta_{82}F2 + \beta_{83}F3 + \beta_{84}F4 + \beta_{85}F5 + \beta_{86}F6 + \beta_{87}F7 + \varepsilon_5 \quad (10)$$

where:

β_{ij} is the path coefficient, representing the strength of the effect of factor *j* on factor *i*.

ε_1, ε_2, ε_3, ε_4, ε_5 are residual terms for model 1-5 respectively.

F1, F2, F3, F4, F5, F6, F7, F8 represent the variables of SCI, SCO, HRM, Quality, Delivery, Flexibility, Cost, and Business performance, respectively.

3.2.6 Research design

The first survey was conducted from January to April during 2015. A questionnaire was developed and translated into Vietnamese language. There are five-points in the record (1 = strongly disagree to 5 = strongly agree) for eight groups of questions, representing each factor of the hypotheses. The distribution of questionnaires to 1,000 food manufacturing companies in Vietnam was delivered by mail, e-mail, questionnaire website, and direct interviews. From 1,000 surveys in the target sample, 302 responses were used for analysis, indicating a response rate of 30.2%. This is higher than the recommended minimum of 20% for empirical studies in operations management (Malhotra and Grover, 1998). The profile of respondents can be seen in Table 3.2.

Table 3.2: Profile of respondents

	Number of companies	Percentage
Number of employees (persons)		
Under or equal 50	60	19.87
Over 50-100	55	18.21
Over 100-200	49	16.23
Over 200-500	66	21.85
Over 500-1,000	41	13.58
Over 1,000	31	10.26
Total	**302**	**100**
Registered capital (VND: US $1 ≈ 21,000 VND)		
Under or equal 1 billion	26	8.61
Over 1-10 billion	61	20.20
Over 10-50 billion	54	17.88
Over 50-100 billion	50	16.56
Over 100-300 billion	50	16.56
Over 300-500 billion	38	12.58
Over 500 billion	23	7.61
Total	**302**	**100**
Product type		
Meat and meat products	30	9.93
Fresh and processed fruits and vegetables	17	5.63
Cereal products	32	10.60
Fishery products	46	15.23
Spices and condiments	28	9.27
Milk and milk products	18	5.96
Sugar and sweetmeat	32	10.60
Beverage	44	14.57
Tea, coffee, cocoa	40	13.25
Oil and fat	8	2.65
Pet food products	4	1.32
Supplement and other products	3	0.99
Total	**302**	**100**

To assess the threat from non-response bias, a test using the extrapolation method suggested by Armstrong and Overton (1977) was conducted. Early responses returning within 23 days (the median time from the data the survey was distributed until the post mark date on the response envelope) are compared with the late responses returning on or after 23 days. The *t*-test results indicate no significant statistical difference between early and late responses in regard to all variables analyzed, which suggests that non-response bias does not appear to be a major concern of both cases in this study.

This study uses Structural Equation Modeling (SEM) with the SAS program to test the null and research hypotheses. The results indicate the relationships between supply chain capabilities and competitive advantages towards business performance. The standardized coefficients of these relationships are used for calculating the weights of competitive advantages and the scores of relationships between supply chain capabilities and competitive advantages for the QFD matrix. So, these relationships can be transformed into proper strategies for implementation, to gain the highest value of the pre-determined objectives.

3.3 Developing SCM strategies from SEM and Fuzzy-QFD

This stage transforms the competitive advantages and supply chain capabilities into SCM strategies and actions. In the first model, competitive advantages are treated as the voice of the customer (WHATs), as these are the requirements of an improved business performance or supply chain requirements. All supply chain capabilities that affect competitive advantages are identified as the HOWs in the matrix. Following this procedure, another QFD matrix, focusing on the supply chain strategy development, can be constructed, containing supply chain capabilities as WHATs and SCM strategies as HOWs. These two stage procedures of QFD matrix are presented in Figure 3.7.

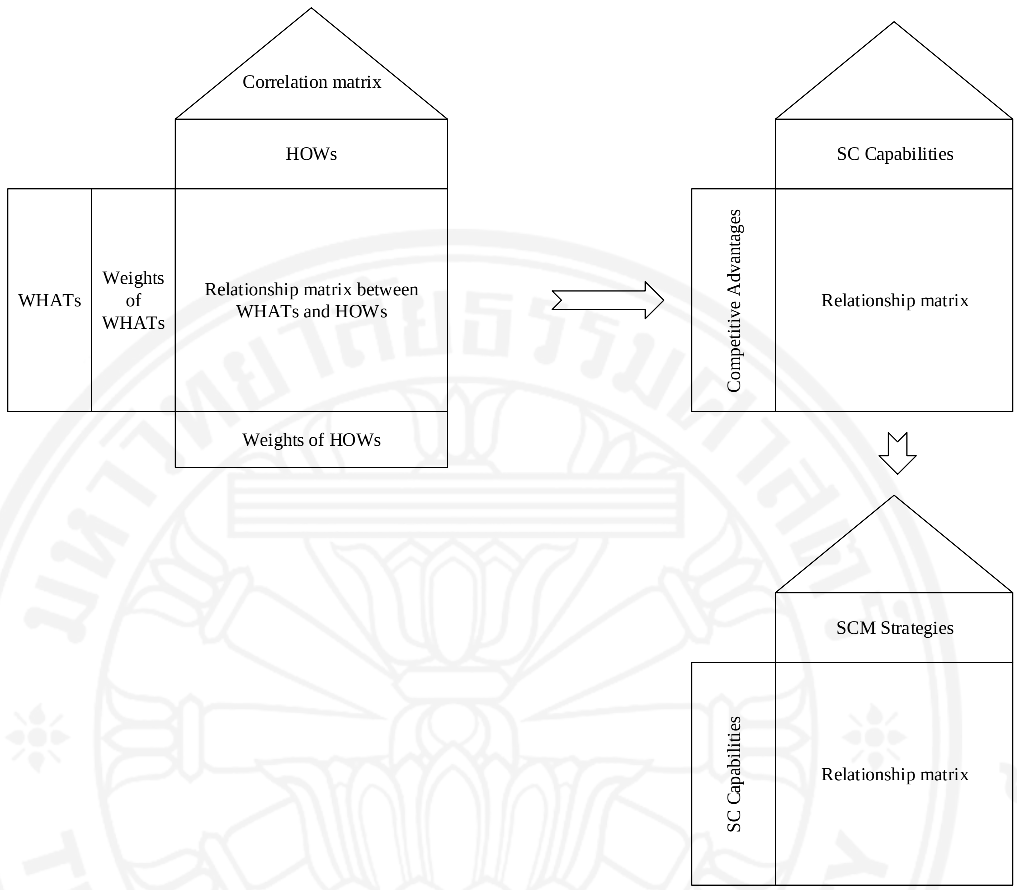


Figure 3.7: Two stage-procedure of QFD matrix in this study

3.3.1 Transforming competitive advantages into supply chain capabilities based on SEM and QFD

The result of SEM is used as input data of QFD as shown in Figure 3.8. In the first QFD matrix, competitive advantages i.e., quality, delivery, flexibility, and cost, are treated as the voice of customers (WHATs). They are considered as requirements of improvement of business performance. Then, supply chain capabilities, including SCI, SCO, and HRM, are treated as HOWs. Results of relationships obtained from SEM are used as input data to QFD because the standardized path coefficients obtained from SEM, representing the strength of the effect of competitive advantages in relation to business performance, can also represent the relative importance among them. In addition, the standardized path coefficients obtained from SEM, representing the strength of the effect of supply chain capabilities in relation to competitive advantages, can represent the correlation scores between them.

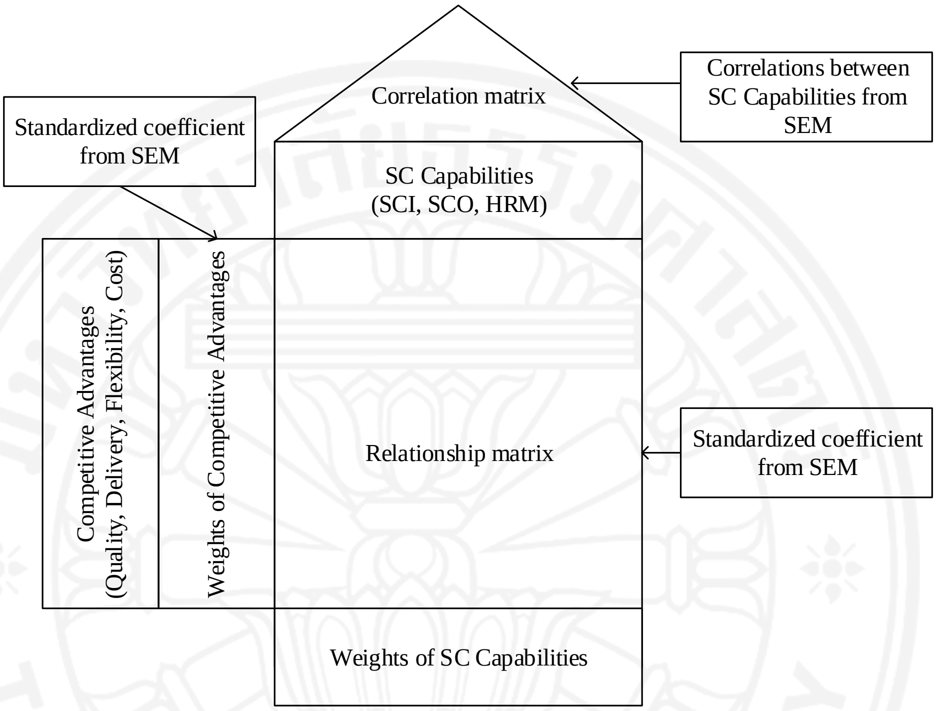


Figure 3.8: Integrated SEM and QFD matrix

In the past, the standardized coefficients have also been used as a measure of relative importance or weight (Pedhazur, 1982; Afifi et al., 1990; Darlington, 1990). Under the scope of the study, the weights of various competitive advantages are determined by standardized coefficients, obtained from the relationships between these factors and business performance, as suggested by SEM. Then, the correlation scores between competitive advantages (WHATs) and supply chain capabilities (HOWs) are also determined by the standardized coefficients of the relationships between these factors, obtained from SEM analysis. These weights and scores include both direct and indirect effects among factors.

For example, with four factors (F1 to F4) under consideration (as seen in Figure 3.9), F1 has a direct impact on F4, but has an indirect impact on F4 via F2 and F3. Numbers in boxes denote standardized path coefficients.

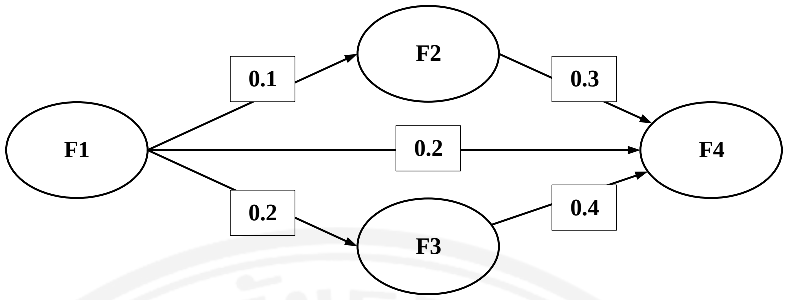


Figure 3.9: Example of relationships between factors

As a result, the total relationship weight or score calculation between F1 and F4
= direct relationship effect + indirect relationship effect
= 0.2 + (0.1*0.3) + (0.2*0.4) = 0.31

This value indicates the level of the relationship between F1 and F4, or how much F1 has an impact on F4. So, it can be used to represent the weight and score among factors in this study.

Then, the weighted score of supply chain capabilities (HOWs) is equal to the total of multiplying the scores of relationships between WHATs and HOWs with the weights of the competitive advantages (WHATs). These weighted scores are used as the input data for the following steps.

The correlations among the supply chain capabilities (HOWs) are contained in the roof of the QFD matrix. These values consider the pairs of HOWs, which can be parallel improvements or inconsistent with each other. For example, with positive correlation value between Human Resource Management (HRM) and Supply Chain Operation (SCO), the manufacturing systems can be operated more effectively with skillful staffs. So, when HRM is improved, SCO can also be improved. In addition, it also means that there is no conflict among these factors.

3.3.2. Transforming supply chain capabilities into SCM strategies, based on fuzzy-QFD

Following the first step, another QFD matrix, focusing on building SCM strategies, is constructed (see Figure 3.10). At this step, the supply chain capabilities determined and measured at the first stage are used as the WHATs in the QFD matrix. Their weights are determined from the result of the first QFD matrix.

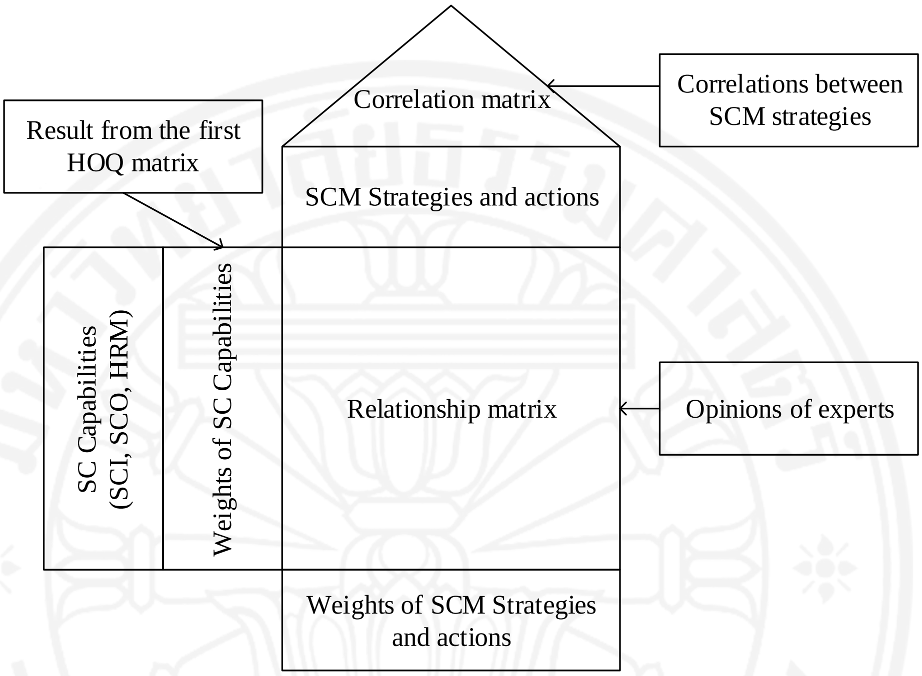


Figure 3.10: Integrated Fuzzy-QFD matrix

Another set of questionnaires is designed and distributed to academic experts, who are in the field of supply chain management, to identify the relationships of SCM strategies, which are related to building SCI, SCO, and HRM. They are considered as specific actions for improving supply chain capabilities, subsequently improving competitive advantages and business performance. These strategies and actions have been identified from the literature and related to building supply chain capabilities.

The relationships between supply chain capabilities and SCM strategies are identified by the academic experts. Since these relationships cannot be explained by exact numbers, linguistic terms are used. Expert opinions on the relationships between SC capabilities and SCM strategies (WHATs–HOWs) are expressed by using one of the five linguistic variables. A linguistic set of U: U = {VL; L; M; H; VH}, where VL = very low, L = low, M = medium, H = high, and VH = very high. All 17 SCM strategies are shown in Table 3.3. The linguistic variable of U is then quantified using triangular fuzzy numbers: VL → (0, 1, 2); L → (2, 3, 4); M → (4, 5, 6); H → (6, 7, 8); VH → (8, 9, 10).

Table 3.3: SCM strategies for Vietnamese food companies
(Second questionnaire survey shown in Appendix A.2)

Item	SCM Strategy
1	In order to select a suitable supplier and build a long term relationship with them, their strengths and weaknesses are continuously considered through a proper selection method such as the Ranking and Scoring method to select the best supplier to buy each type of material.
2	Information sharing of customer demand, production level, or inventory status with suppliers and customers should be done electronically through on-line systems, such as Electronic Data Interchange (EDI), so that information can be updated instantly.
3	The role to inventory replenishment of your firm can be done by your suppliers so that your suppliers take full responsibility, to replenish inventory of your firm both on time and accurately through Vendor Manage Inventory (VMI), thereby inventory cost can be reduced.
4	Production planning and control should be done by effective systems such as Material Requirements Planning (MRP), and Enterprise Resource Planning (ERP), to assure that required materials are available when needed, so that the production system can be done more effectively.
5	Proper demand forecasting methods/software should be used to accurately forecast the customer demand in advance, so that production planning can be done more effectively.
6	Just-In-Time (JIT), in which materials and products are received only as they are needed, should be implemented, so that production flow time as well as response times from suppliers to customers can be reduced, thereby reducing inventory costs.
7	Implementing both vertical job enlargement (employees are trained and assigned a higher level of responsibility for their job) and horizontal job enlargement (employees are trained and assigned more job duties and responsibilities) should be simultaneously done so that employee skills can be further improved.
8	Systematic job recruitment should be implemented by carefully planning and using effective interview methods (structured interview, situational judgment tests), to evaluate and select the right candidates, so that empty staff positions can be filled effectively.

Item	SCM Strategy
9	Incentive programs such as bonuses, profit sharing, and welfare should be implemented to motivate and improve employee productivity, as well as maintain them with the firm for a long time.
10	Program of 5S (Seiri – Sorting out, Seiton – Storage, Seiso – Shining the workplace, Seiletsu – Setting standards, and Shitsuke – Sticking to the rule) should be implemented, to improve work the environment, as well as a firm's productivity.
11	Quality control should be implemented by effective systems/methods such as Statistical Process Control (SPC) or proper sampling plan, so that defective units can be detected before leaking to the customers.
12	International quality standard such as ISO 9001, ISO 22000, HACCP should be implemented, to ensure that quality is consistently improved, and products consistently meet customer requirements.
13	Suitable delivery route in Vehicle Routing Problem (VRP) to deliver the products to customers, needs to be calculated by effective software/systems/methods, so that the delivery can be done with shorter delivery time and minimum cost.
14	Production batch size can be reduced by proper techniques such as Single-Minute Exchange of Die (SMED) or One-Touch Exchange of Die (OTED), as the machine set-up time need to be reduced.
15	Advanced Manufacturing Systems and Automation should be implemented, so that more automated equipment can replace traditional manual equipment. As a result, the system becomes more reliable and flexible.
16	Proper accounting systems/software (e.g., QuickBooks Accounting Software) should be done so that all costs can be accurately charged. As a result, the product price can be established more correctly.
17	Effective maintenance methods such as Preventive Maintenance need to be implemented so that machines and equipment are well maintained and do not breakdown during operation.

Relationships between supply chain capability and SCM strategy, and the weight of SCM strategy are calculated step by step by the following equations:

$$S_{ij} = \frac{1}{n} * \sum_{k=1}^{n} S_{ijk} \tag{11}$$

$$AS_{ij} = (S_{ij} * weight_i) \tag{12}$$

$$TS_j = \frac{1}{m} * \sum_{i=1}^{m} AS_{ij} \tag{13}$$

$$FS_j = \frac{1}{3} * (TS_{j\alpha} + TS_{j\beta} + TS_{j\gamma}) \tag{14}$$

where:

$\boldsymbol{S_{ijk}}$ = Score of the relationship between supply chain capability i and SCM strategy *j* assigned by expert number *k*

$\boldsymbol{n}$ = the number of experts

$\boldsymbol{S_{ij}}$ = Average score of the relationship between supply chain capability i and SCM strategy *j* obtained from *n* experts, as expressed in triangular fuzzy numbers: $S_{ij} = (S_{ij\alpha}, S_{ij\beta}, S_{ij\gamma})$.

$\boldsymbol{weight_i}$ = weight of supply chain capability i

$\boldsymbol{AS_{ij}}$ = Aggregated score of relationship between supply chain capability i and SCM strategy *j*, as expressed in triangular fuzzy numbers: $AS_{ij} = (AS_{ij\alpha}, AS_{ij\beta}, AS_{ij\gamma})$, which are obtained by multiplying average score(S_{ij}) with the weights of supply chain capability i ($weight_i$).

m = number of supply chain capabilities

$\boldsymbol{TS_j}$ = Total score of the SCM strategy j, as expressed as fuzzy set: $TS_j = (TS_{j\alpha}, TS_{j\beta}, TS_{j\gamma})$, which is calculated by averaging the aggregated scores AS_{ij}.

$\boldsymbol{FS_j}$ = Final scores for the weight of the SCM strategy *j*

Then, the final scores (FS_j) are normalized and transferred into 5-points to obtain normalized relative technical importance, for using in the next stage.

Measuring the correlations between the SCM strategies (HOWs) enables a group to know which pairs of HOWs have positive correlation or negative correlation. The pairs of HOWs, which have positive correlation mean that these HOWs should be improved synchronously. The pairs of HOWs, which have negative correlation imply that there exists conflicts between these HOWs, which need to be resolved. In this study, all correlations between HOWs are positive or none. So, conflicts among these strategies are not a problem in this study.

3.4 Multi-objective Linear Programming Model for choosing suitable SCM strategies among conflicting objectives under the budget constraint

Normally, companies have different objectives when they consider what strategy should be implemented. These objectives can somehow conflict with each other. For example, a high benefit strategy may require high investment cost, to maximize the benefits, but minimize the investment cost. Four objectives, i.e., technical importance, investment cost, benefit value, and feasibility to be implemented are selected to form the objective function in this study. These four objectives present the overall view of decision makers, who make a decision on which strategies should be implemented. The relative importance of these objectives is further explored by the sensitivity analysis on their assigned weights. The notations and mathematical model are presented below:

N: Total number of SCM strategies and actions

$NRTIR_j$: Normalized relative technical importance rating for each SCM strategy *j*, given by Fuzzy-QFD analysis results

$COST_j$: Investment cost of SCM strategy *j*

$VALUE_j$: Benefit value from implementing SCM strategy *j*, determined by possible cost reduction or revenue increase

$FEASIBILITY_j$: Feasibility to implement SCM strategy *j*

X_j : Binary decision variable that equals 1 if SCM strategy *j* is selected, and 0 otherwise

w_y: Weight of criterion y

The mathematical model for choosing suitable SCM strategies under a limited budget with four objectives (Technical importance, Investment cost, Value, and Feasibility) is shown below:

$$Max\ Z = w_1 \sum_{j=1}^{N} NRTIR_j * X_j - w_2 \sum_{j=1}^{N} COST_j * X_j + w_3 \sum_{j=1}^{N} VALUE_j * X_j + w_4 \sum_{j=1}^{N} FEASIBILITY_j * X_j \quad (15)$$

s.t.

$$\sum_{j=1}^{N} COST_j * X_j \leq BUDGET \quad (16)$$

$$X_j\ is\ binary\ \forall\ j \quad (17)$$

In the objective function, the first objective represents the maximization of the total technical importance of the SCM strategies that are selected. The second objective is the minimization of total investment cost of selected SCM strategies. The third objective is for the maximization of total benefit value, as revenue increment or cost saving. The fourth objective is for the maximization of the total feasibility to implement. Equation (16) ensures that the total budget is not exceeded, and equation (17) represents the binary decision variables.

In this study, sensitivity analysis is used for determining the weight of four criteria (Technical importance, Investment cost, Value, and Feasibility). The set of weight is determined as $w_y = \{w_1, w_2, w_3, w_4\}$. In the assumption that the lowest possible value of w_y is 0.1 (Equation 18) and total weights of four criteria equals 1 (Equation 19), total possible 97 weighted sets for the four criteria are obtained. These sets comprise all possible situation combinations, when four criteria have equal weight, or a criterion is assigned a higher weight as compared to others, or two or three criteria are assigned higher weights, as compared to the others.

$$w_y \geq 0.1, y = 1, \ldots, 4 \quad (18)$$

$$\sum_{y=1}^{4} w_y = 1 \quad (19)$$

Chapter 4
Results and Discussion

This chapter is divided into two parts. The first part includes the results of all companies. In the second part, the analysis is divided into two scenarios (small sized and large sized companies), based on the number of employees. Discussion and implemental implications of each scenario are also be mentioned in each part.

4.1 Results for all companies

In this section, the results of SEM analysis, including measurement model and structural model are shown. Then, discussion and managerial implications are also presented.

4.1.1 Goodness of fit test of the measurement model

Confirmatory Factor Analysis (CFA) was used to validate measures of constructs for developing the measurement. The measurement model was analyzed by using the SAS program and CALIS procedure. An adequate fit was achieved for the measurement model.

The chi-square to degree of freedom ratio is 2.09, the Bentler's Comparative Fit Index (CFI) is 0.9315, and Bentler and Bonett's Non-normed Fit Index (NNFI) is 0.9229. All of the *t*-statistic for the indicator variables are greater than 2.576, significant at $p < 0.01$. All standardized factor loadings range from 0.6024 to 0.9113, indicating an acceptable value. The distribution of residual matrix is normal and symmetrical. The CFA resulted in the elimination of a few individual items such as V6, V15, V23, V28, V32, and V35. Table 4.1 provides unstandardized coefficients, standard errors, *t*-values, and standardized coefficients for each individual item. These numbers provide information about the local fit, that is, how well individual item measures its respective factor.

Table 4.1: Measurement model

Indicators	Unstandardized Coefficient	Standard Error	*t*-value	Standardized Coefficient
F1: Supply Chain Integration				
V1: Your firm has a policy to build long-term relationships with key suppliers without changing them too often.	0.7114	0.0409	17.4093	0.8363
V2: Your firm has close and frequent communication with suppliers.	0.7728	0.0433	17.8321	0.8491
V3: Your firm has a computer network linking information with suppliers so that the information can be updated constantly.	0.5156	0.0363	14.2153	0.7285
V4: There is an exchange of important information such as production details, production level, and customer demand between the firm and its suppliers.	0.6835	0.0396	17.2505	0.8314
V5: Your firm and your suppliers always opt for an improvement and find a way to collaborate in problem solving.	0.6277	0.0384	16.3509	0.8082
F2: Supply Chain Operation				
V7: Your firm is currently utilizing effective production planning and control systems such as Material Requirements Planning (MRP) System, Application and Products in Data Processing (SAP), and Enterprise Resource Planning (ERP) so the production control can be done effectively.	0.7676	0.0437	17.5578	0.8413
V8: Your firm has suitable methods and tools to manage the transportation routes to minimize the transportation costs under the required delivery time window (deadline).	0.6888	0.0391	17.6012	0.8426

Indicators	Unstandardized Coefficient	Standard Error	*t*-value	Standardized Coefficient
V9: Your firm always uses the concept of Just-In-Time (JIT) and Lean Manufacturing System to produce the products, as the customer demand is used to drive raw material ordering and production processes.	0.8010	0.0451	17.7732	0.8478
V10: Your firm has employed an effective system to evaluate the strengths and weakness of each supplier so that the firm can select the suppliers for every material suitably.	0.5670	0.0389	14.5815	0.7421
F3: Human Resource Management				
V11: Your firm has a capability to recruit and completely fill new staff positions as required by each division.	0.5010	0.0325	15.4175	0.7768
V12: Your firm can continuously maintain suitable training programs to improve the capability of the staff.	0.6387	0.0402	15.8766	0.7962
V13: Your firm can maintain capable staff, as the incentives and benefits provided by the firm are fair and attractive.	0.6153	0.0385	15.9635	0.7955
V14: Your firm has an open mind and always listens to staff opinions, so a corporative and friendly working environment can be achieved.	0.5924	0.0412	14.3628	0.7390
F4: Competitive Advantages - Quality				
V16: Your firm has made the product quality to be the first priority.	0.7676	0.0461	16.6460	0.8109
V17: Products manufactured from your firm have received certified national or international standards.	0.7277	0.0417	17.4600	0.8365
V18: Your firm has never received complaints from the customers about the quality of products during the past six months.	0.5789	0.0417	13.8880	0.7146

Indicators	Unstandardized Coefficient	Standard Error	*t*-value	Standardized Coefficient
V19: Products of your firm have never been returned from the customers as defective units during the past six month.	0.7069	0.0420	16.8385	0.8171
V20: Your firm has been increasingly recognized for the quality of products from the customers.	0.6583	0.0386	17.0589	0.8240
F5: Competitive Advantages - Delivery				
V21: Your firm is capable of forecasting and planning for its transportation resources effectively, such as always managing for suitable number of trucks, delivery staff, etc.	0.6474	0.0353	18.3325	0.8707
V22: Your firm always delivers its products to customers within the due-date.	0.4427	0.0380	11.6637	0.6319
V24: Your firm has never had to pay compensation due to the damage caused by the delivery.	0.5173	0.0433	11.9555	0.6443
V25: Your firm has a systematic system to issue complete and suitable delivered documents with each delivery so that the post-evaluation can be done readily and effectively.	0.6683	0.0365	18.3091	0.8700
F6: Competitive Advantages - Flexibility				
V26: Production lot/batch sizes can be continuously reduced.	0.5263	0.0500	10.5194	0.6024
V27: Process set-up or change over time can be gradually reduced.	0.5018	0.0452	11.0975	0.6290
V29: Your firm has the ability to quickly adjust its production plan according to urgent customer requirements.	0.4899	0.0367	13.3324	0.7257
V30: Your firm is capable of adjusting its production system to produce a variety of products.	0.4681	0.0323	14.5013	0.7731

Indicators	Unstandardized Coefficient	Standard Error	*t*-value	Standardized Coefficient
F7: Competitive Advantages - Cost				
V31: Production cost of your firm can be continuously reduced.	0.7098	0.0420	16.8894	0.8388
V33: Your firm can reduce its waste continuously.	0.4688	0.0394	11.9025	0.6474
V34: The firm's inventory level can be continuously reduced.	0.5148	0.0372	13.8585	0.7268
F8: Firm performance during past 5 years				
V36: Market share	0.7524	0.0391	19.2497	0.8842
V37: Sale revenue	0.8618	0.0425	20.2625	0.9113
V38: Production capacity	0.6902	0.0392	17.6270	0.8374
V39: Return on investment	0.6669	0.0367	18.1773	0.8538
V40: Profit as a percentage of sales	0.6810	0.0386	17.6344	0.8376

Table 4.2 provides the results of composite reliability and variance extracted test. The composite reliability reflects the internal consistency of the indicator measuring a given factor. The variance extracted identifies the amount of variance that is captured by factor in relation to the amount of variance due to measurement error. The minimal acceptable level of composite reliability and variance extracted are 0.6 and 0.5, respectively.

Table 4.2: Composite reliability and variance extracted estimate of each latent variable

Constructs and Indicators	Standardized Loading L_i	Indicator Reliability ${L_i}^2$	Error Variance $1 - {L_i}^2$ or $Var\ (E_i)$	Composite Reliability $\frac{(\sum L_i)^2}{(\sum L_i)^2 + \sum Var\ (E_i)}$	Variance Extracted Estimate $\frac{\sum {L_i}^2}{\sum {L_i}^2 + \sum Var\ (E_i)}$
F1 (SCI)				0.9060	0.6591
V1	0.8363	0.6994	0.3006		
V2	0.8491	0.7210	0.2790		
V3	0.7285	0.5307	0.4693		
V4	0.8314	0.6912	0.3088		
V5	0.8082	0.6532	0.3468		
Total	4.0535	3.2955	1.7045		
F2 (SCO)				0.8909	0.6718
V7	0.8413	0.7078	0.2922		
V8	0.8426	0.7100	0.2900		
V9	0.8478	0.7188	0.2812		
V10	0.7421	0.5507	0.4493		
Total	3.2738	2.6872	1.3128		
F3 (HRM)				0.8591	0.6041
V11	0.7768	0.6034	0.3966		
V12	0.7962	0.6339	0.3661		
V13	0.7955	0.6328	0.3672		
V14	0.7390	0.5461	0.4539		
Total	3.1075	2.4163	1.5837		
F4 (QU)				0.8998	0.6429
V16	0.8109	0.6576	0.3424		
V17	0.8365	0.6997	0.3003		
V18	0.7146	0.5107	0.4893		
V19	0.8171	0.6677	0.3323		
V20	0.8240	0.6790	0.3210		
Total	4.0031	3.2146	1.7854		
F5 (DE)				0.8449	0.5824
V21	0.8707	0.7581	0.2419		
V22	0.6319	0.3993	0.6007		
V24	0.6443	0.4151	0.5849		
V25	0.8700	0.7569	0.2431		
Total	3.0169	2.3294	1.6706		

Constructs and Indicators	Standardized Loading	Indicator Reliability	Error Variance	Composite Reliability	Variance Extracted Estimate
	L_i	${L_i}^2$	$1 - {L_i}^2$ or $Var\ (E_i)$	$\frac{(\sum L_i)^2}{(\sum L_i)^2 + \sum Var\ (E_i)}$	$\frac{\sum {L_i}^2}{\sum {L_i}^2 + \sum Var\ (E_i)}$
F6 (FL)				0.7788	0.5824
V26	0.6024	0.3629	0.6371		
V27	0.6290	0.3956	0.6044		
V29	0.7257	0.5266	0.4734		
V30	0.7731	0.5977	0.4023		
total	2.7302	1.8829	2.1171		
F7 (CO)				0.7840	0.5503
V31	0.8388	0.7036	0.2964		
V33	0.6474	0.4191	0.5809		
V34	0.7268	0.5282	0.4718		
total	2.2130	1.6510	1.3490		
F8 (BP)				0.9371	0.7488
V36	0.8842	0.7818	0.2182		
V37	0.9113	0.8305	0.1695		
V38	0.8374	0.7012	0.2988		
V39	0.8538	0.7290	0.2710		
V40	0.8376	0.7016	0.2984		
Total	4.3243	3.7441	1.2559		

Remarks:
L_i is standardized factor loading for indicator variable *i*
$Var\ (E_i)$ is error variance associated with the indicator variables *i*

4.1.2 Convergent validity

Convergent validity is used to measure the similarity or convergence between the indicators measuring the same construct. Convergent validity is demonstrated when the correlations between these indicators are relatively strong. In this study, convergent validity was assessed by testing whether the coefficient of each individual item was significant, that is greater than twice standard error (Lemak et al., 1997). As can be seen from Table 4.3, the coefficients for all items are far greater than twice their standard errors. In addition, all coefficients are large and strongly significant at $p < 0.01$. Thus, these results provide strong evidence to support convergent validity for these items.

Table 4.3: Convergent validity for all items

Indicators	Factor Loading	Standard Error	Twice of Standard Error	*t*-value
V1	0.7114	0.0409	0.0818	17.4093
V2	0.7728	0.0433	0.0866	17.8321
V3	0.5156	0.0363	0.0726	14.2153
V4	0.6835	0.0396	0.0792	17.2505
V5	0.6277	0.0384	0.0768	16.3509
V7	0.7676	0.0437	0.0874	17.5578
V8	0.6888	0.0391	0.0782	17.6012
V9	0.8010	0.0451	0.0902	17.7732
V10	0.5670	0.0389	0.0778	14.5815
V11	0.5010	0.0325	0.0650	15.4175
V12	0.6387	0.0402	0.0804	15.8766
V13	0.6153	0.0385	0.0770	15.9635
V14	0.5924	0.0412	0.0824	14.3628
V16	0.7676	0.0461	0.0922	16.6460
V17	0.7277	0.0417	0.0834	17.4600
V18	0.5789	0.0417	0.0834	13.8880
V19	0.7069	0.0420	0.0840	16.8385
V20	0.6583	0.0386	0.0772	17.0589
V21	0.6474	0.0353	0.0706	18.3325
V22	0.4427	0.0380	0.0760	11.6637
V24	0.5173	0.0433	0.0866	11.9555
V25	0.6683	0.0365	0.0730	18.3091
V26	0.5263	0.0500	0.1000	10.5194
V27	0.5018	0.0452	0.0904	11.0975
V29	0.4899	0.0367	0.0734	13.3324
V30	0.4681	0.0323	0.0646	14.5013
V31	0.7098	0.0420	0.0840	16.8894
V33	0.4688	0.0394	0.0788	11.9025
V34	0.5148	0.0372	0.0744	13.8585
V36	0.7524	0.0391	0.0782	19.2497
V37	0.8618	0.0425	0.0850	20.2625
V38	0.6902	0.0392	0.0784	17.6270
V39	0.6669	0.0367	0.0734	18.1773
V40	0.6810	0.0386	0.0772	17.6344

4.1.3 Discriminant validity

Discriminant validity is demonstrated when the correlations between different indicators measuring different constructs are relatively weak. There are three methods to test the discriminant validity.

4.1.3.1 Chi-square difference test

The measurement model can be analyzed by the significant of changes in the chi-square value when setting the covariance between each pair of latent variance to be 1. If chi-square difference between the measurement model and discriminant model is significant, the model is supported to have discriminant validity.

In the measurement model, the strongest correlation between factors occurs at the correlation between F1 (SCI) and F8 (BP), so it is set to be 1. Then, the discriminant model is analyzed.

The chi-square of final measurement model is 1,044.9185 and df is 499.

The chi-square of discriminant model is 1,124.4342 and df is 500.

The difference in chi-square between two models:

1,124.4342 - 1,044.9185 = 79.5157

The difference in df between two models: 500 - 499 = 1

The critical chi-square value of 1 degree of freedom different (p < 0.01) is 6.6349. The chi-square difference value is greater than the critical value, so this chi-square difference test suggests having the discriminant validity between F1 (SCI) and F8 (BP).

4.1.3.2 Confidence interval test

To assess discriminant validity, the confidence interval around the correlation for each pair of factors is determined. The confidence interval is equal to plus or minus two standard errors of the respective correlation coefficient. If the confidence interval does not include 1.0, then discriminant validity is demonstrated (Anderson and Gerbing, 1988).

The correlation between F1 (SCI) and F8 (BP) is highest, which is 0.9120 and its standard error is 0.01534.

Twice standard error = 2*0.01534 = 0.03068

Lower bound = 0.9120 - 0.03068 = 0.88134

Upper bound = 0.912 + 0.03068 = 0.9427

The range of lower bound and upper bound is 0.88134 and 0.9427, which does not include 1, so there is the discriminant validity between F1 (SCI) and F8 (BP). Table 4.4 shows that none of the confidence intervals for all factor loading includes 1.0.

Table 4.4: Results of confidence interval test for all factor loadings

Correlation factors	*t*-value	Error	Estimate-2SE	Estimate	Estimate+2SE
SCI - SCO	31.61	0.0260	0.7689	0.8209	0.8729
SCI-HRM	26.38	0.0301	0.7331	0.7933	0.8535
SCO-HRM	41.45	0.0216	0.8507	0.8939	0.9371
SCI-QU	31.36	0.0260	0.7643	0.8163	0.8683
SCO-QU	51.14	0.0178	0.8747	0.9103	0.9459
HRM-QU	44.77	0.0202	0.8639	0.9043	0.9447
SCI-DE	20.64	0.0350	0.6531	0.7231	0.7931
SCO-DE	27.64	0.0290	0.7430	0.8010	0.8590
HRM-DE	29.09	0.0284	0.7693	0.8261	0.8829
QU-DE	33.90	0.0249	0.7929	0.8427	0.8925
SCI-FL	16.39	0.0420	0.6045	0.6885	0.7725
SCO-FL	16.92	0.0415	0.6194	0.7024	0.7854
HRM-FL	16.70	0.0426	0.6252	0.7104	0.7956
QU-FL	15.78	0.0430	0.5925	0.6785	0.7645
DE-FL	18.78	0.0393	0.6597	0.7383	0.8169
SCI-CO	30.58	0.0280	0.7985	0.8545	0.9105
SCO-CO	28.93	0.0293	0.7879	0.8465	0.9051
HRM-CO	20.83	0.0371	0.6982	0.7724	0.8466
QU-CO	23.73	0.0334	0.7260	0.7928	0.8596
DE-CO	19.02	0.0388	0.6602	0.7378	0.8154
FL-CO	17.26	0.0430	0.6563	0.7423	0.8283
SCI-BP	59.47	0.0153	0.8814	0.9120	0.9426
SCO-BP	43.89	0.0199	0.8324	0.8722	0.9120
HRM-BP	34.94	0.0242	0.7962	0.8446	0.8930
QU-BP	54.25	0.0166	0.8685	0.9017	0.9349
DE-BP	35.07	0.0239	0.7893	0.8371	0.8849
FL-BP	18.17	0.0391	0.6321	0.7103	0.7885
CO-BP	40.22	0.0225	0.8585	0.9035	0.9485

4.1.3.3 Variance extracted test

The discriminant validity test may also be assessed by a variance extracted test (Fornell and Larcker, 1981). The variance extracted test estimates the two factors of interest, and compares these estimates to the square of the correlation between the two factors. Discriminant validity is demonstrated if both variance extracted estimates are greater than this squared correlation.

In this test, the correlation of F1 (SCI) and F8 (BP) is 0.9120, the square of this correlation is 0.8317. The variance extracted estimates are calculated and shown in table 4.3 in which the variance extracted estimates is 0.6591 for F1 (SCI) and 0.7488 for F8 (BP).

This is fail to support the discriminant validity between F1 (SCI) and F8 (BP). However, the discriminant validity between F1 (SCI) and F8 (BP) is still expected to occur because of the results of the chi-square difference test and confidence interval test.

4.1.4 Goodness of fit test of the structural model

Goodness of fit is determined by comparing the structural model (the full maintained model) to alternative models. One tests alternative models by sequentially deleting or adding paths. The measures of goodness-of-fit for all models are shown in Table 4.5.

Table 4.5: Goodness of fit of all models

Model	X^2	df	X^2/df	NNFI	CFI
Null model	8,525.8	561	15.20	-	-
Uncorrelated model	3,294.8849	527	6.25	0.6301	0.6525
Measurement model	1,044.9185	499	2.09	0.9229	0.9315
Full maintained model	1,044.9185	493	2.12	0.9211	0.9307
PF4F7 path deleted	1,044.9185	494	2.12	0.9214	0.9308
PF5F2 path deleted	1,044.9186	495	2.11	0.9218	0.931
PF7F5 path deleted	1,044.9185	496	2.11	0.922	0.9311
PF4F5 path deleted	1,044.9185	497	2.10	0.9223	0.9312
PF5F1 path deleted	1,044.92	498	2.10	0.9226	0.9313
PF4F6 path deleted	1,044.9195	499	2.09	0.9229	0.9315
PF6F7 path deleted	1,044.9198	500	2.09	0.9232	0.9316
PF5F6 path deleted	1,044.9269	501	2.09	0.9235	0.9317
PF7F4 path deleted	1,044.9664	502	2.08	0.9238	0.9318
PF8F3 path deleted	1,045.121	503	2.08	0.9241	0.9319
PF5F7 path deleted	1,045.7519	504	2.07	0.9243	0.932
PF6F2 path deleted	1,046.622	505	2.07	0.9245	0.932
PF6F4 path deleted	1,047.9415	506	2.07	0.9246	0.932
PF6F3 path deleted	1,049.122	507	2.07	0.9247	0.9319
PF7F3 path deleted	1,050.3924	508	2.07	0.9248	0.9319
PF8F2 path deleted	1,051.8436	509	2.07	0.9249	0.9318
PF8F6 path deleted	1,054.7511	510	2.07	0.9248	0.9316

After deleting 17 insignificant paths, goodness-of-fit indices indicate an acceptable fit of the structural model to the data. The ratio of chi-square to degree of freedom is 2.06, which is below the recommended value of 3.0 for satisfactory fit of a model to data (Hartwick and Barki, 1994). In line with prescription, the Bentler's Comparative Fit Index (CFI) and Bentler and Bonett's Non-normed Fit Index (NNFI) are 0.9316 and 0.9248, greater than 0.90 level (Byrne, 2006), and thus indicate good fit.

4.1.5 Performing a chi-square difference test comparing the theoretical model and measurement model

The chi-square difference test is performed to determine whether there is a significant difference between the fit provided by the theoretical model and the fit provided by the measurement model. If the theoretical model is correct, it should provide a fit to the data that is nearly as good as the fit provided by the measurement model, even after eliminating some nonessential covariance between uncorrelated factors.

The chi-square of the measurement model is 1,044.9185 and df is 499.

The chi-square of the theoretical model is 1,054.7511 and df is 510.

$M_t - M_m$ = 1,054.7511 – 1,044.9185 = 9.8326

$df_t - df_m$= 510 – 499 = 11

The critical value of chi-square of 11 degree of freedom ($p < 0.001$) is 31.264. The chi-square difference between two models is less than critical value, so that the chi-square difference test is significant at $p < 0.001$. Thus, the theoretical model successfully account for the relationships between the latent factors.

4.1.6 Parsimony Ratio (PR) and Parsimonious Normed Fit Index (PNFI)

With other factors held constant, the most desirable theoretical model is the most parsimonious model. In the broadest sense, the parsimony of a model refers to its simplicity. The principal of parsimony states that, when several theoretical explanations are equally satisfactory in accounting for some phenomenon, the preferred explanation is the one that is least complicated (the one that makes the fewest assumptions).

One such Index is Parsimony Ratio (PR) (James et al., 1982). The Parsimony Ratio (PR) is easily calculated with the following formula:

$$PR = \frac{df_j}{df_0} \tag{20}$$

where: df_j is the degrees of freedom for the model being studied

df_0 is the degrees of freedom for the null model

The lowest possible value for parsimony ratio is zero, and this value will be obtained for a fully-saturated model in which every V variable is connected to every other V variable by either a covariance or casual path. The upper limit on PR is 1.0, and this value will be obtained for null model in which there is none relationship between any variables.

Parsimony Ratio can help to choose the best model when more than one demonstrates a good fit to the data. When choosing between two nested models that display an acceptable and similar fit, the more desirable model will be the one with the higher parsimony ratio.

The null chi-square for the current analysis is 8,525.8 with 561 degrees of freedom. The degrees of freedom of the theoretical model is 510. The Parsimony Ratio (PR) for the theoretical model is calculated as below:

$$PR = \frac{510}{561} = 0.9090$$

This value is used to calculate a second index that also reflects the parsimony of a model, called Parsimonious Fit Index (PNFI). The Parsimonious Fit Index (PNFI) is calculated by using the following formula:

$$PNFI = (PR)*(NFI) \tag{21}$$

where: PR is Parsimony Ratio

NFI is Normed Fit Index

The Normed Fit Index (NFI) is a measure of overall fit of a model that may range from zero to 1, with higher values reflecting a better fit. The NFI of the model is 0.8763. The PNFI for the model can be obtained:

$$PNFI = 0.9090 * 0.8763 = 0.7966$$

PNFI is similar to NFI in that the higher values indicate a more desirable model. Like the PR, the PNFI can help in selecting a best model when more than one provides an acceptable fit to the data. Mulaik et al. (1989) indicated that it is possible to have acceptable models with the PNFI in the 0.50.

4.1.7 Relative Normed-Fit Index (RNFI)

Relative Normed-Fit Index (RNFI) reflects the fit in just the structural portion of the model, and is not influenced by the fit of the measurement model. The higher values of RNFI (nearer to 1.0) indicate that the hypothesized casual relationships between the structural variables provide a good fit to the data. The RNFI can be calculated as the following formula:

$$RNFI = \frac{F_u - F_j}{F_u - F_m - (df_j - df_m)} \tag{22}$$

where: F_u is the chi-square of the uncorrelated factors model

F_j is the chi-square of the interested model

F_m is the chi-square of the measurement model

df_j is the degrees of freedom of the interested model

df_m is the degrees of freedom of the measurement model

$$\text{RNFI} = \frac{3{,}294.8849 - 1{,}054.7511}{3{,}294.8849 - 1{,}044.9185 - (510 - 499)} = 1.0005$$

RNFI for the theoretical model is 1.0005. This indicates the fit demonstrated by just the structural portion of the theoretical model, irrespective of how well the latent variables were measured by their indicators. RNFI of 1.0005 indicates a minimally acceptable, although not outstanding fit.

4.1.8 Relative Parsimony Ratio (RPR) and Relative Parsimonious Fit Index (RPFI)

Relative Parsimony Ratio (RPR) can be computed to determine the parsimony of the structural model (Mulaik et al., 1989). RPR for the structural portion of a model range from 0.0 (for the measurement model in which every F variable is related to every other F variable) to 1.0 (for the uncorrelated factors model). The formula for the Relative Parsimony Ratio (RPR) is:

$$RPR = \frac{df_j - df_m}{df_u - df_m} \tag{23}$$

where: df_j is the degrees of freedom of the interested model

df_m is the degrees of freedom of the measurement model

df_u is the degrees of freedom of the uncorrelated factors model

$$RPR = \frac{510 - 499}{527 - 499} = 0.3929$$

The RPR of the theoretical model is 0.3929. This value does not tell whether to accept or reject this model. However, if there are a number of models that are equally acceptable according to other criteria, the model with the higher RPR may be preferred.

RNFI may now be multiplied by the RPR to produce the Relative Parsimonious Fit Index (RPFI). RNFI provides information about the fit in just the structural portion of the model, while RPR provides information about the parsimony of that part of the model. Multiplying them together will provide a single index that simultaneously reflects both the fit and the parsimony in just the structural portion of the model. The Relative Parsimonious Fit Index (RPFI) is computed for the current model as following:

RPFI = (RNFI)* (RPR) = 1.0005 * 0.3929 = 0.3930

Table 4.6 shows results for testing structural portion of all models. The first line of the table presents information about the null model in which all variables are completely unrelated to all other variables. The second line of the table presents results for the uncorrelated factors model in which the covariance between all latent variables have been fixed at zero. The third line shows results of measurement model. The fourth to twenty-first lines summarize results from the estimation of the theoretical model and all alternative models.

Table 4.6: Goodness of fit and parsimony indices of all models

Model	X^2	df	X^2/df	NFI	NNFI	CFI	PR	PNFI	RNFI	RPR	RPFI
Null model	8,525.8	561	15.20	-	-	-	-	-	-	-	-
Uncorrelated model	3,294.8849	527	6.25	0.6135	0.6301	0.6525	-	-	-	-	-
Measurement model	1,044.9185	499	2.09	0.8774	0.9229	0.9315	-	-	-	-	-
Full maintained model	1,044.9185	493	2.12	0.8774	0.9211	0.9307	0.8788	0.7710	0.9973	-0.2143	-0.2137
PF4F7 path deleted	1,044.9185	494	2.12	0.8774	0.9214	0.9308	0.8806	0.7726	0.9978	-0.1786	-0.1782
PF5F2 path deleted	1,044.9186	495	2.11	0.8774	0.9218	0.9310	0.8824	0.7742	0.9982	-0.1429	-0.1426
PF7F5 path deleted	1,044.9185	496	2.11	0.8774	0.9220	0.9311	0.8841	0.7757	0.9987	-0.1071	-0.1070
PF4F5 path deleted	1,044.9185	497	2.10	0.8774	0.9223	0.9312	0.8859	0.7773	0.9991	-0.0714	-0.0714
PF5F1 path deleted	1,044.92	498	2.10	0.8774	0.9226	0.9313	0.8877	0.7789	0.9996	-0.0357	-0.0357
PF4F6 path deleted	1,044.9195	499	2.09	0.8774	0.9229	0.9315	0.8895	0.7804	1.0000	0.0000	0.0000
PF6F7 path deleted	1,044.9198	500	2.09	0.8774	0.9232	0.9316	0.8913	0.7820	1.0004	0.0357	0.0357
PF5F6 path deleted	1,044.9269	501	2.09	0.8774	0.9235	0.9317	0.8930	0.7836	1.0009	0.0714	0.0715
PF7F4 path deleted	1,044.9664	502	2.08	0.8774	0.9238	0.9318	0.8948	0.7851	1.0013	0.1071	0.1073
PF8F3 path deleted	1,045.121	503	2.08	0.8774	0.9241	0.9319	0.8966	0.7867	1.0017	0.1429	0.1431
PF5F7 path deleted	1,045.7519	504	2.07	0.8773	0.9243	0.9320	0.8984	0.7882	1.0019	0.1786	0.1789
PF6F2 path deleted	1,046.622	505	2.07	0.8772	0.9245	0.9320	0.9002	0.7896	1.0019	0.2143	0.2147
PF6F4 path deleted	1,047.9415	506	2.07	0.8771	0.9246	0.9320	0.9020	0.7911	1.0018	0.2500	0.2504
PF6F3 path deleted	1,049.122	507	2.07	0.8769	0.9247	0.9319	0.9037	0.7925	1.0017	0.2857	0.2862
PF7F3 path deleted	1,050.3924	508	2.07	0.8768	0.9248	0.9319	0.9055	0.7940	1.0016	0.3214	0.3219
PF8F2 path deleted	1,051.8436	509	2.07	0.8766	0.9249	0.9318	0.9073	0.7953	1.0014	0.3571	0.3576
PF8F6 path deleted	1,054.7511	510	2.07	0.8763	0.9248	0.9316	0.9091	0.7966	1.0005	0.3929	0.3931

The R^2 values for the structural equations, which represent the variance explained by the endogenous factors of F8 (Business performance), F7 (Cost), F6 (Flexibility), F5 (Delivery), and F4 (Quality) are 0.9299, 0.7965, 0.5901, 0.7394 and 0.8720, respectively. For instance, 87.20 percent of variance in quality can be explained by supply chain integration, supply chain operation, and human resource management. The results of the hypothesis tests, represented by individual paths between factors within the model, are included in Table 4.7 as well as shown in Figure 4.1.

Table 4.7: Test results of the structural model for all companies

Hypothesis	Path from	To	Regression weight	Standard error	*t*-value
H1a	SCI	QU	0.1384	0.0636	2.1768
H1c	SCI	FL	0.1933	0.0501	3.8558
H1d	SCI	CO	0.4099	0.0857	4.7797
H1e	SCO	QU	0.3911	0.1030	3.7951
H1h	SCO	CO	0.2987	0.0804	3.7125
H1i	HRM	QU	0.4759	0.1282	3.7135
H1j	HRM	DE	0.3924	0.1460	2.6881
H1m	SCI	BP	0.3948	0.0789	5.0037
H2a	QU	BP	0.3090	0.0891	3.4658
H2b	DE	BP	0.2160	0.0778	2.7764
H2d	CO	BP	0.3218	0.0914	3.5213
H3a	QU	DE	0.4545	0.1220	3.7245
H3e	DE	FL	0.3692	0.0623	5.9276
H3i	FL	CO	0.2980	0.1074	2.7762

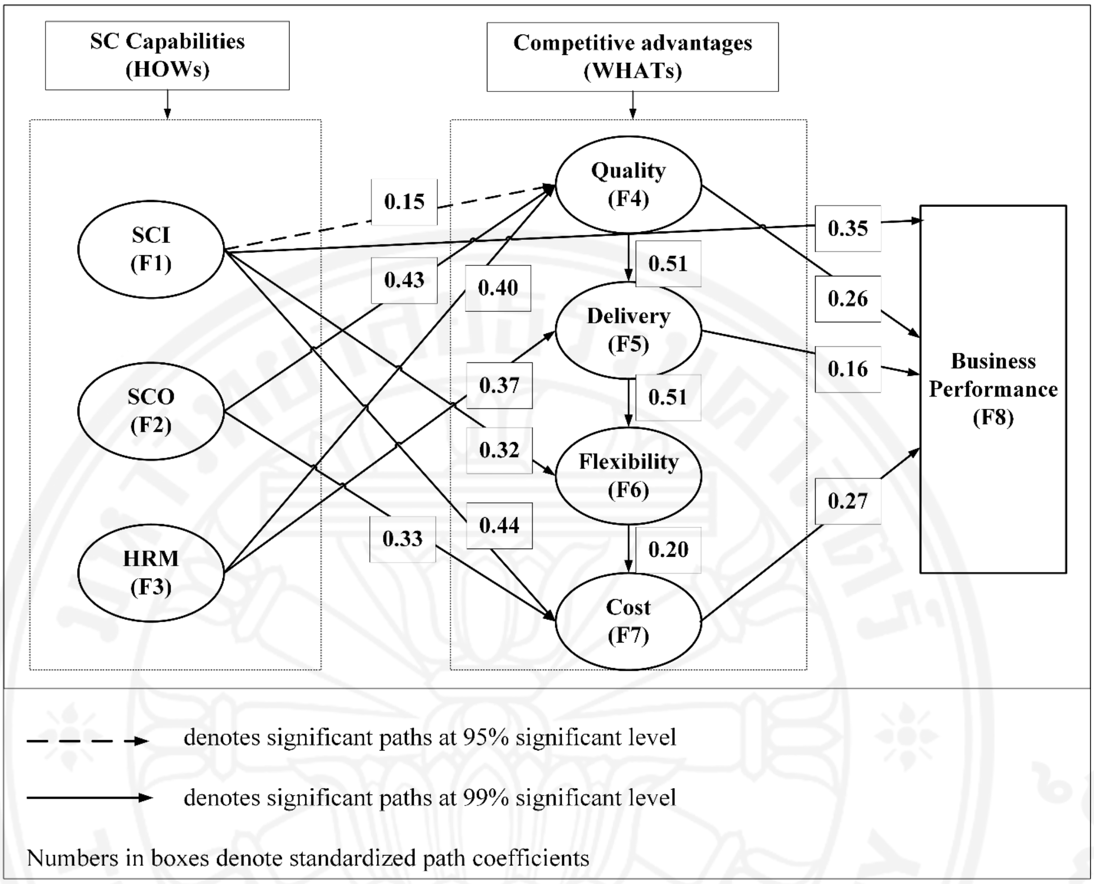


Figure 4.1: Final relationships of all companies

4.1.9 Discussion and managerial implications for the case of all companies

The discussion and managerial implications for the case of all companies are shown, including the effects of the supply chain capabilities on the competitive advantages, the effects of the competitive advantages on business performance, the effects among competitive advantages, and the effects of the supply chain capabilities on business performance.

4.1.9.1 The effects of the supply chain capabilities on the competitive advantages

This study shows the importance for manufacturers to cooperate closely with their external customers and suppliers by empirically linking Supply Chain Integration (SCI) to three competitive priorities, namely, quality ($p < 0.05$), flexibility, and cost ($p < 0.01$). Numerous studies reported that, the implementation of various SCM practices, such as strategic supplier partnerships and customer relationship building, may provide the organization a competitive advantage on cost, quality, dependability, flexibility, and time-to-market dimensions (Rosenzweig et al., 2003; Li et al., 2006; Prajogo and Olhager, 2012). In addition, vendors' participation during the initial design of new products and in problem solving is important to achieve high quality and faster response to market needs (Crosby, 1979; Lascelles and Dale, 1988). Koçoğlu et al. (2011) also argued that based on the strategic relationships between supply chain partners, the value transferred to customers as well as all the entities in the supply chain would increase, costs would decrease, the quality of products and services offered to the market would improve, and consequently, the achievement of sustainable competitive advantages would be facilitated.

The paths from Supply Chain Operation (SCO) to quality and cost are positive and significant. Manufacturing product outcomes are product attributes that reflect the cost, quality, and timing of production as well as the additional services provided by the operation (Corbett and Wassehnove, 1993). In order to increase outcome performance, companies have to focus on the improvement of manufacturing activities by applying effective systems, methods, and technologies, such as a Just-In-Time (JIT) system, or Lean manufacturing. As better production methods are developed, quality and variety may increase. Also, effective Lean practices help reduce lead time and may lead to increase productivity (Saleeshya et al., 2015). When productivity increases, product costs decline and product price can be reduced. Especially, inventories have been the focus of cost reduction for manufacturers and are one of the justifications for a JIT system. Realizing a low inventory level and reducing machine time are positive factors of the cost efficiency construct (Li, 2000).

The analysis reveals that Human Resource Management (HRM) plays an important role in the improvement of quality and delivery. Schuler and Jackson (1987) reported that companies, who consider quality as core competence, need to enhance systematically skill levels of their employees. Indeed, for most total quality management theorists, human capital lies at the heart of a successful quality strategy due to the importance of workforce skills in teams, working, and problem solving (Crosby, 1979; Deming, 1982). As a result, to gain competitive advantage through the quality strategy, the key HRM practices need to be improved, such as quality of recruitment, level of employee's participation in decisions related to their work, and quality and frequency of training programs.

Delivery services reflect how well the manufacturer manages their production and how well they schedule and control delivery capacities, including both delivery staff and vehicles. So to provide a good delivery service in order to differentiate itself from competitors, the manufacturer is encouraged to build good staff, who can manage as well as implement a flexible delivery environment. A more powerful and skillful staff has a stronger ability to react to production problems and schedule variations to meet on-time delivery requirements (Swink and Hegarty, 1998). Reflecting this relationship, human capital is a key to success, a source of competitive advantage, and should be managed strategically (Ahmad and Schroeder, 2003; Ismail et al., 2014). Therefore, companies must develop and realize the full potential of the work force and maintain an environment conducive to full participation, quality leadership, and personal and organizational growth (Raghunathan et al., 1997).

4.1.9.2 The effects of the competitive advantages on business performance

The paths from quality, delivery and cost to business performance are positive and significant at $p < 0.01$. The path from flexibility was recommended to be deleted in the Wald test ($p > 0.05$). This supports the fact that quality, delivery, and cost are very important for improving business performance in the Vietnamese food industry, while better flexibility is considered to be less of a concern among respondents.

Hatani et al. (2013) indicated that the improvement of quality continuously is the key element for the improvement of competitiveness and business performance. Quality helps a company gain a competitive advantage by delivering goods to the marketplace that meets customer needs. With high quality, a product would be increasingly recognized by customers, which in turn, leads to improved performance in terms of sales growth and market share (Forker et al., 1996; Laosirihongthong et al., 2013). These findings are also compatible with the findings of previous studies such as Özdemir and Aslan (2011), and Ward and Duray (2000). These findings support that quality is not only an important element in operation but also the key for company success.

The consequence of early and late deliveries into the supply chain should be considered as wastes. Early deliveries contribute to an increase in inventory holding costs, while late deliveries may be a source for the cost of production stoppage and loss of customer orders (Guiffrida and Nagi, 2006). On-time deliveries help reduce these costs, and further contribute to reduce the bullwhip effect in the supply chain. So, delivery ability is considered as an important component in the improvement of supply chain operations. Many companies focus on the improvement of speed and reliable delivery to reach and maintain customer loyalty (Li, 2000). The market when sales is driven by consumers always has a high competitive level. Consumers will search for competitors if they do not receive good service, hence, delivery service affects business performance positively and significantly.

Market dynamics, competitive pressures, and the effects of new technologies and low priced imports, all focus attention on cost effectiveness as an essential ingredient of business development. Clearly, if a business has high costs that it cannot stand, the result will be higher prices for its customers, leading to falling sales and falling profits. So, competing in the dynamic marketplace requires low-cost production as a basic approach. This is the key element to attract customers among competitors. Companies, who can reduce unit cost, can provide compatible prices that lead directly to increased sales, revenue, and market performance. Rosenzweig et al. (2003) also found that there is positive and significant influences from delivery reliability and cost leadership for business performance.

Importantly, it was also found that flexibility is not considered as an important factor for business improvement in both cases. Vietnamese companies tend to obtain competitiveness by improving product quality, delivery service, and cost. They do not pay much attention to make their production systems to be flexible as a priority. It was found that without improving product quality, delivery service, or reducing cost, better business performance could not be achieved (Chiadamrong and Sophonsaritsook, 2015). Indeed, Upton (1995) found that about 40% of total 61 factories studied in North America were considered as unsuccessful in flexibility improvement. This failure was caused by the limited understanding of managers about the kind of flexibility that should be developed.

4.1.9.3 The effects among competitive advantages

Out of 12 paths in the proposed model, three paths from quality to delivery, delivery to flexibility, and flexibility to cost are positive and significant in our study. Our result also follows the sand cone model, which was proposed by Ferdows and De Meyer (1990). In this model, the typical sequence recommended focusing on quality, delivery, flexibility, and cost efficiency. This shows that product quality has to be considered as the base capability that supports other capabilities. When a company has a high quality product, it may provide better delivery to its customers. While the efforts to improve the quality and delivery are gained, these efforts should make the production system more flexible. A high level of flexibility is a result of reducing set-up time, process cycle time, and batch size, which significantly contribute to the lower production cost. These findings are also partial consistent with the findings from previous studies (Größler and Grübner, 2006; Amoako-Gyampah and Meredith, 2007; Sum et al., 2012).

4.1.9.4 The effects of the supply chain capabilities on business performance

In our findings, except for Supply Chain Integration (SCI), other factors of supply chain capabilities do not have a direct relationship with business performance.

This implies that only improvements of Supply Chain Operation and Human Resource Management cannot help improve a company's performance. This improvement must somehow increase one of company's competitive advantages to have an impact on the company's business performance. However, improvement on the SCI can show both direct and indirect effects on the business performance.

Previous studies have come to a consensus that SCI improves competitive advantages (Li et al., 2009), increases the effectiveness of product development process (Chroneer, 2005), lowers transaction costs (Zhao et al., 2008), enhances flexibility (Clark and Lee, 2000), reduces inventories, eliminates bullwhip effect (Lee et al., 2004; Collan et al., 2014), improves delivery quality, and gains better company performance (Kim, 2006; 2009; Özdemir and Aslan, 2011). Through building long term relationships and sharing of information between supply chain partners, parties attain timely and accurate information (Pujara and Kant, 2013). This allows companies to make better decisions on ordering, capacity allocations, production, and material planning (Koçoğlu et al., 2011). Ragatz et al. (1997) also found that using the knowledge and expertise of suppliers to complement internal capabilities can help reduce cycle time and costs and improve the overall design effort. Highly integrated organizations are able to offer an initial competitive price. This can also potentially stave off the competition longer, and thereby derive good revenue performance from their new products (Fisher, 1997). In addition, suppliers can help companies establish contacts with new potential exchange partners such as new customers, so market performance can be increased, consequently, better company performance can be achieved.

4.2 Multi-group analysis for small sized and large sized companies

The data was also divided into two groups by the number of employees. The first group includes 164 companies, which have less than or equal to 200 employees. The other group comprises 138 companies, which have more than 200 employees. This decision is based on the definition of business size from the Vietnamese Government in terms of their size, i.e., a small sized company (≤ 200 employees) and medium and large sized companies (> 200 employees) (Government’s Decree No. 56/2009/ND-CP)[4]. These two groups were analyzed through SEM multi-group analysis.

4.2.1 Results of small sized and large sized companies

For small sized companies, two paths (from HRM to Delivery and from Delivery to business performance) are insignificant compared to the model of all companies. The ratio of chi-square to degree of freedom is 1.55. The Bentler’s Comparative Fit Index (CFI), and Bentler and Bonett’s Non-normed Fit Index (NNFI) are 0.9272 and 0.9202, respectively.

For large sized companies, two paths (from SCI to Quality and from SCI to Cost) are insignificant compared to the model of all companies. Goodness-of-fit indices also indicate an acceptable fit of the structural model to the data. The ratio of chi-square to degree of freedom is 1.52. The Bentler’s Comparative Fit Index (CFI) is 0.9358, and Bentler and Bonett’s Non-normed Fit Index (NNFI) is 0.9296, all above the desired 0.90 level (Byrne, 2006). The results of the structural model for small sized and large sized companies are shown in Table 4.8 as well as Figure 4.2 and Figure 4.3.

[4] Government’s Decree No. 56/2009/ND-CP of June 30, 2009, on assistance to the development of small and medium sized enterprises, available at http://www.kenfoxlaw. com/resources/legal-documents/governmental-decrees/2424-vbpl-sp21986.html (accessed on 25 January 2015)

Table 4.8: Test results of the structural model for small sized and large sized companies

Hypothesis	Path from	To	Small sized companies		Large sized companies	
			Regression weight	*t*-value	Regression weight	*t*-value
H1a	SCI	QU	0.1729	2.7241	-	Insignificant
H1c	SCI	FL	0.1613	2.4453	0.2235	2.7871
H1d	SCI	CO	0.4505	4.1407	-	Insignificant
H1e	SCO	QU	0.4042	3.2198	0.4916	3.3489
H1h	SCO	CO	0.3255	3.2109	0.5702	6.0480
H1i	HRM	QU	0.3526	2.1332	0.5562	3.2195
H1j	HRM	DE	-	Insignificant	0.4719	2.8890
H1m	SCI	BP	0.3340	3.5966	0.4005	4.4278
H2a	QU	BP	0.4557	4.3335	0.2444	2.1738
H2b	DE	BP	-	Insignificant	0.2925	2.4130
H2d	CO	BP	0.3792	3.3939	0.3658	3.6333
H3a	QU	DE	0.8217	9.8500	0.3580	2.6547
H3e	DE	FL	0.3815	4.4838	0.3409	3.5177
H3i	FL	CO	0.3223	2.0209	0.4139	2.8037

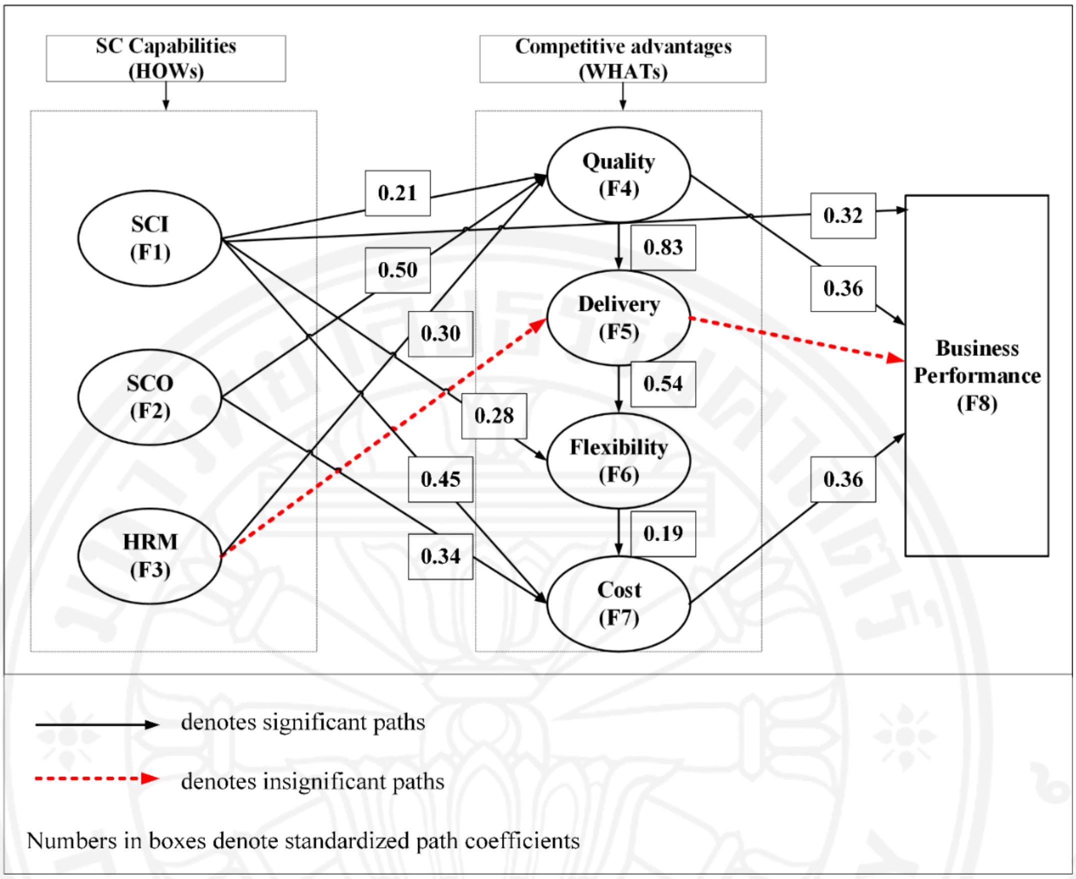


Figure 4.2: Final relationships of small sized companies

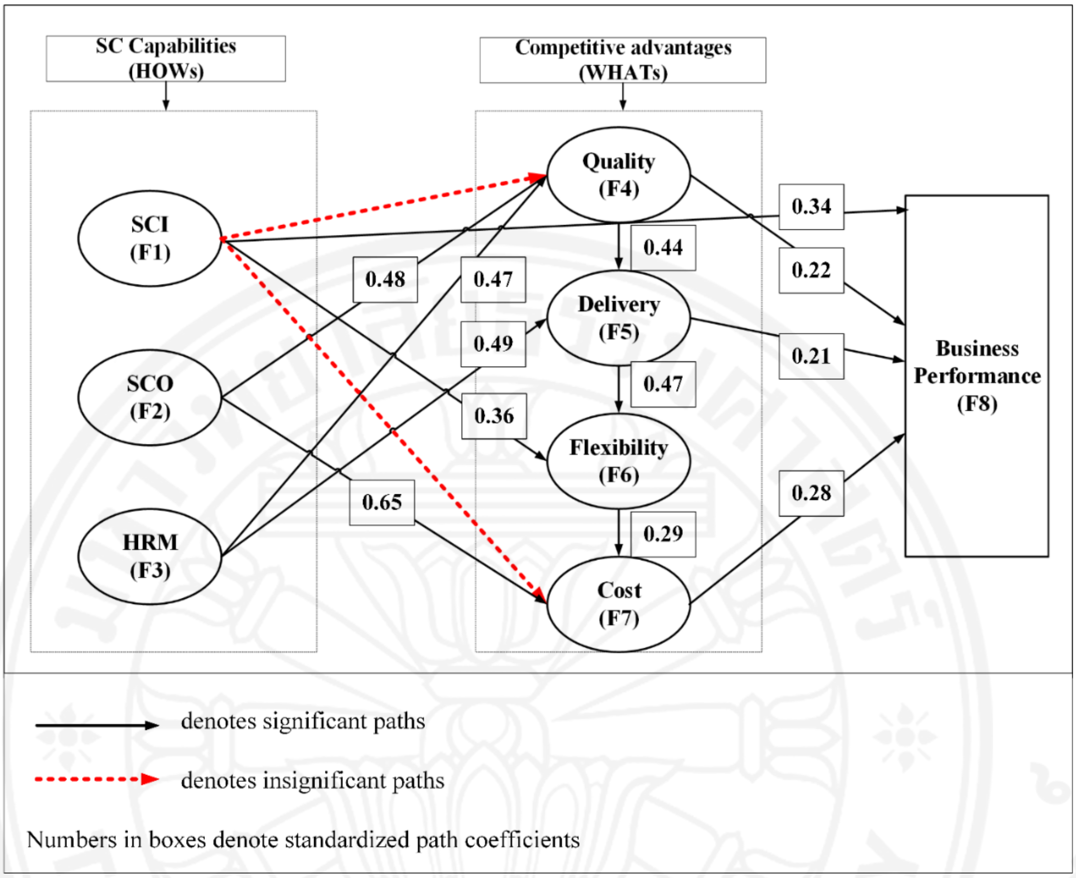


Figure 4.3: Final relationships of large sized companies

4.2.2 Discussion and managerial implications considering the size of companies

When different sizes of the companies are taken into the consideration, the results from the multi-group analysis show that ten significant paths are similar, and four paths are different between the two groups. Figure 4.4 summarizes all significant and insignificant paths in small sized companies and large sized companies.

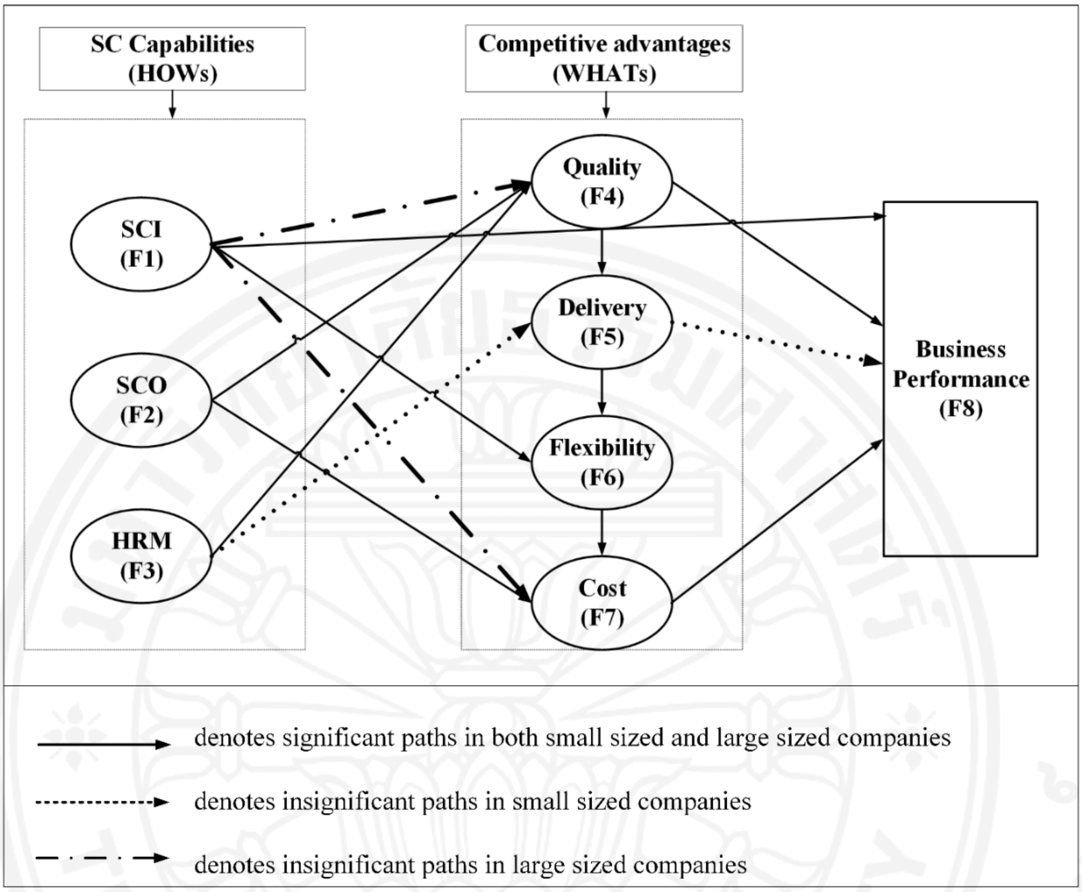


Figure 4.4: Final relationships of small sized and large sized companies: Summary

The first difference is that there is no significant effect from Human Resource Management (HRM) on delivery in small sized companies. Even though the path from HRM to quality is significant, the evidence is not as strong as that in large sized companies (paths are significant at $p < 0.05$ and $p < 0.01$ in the small sized companies and large sized companies, respectively). This result means that HRM is not regarded as very important for small sized companies, while it is a source of competitiveness in large sized companies. Unlike large sized companies, recruiting, motivating, and retaining employees are big problems for small sized companies (Mathis and Jackson, 1991). In small sized companies, other functional areas such as finance, production, and marketing usually get preference over personnel management (McEvoy, 1984). Also, some researchers reported that managers of small sized companies lack training in formal personnel management practices and they do not consider the use of generally accepted HRM practices as essential for improving productivity (McEvoy, 1984). In addition, in the study of Greenidge et al. (2012), large sized companies are more likely to consider and treat their employees as core competencies to increase labor productivity, flexibility, workforce adaptability, and innovation than small sized companies. The importance of training programs is strongly recognized (Boxall, 1996), but it is not considered a requirement in small sized companies. If training occurs, it is characterized as reactive, informal, short-term, and directed to the solution of immediate work-related problems (Hill and Stewart, 2000).

As mentioned from the above discussion, delivery service depends largely on workforce in planning and managing the production to get customer requirements (Youndt et al., 1996; Swink and Hegarty, 1998). A company with better skilled staff can plan and manage operation easily, so delivery service can be done effectively. Small sized companies do not consider HRM as an important source for business development. They do not have professional staff due to the lack of formal recruitment and formal training process (Greenidge et al., 2012). In addition, small sized companies have not applied information technology, which is considered a source of delivery capability. Hence, due to lacks of investment, knowledge and skills, vehicles, and flexible ability to meet delivery requirements, delivery capability may not likely be considered as a core competence to improve business performance in small sized companies. This result supports the result of Özdemir and Aslan (2011), who examined the relationships between supply chain integration, competitive capabilities, and business performance in small companies which have less than 250 employees. They also found that there is no significant effect of the customer service ability on any subtitles in performance.

It is surprising that small sized companies realize significant benefits from Supply Chain Integration (SCI) for improving competitive advantages, while large sized companies may not be able to get the depth of benefits that are provided by SCI. This result stems from the fact that small sized companies are characterized by severe constraints on resources such as finance, advanced systems, and technologies (Thong and Yap, 1995), and knowledge and human assets (Greenidge et al., 2012). They also do not have size and power to control their operations in supply chains effectively (Kim, 2009), so it is necessary to integrate with other bigger companies due to the benefits that they get, for example, investment support or future orders. Meanwhile, large sized companies can be independent from economies and assets, advanced technology, more knowledge, and staff. Hence, they would consider that integrating may not be as much important to them. However, the above argument does not mean that, in large sized companies, the importance of SCI can be diminished.

Chapter 5
Integrated approach with SEM, Fuzzy-QFD, and MLP

In this chapter, two examples of small sized and large sized companies are shown, to illustrate the proposed methodology in which an integrated approach with SEM, Fuzzy-QFD, and MLP is used to suggest suitable SCM strategies under the limited budget.

5.1 Illustrative example of SCM strategy development for small sized and large sized companies

This section shows the results of three step procedures of the proposed methodology, including the results of SEM analysis, the result of QFD matrix, and the results of testing MLP model.

5.1.1 SEM results from testing relationships between supply chain capabilities and competitive advantages towards business performance

Three hierarchical levels of structure are constructed to test the relationships between SC Capabilities (as HOWs in the first QFD matrix) and Competitive advantages (as WHATs in the first QFD matrix), and the relationships between Competitive advantages (as WHATs in the first QFD matrix) and business performance. Figure 5.1 and Figure 5.2 show the results of these relationships obtained from SEM analysis for the small sized and large sized companies, respectively. However, only the direct impacts among two consecutive levels are allowed as the direct impact of SC capabilities to business performance is not considered in the QFD matrix.

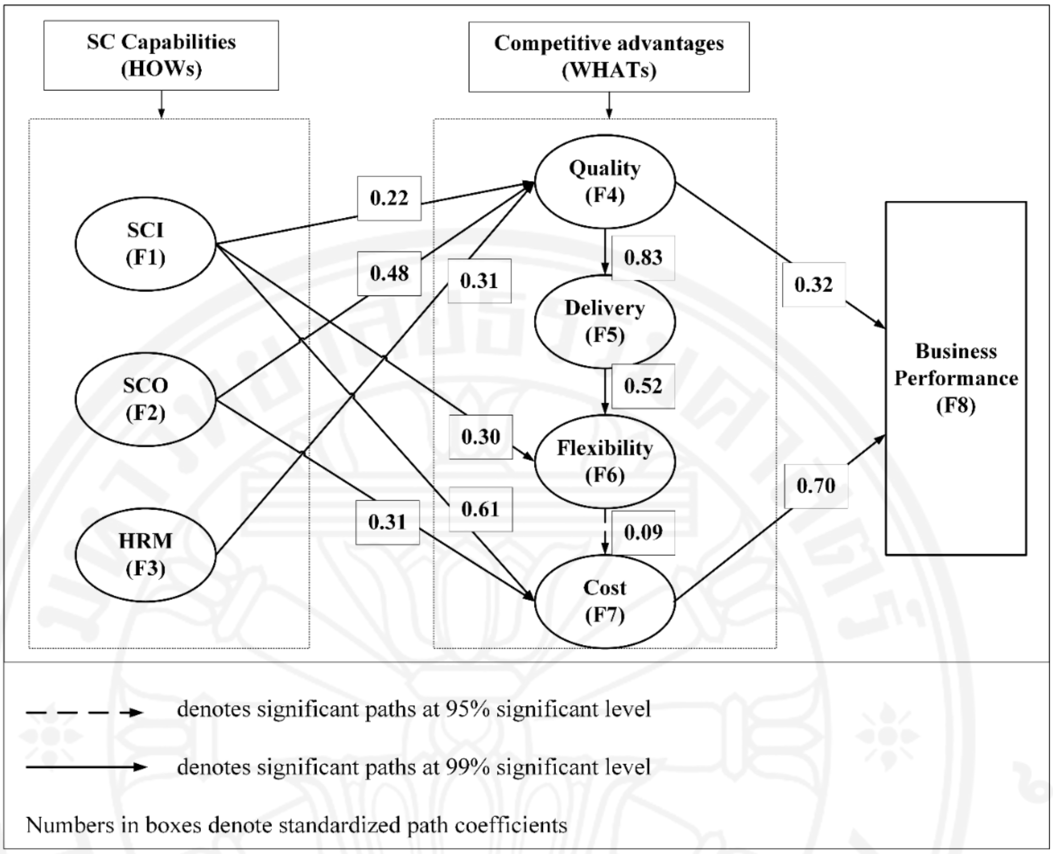


Figure 5.1: Results of relationships for small sized companies

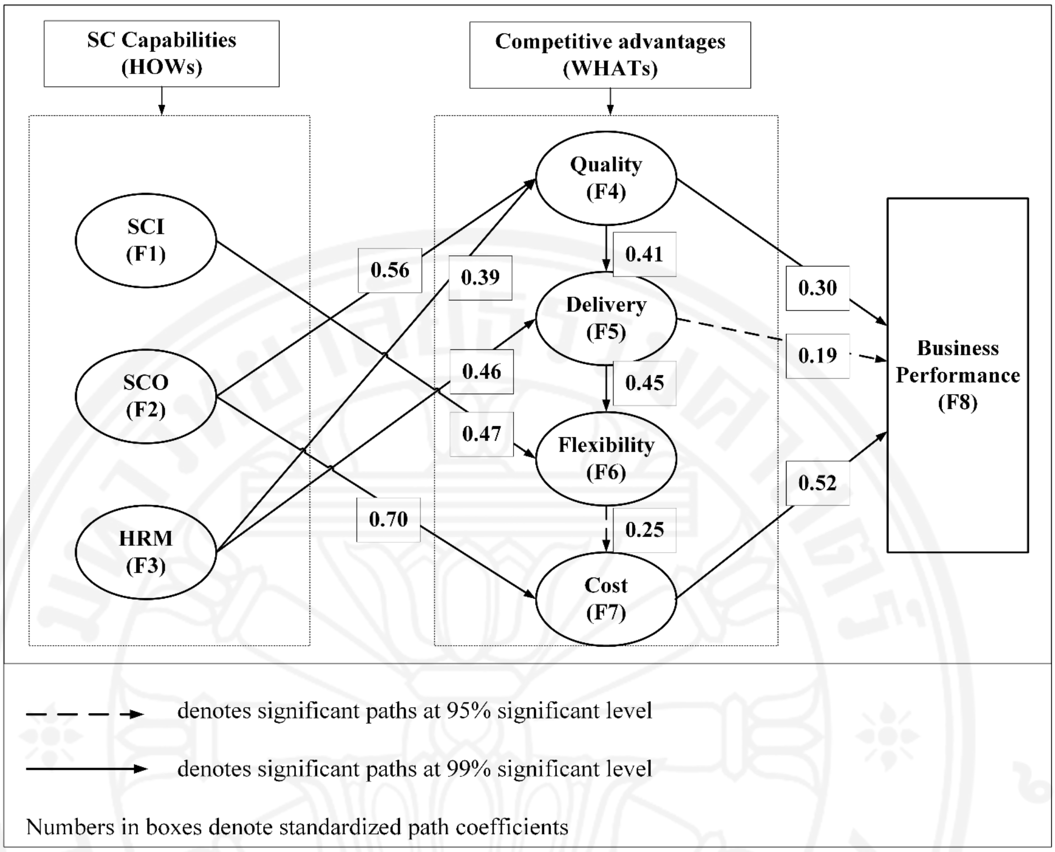


Figure 5.2: Result of relationships for large sized companies

5.1.2. Supply chain capabilities development based on SEM-QFD matrix

First, the first QFD matrix is built, based on the results of SEM analysis, in order to transform competitive advantages (WHATs) into supply chain capabilities (HOWs). The weights of competitive advantages (WHATs) are calculated from transforming standardized coefficients of the relationships between these factors both directly and indirectly, obtained from the results of SEM.

For example (see Figure 5.3 for the impact of quality factor on business performance in small sized company):

Impact of quality on business performance = direct effect + indirect effect

= 0.32 + (0.83*0.52*0.09*0.70) = 0.35

As a result, the initial weight of quality = 0.35, but it needs to be normalized to a total weight of 1.

So, the normalized weight of quality = $\frac{0.35}{1.14}$ = 0.3

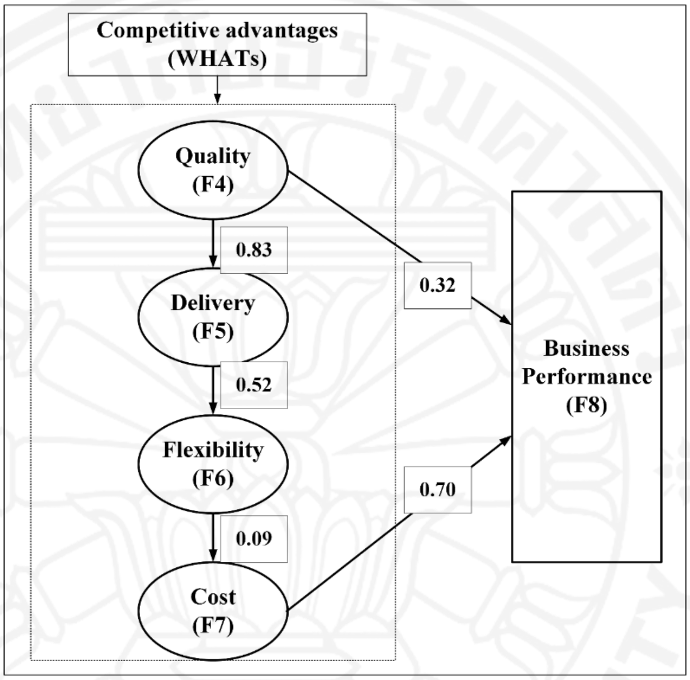


Figure 5.3. Relationships between competitive advantages and business performance for small sized companies

Then, the relationships between competitive advantages (WHATs) and supply chain capabilities (HOWs) are again calculated by using standardized coefficients of the relationships between supply chain capabilities and competitive advantages, both direct and indirect, obtained from the results of SEM.

For example (see Figure 5.4 for the impact of SCI on cost factor in small sized company):

The score of the relationship between SCI and Cost = direct effect + indirect effect

= 0.61 + (0.22*0.83*0.52*0.09) + (0.30*0.09) = 0.65

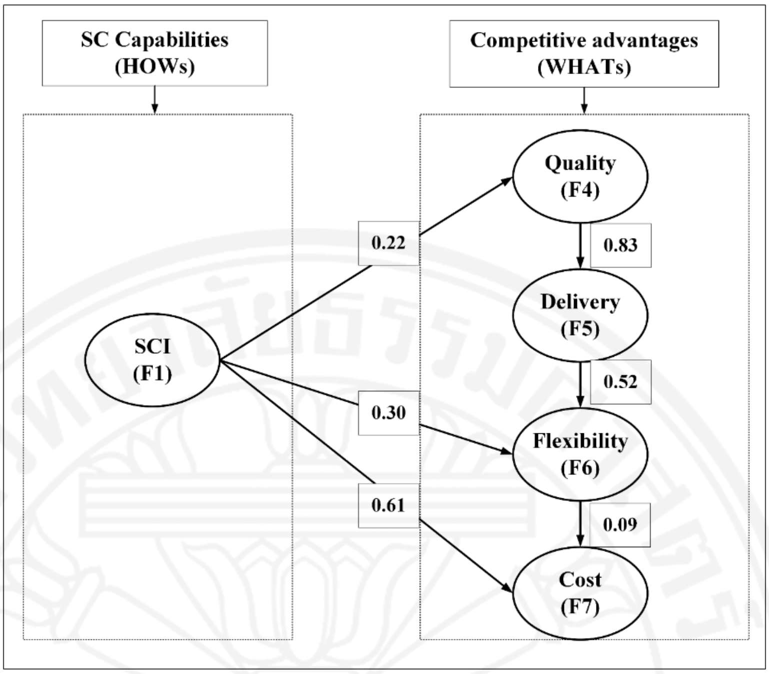


Figure 5.4. Relationships between SCI and competitive advantages
for small sized companies

Then, the weighted score of supply chain capabilities (HOWs) are calculated as follows (see Figure 5.5):

Weighted score of SCI = (0.30*0.22) + (0.03*0.18) + (0.06*0.39) + (0.61*0.65)

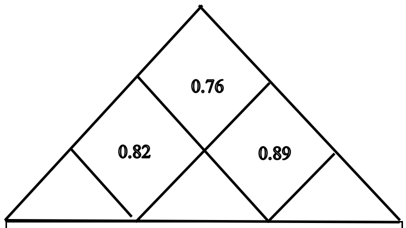
= 0.49

This weighted score is also required to be normalized by the total weights of SCI, SCO, and HRM. The weighted scores of supply chain capabilities in this step are used as an input into the next step.

In this study, the correlations between HOWs are reported by SEM analysis. All correlation values are highly positive, so SCI, SCO, and HRM should positively contribute to each other. The first QFD matrix for small sized and large sized companies are shown in Figure 5.5 and 5.6.

			SC Capabilities (HOWs)		
Competitive Advantages (WHATs)	Initial Weight	Normalized weight of WHATs	SCI	SCO	HRM
Quality	**0.35**	**0.30**	0.22	0.48	0.31
Delivery	0.03	0.03	0.18	0.40	0.26
Flexibility	0.06	0.06	0.39	0.21	0.13
Cost	0.70	0.61	**0.65**	0.33	0.01
	Sum of initial weights	Weight of HOWs	**0.49**	0.37	0.12
	1.14	Normalized weight of HOWs	0.50	0.38	0.12

Figure 5.5: SEM-QFD matrix for weighting SC capabilities for small sized companies



Competitive Advantages (WHATs)	Initial Weight	Normalized weight of WHATs	SC Capabilities (HOWs)		
			SCI	SCO	HRM
Quality	0.40	0.31	0.00	0.56	0.39
Delivery	0.25	0.19	0.00	0.23	0.62
Flexibility	0.13	0.10	0.47	0.10	0.28
Cost	0.52	0.40	0.12	0.73	0.07
	Sum of initial weights	Weight of HOWs	0.09	0.52	0.29
	1.30	Normalized weight of HOWs	0.10	0.57	0.33

Figure 5.6: SEM-QFD matrix for weighting SC capabilities for large sized companies

5.1.3 Supply chain strategy development based on Fuzzy-QFD

Following the first QFD matrix, which transforms the competitive advantages into supply chain capabilities, the second QFD matrix is then built to transform supply chain capabilities (WHATs) into specific SCM strategies and actions (HOWs). The opinions from three decision makers (academic experts), as marked as DM1, DM2, and DM3, on the level of relationships between supply chain capabilities and SCM strategies, are shown in Table 5.1. The results of Fuzzy-QFD matrixes of small sized and large sized company are shown in Table 5.2 and Table 5.3.

Table 5.1: Opinions on the correlation score between SC capabilities and SCM strategies

SCM Strategy	Supply chain capabilities								
	Supply Chain Integration (SCI)			Supply Chain Operation (SCO)			Human Resource Management (HRM)		
	DM1	DM2	DM3	DM1	DM2	DM3	DM1	DM2	DM3
1	VH	VH	VH	M	L	H	L	VL	L
2	VH	VH	VH	M	H	M	L	VL	L
3	VH	VH	H	M	VH	VH	L	VL	L
4	VH	L	VH	VH	VH	VH	M	VL	L
5	VH	H	H	VH	VH	VH	M	VL	L
6	H	M	H	VH	M	VH	M	VL	L
7	L	L	M	H	L	L	VH	VH	VH
8	VL	VL	H	M	M	L	VH	VH	VH
9	VL	VL	M	H	M	M	VH	VH	VH
10	L	VL	VH	VH	VH	VH	VH	M	L
11	H	L	VH	VH	VH	VH	H	L	L
12	H	L	VH	VH	L	VH	M	L	VH
13	H	M	VH	VH	VH	VH	L	L	L
14	M	H	VH	VH	VH	M	H	VL	L
15	VL	H	M	VH	VH	VH	VL	VL	L
16	L	M	M	VH	M	VH	M	L	VL
17	VL	L	M	VH	VH	VH	M	M	VL

Table 5.2: Fuzzy-QFD matrix for weighting SCM strategies of small sized companies

Weight of SCI | Final score of Strategy 1 | Normalized relative technical importance of Strategy 1

SC Capabilities (WHATs)	Weight of WHATs	SCM Strategies																										
		1			2			3			4			5			6			7			8			9		
SCI	**0.50**	4.0	4.5	5.0	4.0	4.5	5.0	3.7	4.2	4.7	3.0	3.5	4.0	3.3	3.8	4.4	2.7	3.2	3.7	1.3	1.8	2.3	1.0	1.5	2.0	0.7	1.2	1.7
SCO	0.38	1.5	1.9	2.3	1.8	2.1	2.5	2.5	2.9	3.3	3.0	3.4	3.8	3.0	3.4	3.8	2.5	2.9	3.3	1.3	1.6	2.0	1.3	1.6	2.0	1.8	2.1	2.5
HRM	0.12	0.2	0.3	0.4	0.2	0.3	0.4	0.2	0.3	0.4	0.2	0.4	0.5	0.2	0.4	0.5	0.2	0.4	0.5	1.0	1.1	1.2	1.0	1.1	1.2	1.0	1.1	1.2
Total score		**1.9**	**2.2**	**2.6**	2.0	2.3	2.6	2.1	2.5	2.8	2.1	2.4	2.8	2.2	2.5	2.9	1.8	2.1	2.5	1.2	1.5	1.9	1.1	1.4	1.7	1.1	1.5	1.8
Final score		**2.23**			2.31			2.45			2.43			2.54			2.15			1.52			1.41			1.46		
Normalized relative technical importance		**3.91**			4.21			4.71			4.60			5.00			3.61			1.40			1.00			1.20		

SC Capabilities (WHATs)	Weight of WHATs	SCM Strategies																							
		10			11			12			13			14			15			16			17		
SCI	0.50	1.7	2.2	2.7	2.7	3.2	3.7	2.7	3.2	3.7	3.0	3.5	4.0	3.0	3.5	4.0	1.7	2.2	2.7	1.7	2.2	2.7	1.0	1.5	2.0
SCO	0.38	3.0	3.4	3.8	3.0	3.4	3.8	2.3	2.6	3.0	3.0	3.4	3.8	2.5	2.9	3.3	3.0	3.4	3.8	2.5	2.9	3.3	3.0	3.4	3.8
HRM	0.12	0.6	0.7	0.8	0.4	0.5	0.6	0.6	0.7	0.8	0.2	0.4	0.5	0.3	0.4	0.6	0.0	0.1	0.2	0.2	0.4	0.5	0.3	0.4	0.6
Total score		1.8	2.1	2.4	2.0	2.4	2.7	1.8	2.2	2.5	2.1	2.4	2.8	2.0	2.3	2.6	1.6	1.9	2.2	1.5	1.8	2.1	1.4	1.8	2.1
Final score		2.09			2.37			2.17			2.43			2.28			1.90			1.81			1.78		
Normalized relative technical importance		3.40			4.40			3.69			4.60			4.10			2.74			2.43			2.33		

Table 5.3: Fuzzy-QFD matrix for weighting SCM strategies of large sized companies

SC Capabilities (WHATs)	Weight of WHATs	SCM Strategies																										
		1			2			3			4			5			6			7			8			9		
SCI	0.10	0.8	0.9	1.0	0.8	0.9	1.0	0.8	0.9	1.0	0.6	0.7	0.8	0.7	0.8	0.9	0.5	0.7	0.8	0.3	0.4	0.5	0.2	0.3	0.4	0.1	0.2	0.3
SCO	0.57	2.3	2.9	3.4	2.7	3.2	3.8	3.8	4.4	4.9	4.6	5.1	5.7	4.6	5.1	5.7	3.8	4.4	4.9	1.9	2.5	3.0	1.9	2.5	3.0	2.7	3.2	3.8
HRM	0.33	0.4	0.8	1.1	0.4	0.8	1.1	0.4	0.8	1.1	0.7	1.0	1.3	0.7	1.0	1.3	0.7	1.0	1.3	2.6	2.9	3.3	2.6	2.9	3.3	2.6	2.9	3.3
Total score		1.2	1.5	1.8	1.3	1.6	2.0	1.7	2.0	2.3	1.9	2.3	2.6	2.0	2.3	2.6	1.7	2.0	2.3	1.6	1.9	2.3	1.6	1.9	2.2	1.8	2.1	2.5
Final score		1.51			1.64			2.00			2.28			2.30			2.00			1.93			1.91			2.14		
Normalized relative technical importance		1.00			1.53			3.01			4.18			4.27			3.03			2.72			2.63			3.58		

SC Capabilities (WHATs)	Weight of WHATs	SCM Strategies																							
		10			11			12			13			14			15			16			17		
SCI	0.10	0.3	0.4	0.5	0.5	0.7	0.8	0.5	0.7	0.8	0.6	0.7	0.8	0.6	0.7	0.8	0.3	0.4	0.5	0.3	0.4	0.5	0.2	0.3	0.4
SCO	0.57	4.6	5.1	5.7	4.6	5.1	5.7	3.4	4.0	4.6	4.6	5.1	5.7	3.8	4.4	4.9	4.6	5.1	5.7	3.8	4.4	4.9	4.6	5.1	5.7
HRM	0.33	1.5	1.8	2.2	1.1	1.4	1.7	1.5	1.8	2.2	0.7	1.0	1.3	0.9	1.2	1.5	0.0	0.3	0.7	0.7	1.0	1.3	0.9	1.2	1.5
Total score		2.1	2.5	2.8	2.1	2.4	2.7	1.8	2.2	2.5	1.9	2.3	2.6	1.8	2.1	2.4	1.6	2.0	2.3	1.6	1.9	2.3	1.9	2.2	2.5
Final score		2.48			2.40			2.17			2.28			2.10			1.97			1.93			2.21		
Normalized relative technical importance		5.00			4.68			3.70			4.18			3.42			2.89			2.74			3.91		

From Table 5.2 and Table 5.3, the normalized relative technical importance of all 17 strategies for small sized companies and large sized companies are shown. In the case of small sized companies, it was found that Strategy 5 (effective forecasting method) gives the highest technical importance while Strategy 8 (recruitment) shows the lowest value. In the case of large sized companies, strategy 10 (5S) gives the highest technical importance while strategy 1 (supplier selection) shows the lowest value.

Regarding the calculation, the weights of supply chain capabilities are taken from the normalized weighted score of the first QFD matrix. The relationships between WHATs and HOWs are calculated from fuzzy opinions of the experts. For example, in the case of small sized companies, the relationship between SCI and Strategy 1 is calculated as follows:

Opinions of three DMs on the relationship between SCI and Strategy 1 are all VH (very high), which is represented by the fuzzy value of (8, 9, 10).

Average score of relationship between SCI and Strategy 1:

$S_{11} = (S_{11\alpha}, S_{11\beta}, S_{11\gamma})$

$S_{11\alpha} = \frac{1}{3} * (8 + 8 + 8) = 8$

$S_{11\beta} = \frac{1}{3} * (9 + 9 + 9) = 9$

$S_{11\gamma} = \frac{1}{3} * (10 + 10 + 10) = 10$

Aggregated score: $AS_{11} = S_{11} * weight_1$ = (8, 9, 10) * 0.50= (4.0, 4.5, 5.0)

Total score of Strategy 1: $TS_1 = (TS_{1\alpha},\ TS_{1\beta},\ TS_{1\gamma})$

$TS_{1\alpha} = \frac{1}{3} * (4.0 + 1.5 + 0.2) = 1.9$

$TS_{1\beta} = \frac{1}{3} * (4.5 + 1.9 + 0.3) = 2.2$

$TS_{1\gamma} = \frac{1}{3} * (5.0 + 2.3 + 0.4) = 2.6$

Final score of Strategy 1:

$FS_1 = \frac{1}{3} * (TS_{1\alpha} + TS_{1\beta} + TS_{1\gamma}) = \frac{1}{3} * (1.9 + 2.2 + 2.6) = 2.23$

This final score is then normalized and transferred into the full scale of 5 to get the normalized relative technical importance of Strategy 1, of 3.91.

In this study, all correlations between HOWs are positive (marked as +) or none as shown in Figure 5.7. So, conflicts among these strategies are not a problem in this study.

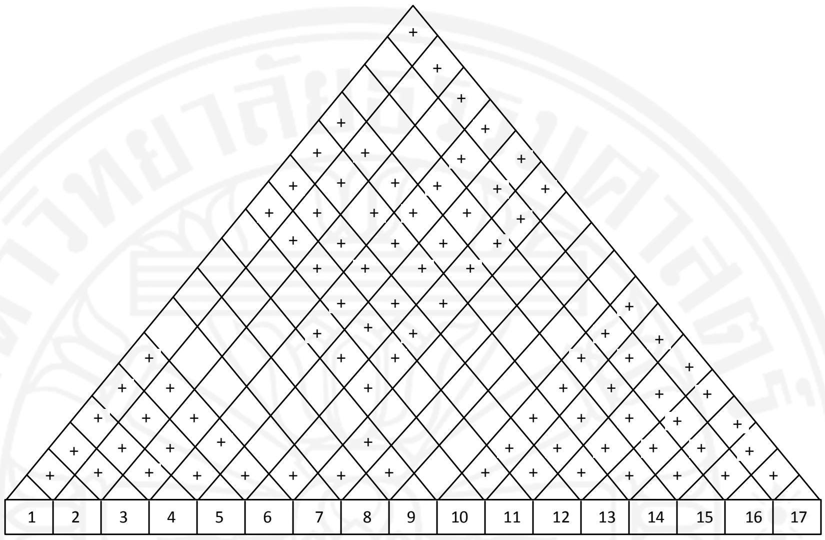


Figure 5.7: Correlation scores among SCM strategies

5.1.4 Results of Multi-objective Linear Programming model (MLP) for choosing suitable SCM strategies and actions

In this study, normalized relative technical importance, investment cost, benefit value, and feasibility to be implemented of SCM strategies have been selected to form the objective function. If each criterion is aimed to optimize only its own objective, which can be conflicting in their nature. For example, cheap investment cost strategy could yield only low benefit value. In this study, each criteria represents one aspect that decision makers expect to gain from implementing a particular strategy. Normalized relative technical importance is the importance levels of such strategy in building supply chain capabilities, obtained from the results of QFD matrix. Investment cost is the estimated investment expense if company has to proceed with each strategy. Benefit value is defined as the benefit that could be gained from implementing such strategies. This benefit value can be calculated from the amount of cost reduction if that strategy can help to reduce the costs, or the amount of increasing revenue if it can help to increase the current sales, and hence increase the revenue. High percentage value indicates more costs can be reduced or more revenue can be gained in relation to the current level of costs or revenue. Feasibility to implement provides the benefit and drawback of each strategy. This is to evaluate the feasibility to implement such strategies in the company.

To demonstrate the proposed methodology for choosing suitable SCM strategies and actions, Sai Gon- Mien Tay Beer Company and Trung Nguyen Coffee Company (two of our respondents) are chosen as examples of small sized and large sized companies, respectively.

An example of small sized companies is Sai Gon- Mien Tay Beer Company. Sai Gon- Mien Tay Beer Company, locating in the South of Vietnam, produces more than 30 kinds of beverages for Vietnamese. Even though, it is considered as a small sized company, which has less than 200 employees, its products have been distributed throughout the nation and have received many certificates from the Vietnamese Government.

Trung Nguyen Coffee Company is a Vietnamese business group involved in the production, processing, and distribution of coffee, is also chosen as an example of large sized companies. Trung Nguyen is the largest domestic coffee brand within Vietnam, and exports its products to more than 60 countries, including major Asian markets such as Japan and Singapore. This company is considered to be a large sized company with more than 1,000 employees. Along with producing and processing coffee beans, Trung Nguyen operates and distributes its products a nationwide chain of over 1,000 coffee shops in Vietnam.

The data of investment cost, value, and feasibility to be implemented with 17 SCM strategies, given by Sai Gon- Mien Tay Beer Company and Trung Nguyen Coffee Company, are shown in Table 5.4 and 5.5. Strategies are selected under a limited budget, which represents approximately 7 billion VND (approximately $US 350,000) and 14 billion VND (approximately $US 700,000), for Sai Gon- Mien Tay Beer Company and Trung Nguyen Coffee Company, respectively.

Table 5.4: Investment cost, value, and feasibility of SCM strategies, given by Sai Gon- Mien Tay Beer Company (small sized company)

SCM strategy	Normalized relative technical importance *	Investment cost	Benefit value	Feasibility to be implemented
1	3.91	1	3	3
2	4.21	3	2	2
3	4.71	2	4	3
4	4.6	4	4	2
5	5.0	2	3	4
6	3.61	3	4	2
7	1.4	3	2	2
8	1.0	2	3	3
9	1.2	3	3	4
10	3.4	1	2	4
11	4.4	2	3	5
12	3.69	4	4	3
13	4.6	2	3	4
14	4.1	3	3	3
15	2.74	5	5	1
16	2.43	3	4	4
17	2.33	2	4	5
* Normalized relative technical importance is obtained from Table 5.2				

Table 5.5: Investment cost, value, and feasibility of SCM strategies, given by Trung Nguyen Coffee Company (large sized company)

SCM strategy	Normalized relative technical importance*	Investment cost	Benefit value	Feasibility to be implemented
1	1.0	1	3	4
2	1.53	4	3	3
3	3.01	2	2	2
4	4.18	4	5	5
5	4.27	3	5	5
6	3.03	3	3	2
7	2.72	4	3	3
8	2.63	2	4	4
9	3.58	4	5	4
10	5.0	1	2	5
11	4.68	3	5	5
12	3.7	3	5	5
13	4.18	2	4	4
14	3.42	2	3	3
15	2.89	5	4	4
16	2.74	2	4	5
17	3.91	2	5	5

* Normalized relative technical importance is obtained from Table 5.3

All data are scaled, ranging from 1 to 5, as shown in Table 5.6, presenting the recommended range in each level.

Table 5.6: Recommended range of investment cost, benefit value, and feasibility to be implemented

Criteria	(1)	(2)	(3)	(4)	(5)
Investment costs (VND)	< 200 million	200 – 500 million	500 million – 2 billion	2 – 5 billion	> 5 billion
Benefit value as revenue increment or cost reduction	None	< 10%	10 - 20 %	20 - 30%	> 30 %
Feasibility to implement	Maybe impossible	Possible with some difficulty	Likely possible	Totally possible	A must, and vital to implement

By solving Equation (15), all 97 solutions with various weighting patterns can be presented in Table 5.7 and Table 5.8. As a result, the companies can select suitable strategies based on their preference of the relative importance among four possible conflicting criteria under a limited investment budget of around 7 billion VND (for a small sized company) and 14 billion VND (for a large sized company), in order to yield the highest objective function values among these objectives.

In addition, for the small sized company (Sai Gon-Mien Tay Beer Company), it was found that case No. 21, where the normalized relative technical importance is prioritized highest at 0.7, while the other criteria are given an equal weight at 0.1, gives the highest objective function value, at 26.82. This is because most of strategies that have high value in technical importance, also have high value in feasibility and low cost. So, when these strategies are selected, the objective function is maximum. In contrast, when the company prioritizes the cost at the highest (0.7), while the others are given an equal weight at 0.1, this case gives the lowest objective function value, at 0.53, and only two strategies (1 and 10) are chosen to be implemented. This is due to the fact that as the minimization of investment cost is the main priority, only cheap implementation strategies are selected.

For the large size company (Trung Nguyen Coffee Company), the result indicates that the highest objective function value (40.97) is obtained from the case No. 81, where the feasibility is prioritized highest at 0.7, while the other criteria are given equal weight at 0.1 gives. This is because most of strategies that have a high value in feasibility have low investment cost, so these strategies are selected to maximize the objective function. So, when the feasibility is prioritized highest at 0.7, the objective function value is maximum. In opposite, when the company prioritizes the cost at the highest (0.7), while the others are given equal weight at 0.1, this case gives the lowest objective function value at 0.6, and only two strategies (1 and 10) are chosen to be implemented. This case is similar to the case of the small sized company.

Table 5.7: Results of the sensitivity analysis for the small sized company

(Sai Gon-Mien Tay Beer Company)

No	Criteria				Selected strategies	Objective function value
	Normalized Relative Technical Importance	Investment Cost	Benefit Value	Feasibility to be implemented		
1	0.25	0.25	0.25	0.25	1, 3, 5, 10, 11, 13, 16, 17	18.45
2	0.3	0.233	0.233	0.233	1, 3, 5, 10, 11, 13, 14, 17	19.30
3	0.4	0.2	0.2	0.2	1, 3, 5, 10, 11, 13, 14, 17	21.18
4	0.4	0.3	0.15	0.15	1, 3, 5, 10, 11, 13, 14, 17	16.88
5	0.4	0.15	0.3	0.15	1, 3, 5, 10, 11, 13, 14, 17	22.88
.6	0.4	0.15	0.15	0.3	1, 3, 5, 10, 11, 13, 14, 17	23.78
7	0.4	0.36	0.12	0.12	1, 3, 5, 10, 11, 13, 14, 17	14.30
8	0.4	0.12	0.36	0.12	1, 3, 5, 6, 10, 11, 13, 17	23.94
9	0.4	0.12	0.12	0.36	1, 3, 5, 10, 11, 13, 14, 17	25.34
10	0.5	0.167	0.167	0.167	1, 3, 5, 10, 11, 13, 14, 17	23.06
11	0.5	0.25	0.125	0.125	1, 3, 5, 10, 11, 13, 14, 17	19.48
12	0.5	0.125	0.25	0.125	1, 3, 5, 10, 11, 13, 14, 17	24.48
13	0.5	0.125	0.125	0.25	1, 3, 5, 10, 11, 13, 14, 17	25.23
14	0.5	0.3	0.1	0.1	1, 3, 5, 10, 11, 13, 14, 17	17.33
15	0.5	0.1	0.3	0.1	1, 3, 5, 10, 11, 13, 14, 17	25.33
16	0.5	0.1	0.1	0.3	1, 3, 5, 10, 11, 13, 14, 17	26.53
17	0.6	0.133	0.133	0.133	1, 3, 5, 10, 11, 13, 14, 17	24.94
18	0.6	0.2	0.1	0.1	1, 3, 5, 10, 11, 13, 14, 17	22.07
19	0.6	0.1	0.2	0.1	1, 3, 5, 10, 11, 13, 14, 17	26.07
20	0.6	0.1	0.1	0.2	1, 3, 5, 10, 11, 13, 14, 17	26.67
21	**0.7**	**0.1**	**0.1**	**0.1**	**1, 3, 5, 10, 11, 13, 14, 17**	**26.82**
22	0.233	0.3	0.233	0.233	1, 3, 5, 10, 11, 13, 16, 17	16.21
23	0.2	0.4	0.2	0.2	1, 3, 5, 10, 11, 13, 16, 17	11.76
24	0.3	0.4	0.15	0.15	1, 3, 5, 10, 11, 13, 14, 17	12.14
25	0.15	0.4	0.3	0.15	1, 3, 5, 10, 11, 13, 16, 17	11.22
26	0.15	0.4	0.15	0.3	1, 3, 5, 10, 11, 13, 16, 17	12.12
27	0.36	0.4	0.12	0.12	1, 3, 5, 10, 11, 13, 14, 17	12.40
28	0.12	0.4	0.36	0.12	1, 3, 5, 10, 11, 13, 16, 17	10.89
29	0.12	0.4	0.12	0.36	1, 3, 5, 10, 11, 13, 16, 17	12.33
30	0.167	0.5	0.167	0.167	1, 3, 5, 10, 11, 13, 16, 17	7.30
31	0.25	0.5	0.125	0.125	1, 3, 5, 10, 11, 13, 14, 17	7.61
32	0.125	0.5	0.25	0.125	1, 3, 5, 10, 11, 13, 16, 17	6.84
33	0.125	0.5	0.125	0.25	1, 3, 5, 10, 11, 13, 16, 17	7.60
34	0.3	0.5	0.1	0.1	1, 3, 5, 10, 11, 13, 14, 17	7.84
35	0.1	0.5	0.3	0.1	1, 3, 5, 10, 11, 13, 16, 17	6.58
36	0.1	0.5	0.1	0.3	1, 3, 5, 10, 11, 13, 16, 17	7.78
37	0.133	0.6	0.133	0.133	1, 3, 5, 10, 11, 13, 17	3.25
38	0.2	0.6	0.1	0.1	1, 3, 5, 10, 11, 13, 17	3.47
39	0.1	0.6	0.2	0.1	1, 3, 5, 10, 11, 13, 17	2.84
40	0.1	0.6	0.1	0.2	1, 3, 5, 10, 11, 13, 17	3.44
41	**0.1**	**0.7**	**0.1**	**0.1**	**1, 10**	**0.53**
42	0.233	0.233	0.3	0.233	1, 3, 5, 10, 11, 13, 16, 17	18.95
43	0.2	0.2	0.4	0.2	1, 3, 5, 10, 11, 13, 16, 17	19.96
44	0.3	0.15	0.4	0.15	1, 3, 5, 6, 10, 11, 13, 17	22.24
45	0.15	0.3	0.4	0.15	1, 3, 5, 10, 11, 13, 16, 17	15.32
46	0.15	0.15	0.4	0.3	1, 3, 5, 10, 11, 13, 16, 17	22.37

The highest objective function value

The lowest objective function value

No	Criteria				Selected strategies	Objective function value
	Normalized Relative Technical Importance	Investment Cost	Benefit Value	Feasibility to be implemented		
47	0.36	0.12	0.4	0.12	1, 3, 5, 6, 10, 11, 13, 17	23.71
48	0.12	0.36	0.4	0.12	1, 3, 5, 10, 11, 13, 16, 17	12.53
49	0.12	0.12	0.4	0.36	1, 3, 5, 10, 11, 13, 16, 17	23.81
50	0.167	0.167	0.5	0.167	1, 3, 5, 10, 11, 13, 16, 17	20.96
51	0.25	0.125	0.5	0.125	1, 3, 5, 6, 10, 11, 13, 17	22.87
52	0.125	0.25	0.5	0.125	1, 3, 5, 10, 11, 13, 16, 17	17.10
53	0.125	0.125	0.5	0.25	1, 3, 5, 10, 11, 13, 16, 17	22.97
54	0.3	0.1	0.5	0.1	1, 3, 5, 6, 10, 11, 13, 17	24.09
55	0.1	0.3	0.5	0.1	1, 3, 5, 10, 11, 13, 16, 17	14.78
56	0.1	0.1	0.5	0.3	1, 3, 5, 10, 11, 13, 16, 17	24.18
57	0.133	0.133	0.6	0.133	1, 3, 5, 10, 11, 13, 16, 17	21.97
58	0.2	0.1	0.6	0.1	1, 3, 5, 6, 10, 11, 13, 17	23.49
59	0.1	0.2	0.6	0.1	1, 3, 5, 10, 11, 13, 16, 17	18.88
60	0.1	0.1	0.6	0.2	1, 3, 5, 10, 11, 13, 16, 17	23.58
61	0.1	0.1	0.7	0.1	1, 3, 5, 10, 11, 13, 16, 17	22.98
62	0.233	0.233	0.233	0.3	1, 3, 5, 10, 11, 13, 16, 17	19.35
63	0.2	0.2	0.2	0.4	1, 3, 5, 10, 11, 13, 16, 17	21.16
64	0.3	0.15	0.15	0.4	1, 3, 5, 10, 11, 13, 16, 17	23.68
65	0.15	0.3	0.15	0.4	1, 3, 5, 10, 11, 13, 16, 17	16.82
66	0.15	0.15	0.3	0.4	1, 3, 5, 10, 11, 13, 16, 17	22.97
67	0.36	0.12	0.12	0.4	1, 3, 5, 10, 11, 13, 14, 17	25.28
68	0.12	0.36	0.12	0.4	1, 3, 5, 10, 11, 13, 16, 17	14.21
69	0.12	0.12	0.36	0.4	1, 3, 5, 10, 11, 13, 16, 17	24.05
70	0.167	0.167	0.167	0.5	1, 3, 5, 10, 11, 13, 16, 17	22.96
71	0.25	0.125	0.125	0.5	1, 3, 5, 10, 11, 13, 16, 17	25.07
72	0.125	0.25	0.125	0.5	1, 3, 5, 10, 11, 13, 16, 17	19.35
73	0.125	0.125	0.25	0.5	1, 3, 5, 10, 11, 13, 16, 17	24.47
74	0.3	0.1	0.1	0.5	1, 3, 5, 10, 11, 13, 16, 17	26.33
75	0.1	0.3	0.1	0.5	1, 3, 5, 10, 11, 13, 16, 17	17.18
76	0.1	0.1	0.3	0.5	1, 3, 5, 10, 11, 13, 16, 17	25.38
77	0.133	0.133	0.133	0.6	1, 3, 5, 10, 11, 13, 16, 17	24.77
78	0.2	0.1	0.1	0.6	1, 3, 5, 10, 11, 13, 16, 17	26.46
79	0.1	0.2	0.1	0.6	1, 3, 5, 10, 11, 13, 16, 17	21.88
80	0.1	0.1	0.2	0.6	1, 3, 5, 10, 11, 13, 16, 17	25.98
81	0.1	0.1	0.1	0.7	1, 3, 5, 10, 11, 13, 16, 17	26.58
82	0.1	0.1	0.4	0.4	1, 3, 5, 10, 11, 13, 16, 17	24.78
83	0.1	0.4	0.1	0.4	1, 3, 5, 10, 11, 13, 16, 17	12.48
84	0.1	0.4	0.4	0.1	1, 3, 5, 10, 11, 13, 16, 17	10.68
85	0.2	0.2	0.3	0.3	1, 3, 5, 10, 11, 13, 16, 17	20.56
86	0.2	0.3	0.2	0.3	1, 3, 5, 10, 11, 13, 16, 17	16.46
87	0.2	0.3	0.3	0.2	1, 3, 5, 10, 11, 13, 16, 17	15.86
88	0.3	0.3	0.2	0.2	1, 3, 5, 10, 11, 13, 14, 17	16.44
89	0.3	0.2	0.3	0.2	1, 3, 5, 10, 11, 13, 14, 17	20.44
90	0.3	0.2	0.2	0.3	1, 3, 5, 10, 11, 13, 14, 17	21.04
91	0.4	0.4	0.1	0.1	1, 3, 5, 10, 11, 13, 14, 17	12.58
92	0.4	0.1	0.4	0.1	1, 3, 5, 6, 10, 11, 13, 17	24.68
93	0.4	0.1	0.1	0.4	1, 3, 5, 10, 11, 13, 14, 17	26.38
94	0.1	0.3	0.3	0.3	1, 3, 5, 10, 11, 13, 16, 17	15.98
95	0.3	0.3	0.3	0.1	1, 3, 5, 6, 10, 11, 13, 17	15.89
96	0.3	0.3	0.1	0.3	1, 3, 5, 10, 11, 13, 14, 17	17.04
97	0.3	0.1	0.3	0.3	1, 3, 5, 10, 11, 13, 16, 17	25.13

Table 5.8: Results of the sensitivity analysis for the large sized company (Trung Nguyen Coffee Company)

No	Criteria				Selected strategies	Objective function value
	Normalized Relative Technical Importance	Investment Cost	Benefit Value	Feasibility to be implemented		
1	0.25	0.25	0.25	0.25	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	27.43
2	0.3	0.233	0.233	0.233	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	28.25
3	0.4	0.2	0.2	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	29.88
4	0.4	0.3	0.15	0.15	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	22.63
5	0.4	0.15	0.3	0.15	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	33.13
.6	0.4	0.15	0.15	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	33.88
7	0.4	0.36	0.12	0.12	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	18.28
8	0.4	0.12	0.36	0.12	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.08
9	0.4	0.12	0.12	0.36	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.28
10	0.5	0.167	0.167	0.167	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	31.52
11	0.5	0.25	0.125	0.125	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	25.48
12	0.5	0.125	0.25	0.125	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	34.23
13	0.5	0.125	0.125	0.25	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	34..86
14	0.5	0.3	0.1	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	21.86
15	0.5	0.1	0.3	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.86
16	0.5	0.1	0.1	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.86
17	0.6	0.133	0.133	0.133	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	33.16
18	0.6	0.2	0.1	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	28.33
19	0.6	0.1	0.2	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.33
20	0.6	0.1	0.1	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.83
21	0.7	0.1	0.1	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	34.80
22	0.233	0.3	0.233	0.233	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	23.93
23	0.2	0.4	0.2	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	16.94
24	0.3	0.4	0.15	0.15	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	16.16
25	0.15	0.4	0.3	0.15	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	16.96
26	0.15	0.4	0.15	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	17.71
27	0.36	0.4	0.12	0.12	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	15.70
28	0.12	0.4	0.36	0.12	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	16.97
29	0.12	0.4	0.12	0.36	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	18.17
30	0.167	0.5	0.167	0.167	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	9.95
31	0.25	0.5	0.125	0.125	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	9.30
32	0.125	0.5	0.25	0.125	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	9.96
33	0.125	0.5	0.125	0.25	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	10.59
34	0.3	0.5	0.1	0.1	1, 3, 5, 8, 10, 11, 12, 13, 14 16, 17	8.96
35	0.1	0.5	0.3	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	9.97
36	0.1	0.5	0.1	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	10.97
37	0.133	0.6	0.133	0.133	1, 5, 8, 10, 11, 12, 13, 14 16, 17	3.47
38	0.2	0.6	0.1	0.1	1, 5, 8, 10, 11, 13, 14 16, 17	3.07
39	0.1	0.6	0.2	0.1	1, 5, 8, 10, 11, 12, 13, 14 16, 17	3.45
40	0.1	0.6	0.1	0.2	1, 5, 8, 10, 11, 12, 13, 14 16, 17	3.95
41	**0.1**	**0.7**	**0.1**	**0.1**	**1, 10**	**0.6**
42	0.233	0.233	0.3	0.233	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	28.60
43	0.2	0.2	0.4	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	30.94
44	0.3	0.15	0.4	0.15	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	33.66
45	0.15	0.3	0.4	0.15	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	23.96
46	0.15	0.15	0.4	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.21

The lowest objective function value

No	Criteria				Selected strategies	Objective function value
	Normalized Relative Technical Importance	Investment Cost	Benefit Value	Feasibility to be implemented		
47	0.36	0.12	0.4	0.12	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.30
48	0.12	0.36	0.4	0.12	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	19.77
49	0.12	0.12	0.4	0.36	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.77
50	0.167	0.167	0.5	0.167	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	33.29
51	0.25	0.125	0.5	0.125	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.55
52	0.125	0.25	0.5	0.125	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	27.46
53	0.125	0.125	0.5	0.25	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.84
54	0.3	0.1	0.5	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.91
55	0.1	0.3	0.5	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	23.97
56	0.1	0.1	0.5	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	38.97
57	0.133	0.133	0.6	0.133	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.63
58	0.2	0.1	0.6	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.44
59	0.1	0.2	0.6	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	30.97
60	0.1	0.1	0.6	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	38.47
61	0.1	0.1	0.7	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.97
62	0.233	0.233	0.233	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	28.93
63	0.2	0.2	0.2	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	31.94
64	0.3	0.15	0.15	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	34.91
65	0.15	0.3	0.15	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	25.21
66	0.15	0.15	0.3	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	35.71
67	0.36	0.12	0.12	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.70
68	0.12	0.36	0.12	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	21.17
69	0.12	0.12	0.36	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.97
70	0.167	0.167	0.167	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	34.95
71	0.25	0.125	0.125	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.43
72	0.125	0.25	0.125	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	29.34
73	0.125	0.125	0.25	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	38.09
74	0.3	0.1	0.1	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	38.91
75	0.1	0.3	0.1	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	25.97
76	0.1	0.1	0.3	0.5	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	39.97
77	0.133	0.133	0.133	0.6	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.96
78	0.2	0.1	0.1	0.6	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	39.94
79	0.1	0.2	0.1	0.6	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	33.47
80	0.1	0.1	0.2	0.6	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	40.47
81	**0.1**	**0.1**	**0.1**	**0.7**	**1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17**	**40.97**
82	0.1	0.1	0.4	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	39.47
83	0.1	0.4	0.1	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	18.47
84	0.1	0.4	0.4	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	16.97
85	0.2	0.2	0.3	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	31.44
86	0.2	0.3	0.2	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	24.44
87	0.2	0.3	0.3	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	23.94
88	0.3	0.3	0.2	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	23.41
89	0.3	0.2	0.3	0.2	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	30.41
90	0.3	0.2	0.2	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	30.91
91	0.4	0.4	0.1	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	15.38
92	0.4	0.1	0.4	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	36.38
93	0.4	0.1	0.1	0.4	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.88
94	0.1	0.3	0.3	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	24.97
95	0.3	0.3	0.3	0.1	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	22.91
96	0.3	0.3	0.1	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	23.91
97	0.3	0.1	0.3	0.3	1, 4, 5, 8, 10, 11, 12, 13, 14 16, 17	37.91

The highest objective function value

5.2. Discussion and managerial implications considering the different company sizes

In this section, discussion about the similarities and differences between the results of the small sized and large sized companies is shown.

5.2.1. Suitable SCM strategies for both small sized and large sized companies

Based on the results in Table 5.7 and 5.8, SCM Strategies 1 (supplier selection), 5 (effective forecasting method), 10 (5S), 11 (Statistical Process Control), 13 (suitable delivery route), 16 (appropriate accounting systems), and 17 (effective maintenance method) are selected to be implemented commonly in both small sized and large sized companies. These strategies directly help improve supply chain capabilities, and subsequently improve competitive advantages and business performance.

To improve SCI under a limited budget of 7 billion VND for small sized and nearly 14 billion VND for large sized companies, appropriate common methods such as the Ranking and Scoring method for supplier selection should be implemented (Strategy 1). Companies can select suitable suppliers for each type of material, and subsequently build long term relationships with them. Through building long term relationships and communicating between supply chain partners, companies obtain timely and accurate information, allowing them to make better decisions on ordering, capacity allocations, and production and material planning (Koçoğlu et al., 2011).

Strategies 5, 10, 11, 13, 16, and 17 should be used for improving internal operations and distribution systems. Companies should focus on the improvement of manufacturing activities by using proper demand forecasting methods and software to accurately forecast the customer demand in advance (Strategy 5). Program of 5S (Strategy 10), including Seiri – Sorting out, Seiton – Storage, Seiso – Shining the workplace, Seiletsu – Setting standards, and Shitsuke – Sticking to the rule, should be implemented to improve basic work environment. In addition, companies should apply effective maintenance methods such as preventive maintenance to ensure that machines and equipment are well maintained and do not breakdown during operation (Strategy

17). Proper accounting systems or software (e.g., QuickBooks Accounting Software) should be used, so all costs can be accurately charged (Strategy 16). As a result, the product price can be established more correctly. In addition, effective quality control methods such as Statistical Process Control (SPC) or proper sampling plan should be implemented, to control product quality and detect defective units before leaking to the customers (Strategy 11). Suitable delivery route as a Vehicle Routing Problem (VRP) for delivering the products to customer needs to be calculated by effective software, systems, or methods, to reduce delivery time and minimize transportation cost (Strategy 13).

The results also reveal that Strategies 1 (supplier selection) and 10 (5S) are always chosen for all cases due to their low investment costs and high feasibility to be implemented. In addition, benefit value and feasibility are not sensitive criteria to be considered when choosing what strategy to be implemented for both small sized and large sized companies. There is only a slight difference when the companies consider these two objectives together with the technical importance.

5.2.2 Differences between small sized and large sized companies

The differences between the results of small sized and large sized companies are shown, in which different strategies are suggested to be implemented in different sizes of companies.

5.2.2.1 Results of the small sized companies

As discussed above, with difference from the case of the large sized company, SCI plays an important role for improving competitiveness and business performance in small sized companies. So, Strategy 3 (VMI) is also suggested for implementing to improve SCI. This strategy states that the role to inventory replenishment can be done by suppliers through Vendor Manage Inventory (VMI). So, inventory cost of the company can be reduced.

Based on the results in Table 5.7, when the company considers equal weight among four objectives, SCM Strategies 1 (supplier selection), 3 (VMI), 5 (effective forecasting method), 10 (5S), 11 (Statistical Process Control), 13 (suitable delivery route), 16 (appropriate accounting systems), and 17 (effective maintenance method) are selected to be implemented. When the companies pay more attention to minimizing investment costs, the findings suggest that Strategy 16 (appropriate accounting systems) is not recommended to be implemented, since this strategy is considered to be too expensive to be implemented. If the weight of cost jumps to the highest weight at 0.7, only Strategies 1 (supplier selection) and 10 (5S) are recommended. When the normalized relative technical importance is assigned at a higher level of weight, Strategy 14 (SMED and OTED) is chosen. It seems Strategy 14 (SMED and OTED) has high technical importance but it is expensive to be implemented, so it is only selected when the technical importance is regarded as high importance. The result also suggests that Strategies 2 (EDI), 4 (MRP and ERP), 7 (Job enlargement), 8 (recruitment), 9 (incentive program), 12 (international quality standards), and 15 (automation) have not been chosen for all cases. Because they are considered to be expensive to be implemented in this company as compared to other strategies.

5.2.2.2. Results of the large sized company

Supply Chain Operation (SCO) and Human Resource Management (HRM) plays an important role for large sized companies. A higher budget allows the companies utilize effective production planning and control systems such as Material Requirements Planning (MRP) System, and Enterprise Resource Planning (ERP), to assure that required materials are available when needed (Strategy 4). So, the production system can be done more effectively. Moreover, companies should obtain international quality standards such as ISO 9001, ISO 22000, HACCP for their products, to ensure that quality is consistently improved, and products consistently meet customer requirements (Strategy 12). Reducing set-up time by applying proper techniques, such as Single-Minute Exchange of Die (SMED) or One-Touch Exchange of Die (OTED), also should be done in the companies (Strategy 14).

Strategy 8, which focuses on improving staff recruitment process, is considered as useful for HRM in large sized company. A systematic job recruitment process should be implemented by carefully planning and using effective interview methods, such as structured interview and situational judgment tests that emphasize superior technical, problem solving, and interpersonal skills. This strategy helps to evaluate and select the right candidates to fill empty staff positions for increasing productivity and ensuring conformance to customer requirements (Youndt et al., 1996).

Based on the results in Table 5.8, when the company considers equal weight among four objectives, SCM Strategies 1 (supplier selection), 4 (MRP and ERP), 5 (effective forecasting method), 8 (recruitment), 10 (5S), 11 (Statistical Process Control), 12 (international quality standards), 13 (suitable delivery route), 14 (SMED and OTED), 16 (appropriate accounting systems), and 17 (effective maintenance method) are selected to be implemented. These strategies are also common solutions for all weighting situations. When the companies pay more attention to minimizing investment costs, the findings suggest that Strategy 4 is not recommended to be implemented, since Material Requirements Planning (MRP) System and Enterprise Resource Planning (ERP) are considered to be too expensive to be implemented. If the weight of cost jumps to the highest weight at 0.7, only Strategies 1 (supplier selection) and 10 (5S) are recommended. When the normalized relative technical importance is assigned at a high level of weight, Strategy 3 (VMI) is chosen. It seems that Strategy 3 has only high technical importance, but low benefit value and feasibility to be implemented. As a result, it is only selected when the weight of technical importance is regarded as very high.

Strategies 2 (EDI), 6 (JIT), 7 (Job enlargement), 9 (incentive program), and 15 (automation) have not been chosen for all cases. As mentioned above, choosing a suitable strategy depends on each company situation. In this case, even though Just-In-Time (JIT) is an effective system for operating, it may not be suitable and necessary to be implemented in Trung Nguyen Coffee Company. Due to the limited budget, Strategies 2 (EDI), 7 (Job enlargement), 9 (incentive program), and 15 (automation) are considered to be too expensive to be implemented in this company as compared to other strategies. So, these strategies have not been considered as essential tools for building supply chain capabilities for this company.

Chapter 6
Conclusions and Further Study

In this study, an integrated approach with SEM, Fuzzy-QFD, and MLP was proposed and adopted to select suitable SCM strategies and actions for improving business performance. Vietnamese food industry was used as a case study to demonstrate the methodology. SEM analysis was used to identify and test the relationships between supply chain capabilities and competitive advantages towards business performance. The Fuzzy-QFD matrixes were built to transform a company's competitiveness into SCM strategies through supply chain capabilities. Then, the MLP model was developed to optimize the objectives function value and select suitable SCM strategies and actions under a limited investment budget.

This has been shown to be an effective methodology due to the significant benefits it provides. SEM analysis allows to consider the relative importance of competitive advantages in the view of interested business performance. Also, using results from SEM analysis, the relative weight of competitive advantages, and the correlation scores between competitive advantages and supply chain capabilities can be considered both directly and indirectly, in which it cannot be done in the case of traditional weighting/scoring methods. The proposed methodology transforms significant relationships between supply chain capabilities, competitive advantages, and business performance into specific SCM strategies and actions. It provides a comprehensive integrated picture for companies to manage their supply chains and improve their business performance. Without considering the importance of such relationships, business strategies and actions could be implemented in a wrong direction, which may not be matched with the companies' capabilities and required competitive advantages. Without such an integration between SEM, Fuzzy-QFD, and MLP, suitable strategies and actions for building required supply chain capabilities and significant competitive advantages of the companies in each particular industry, cannot be identified and put into action. This proposed methodology also allows companies in each industry to obtain optimal solutions for selecting specific strategies according to their preference on the relative importance among conflicting criteria under a limited investment budget.

The results from SEM of the food industry in Vietnam strongly supported that supply chain capabilities play an important role to gain competitive advantages and differentiate companies from competitors. SCI can help to gain benefits such as improved quality, flexibility, and cost. Manufacturers should recognize the dual influence of system integration, i.e., not only on the implementation process, but also in generating competitive advantages to get better improvement. Manufacturers should improve their business performances by improving their operational level and human resource management, to get competitive advantages such as quality, delivery, and cost. In addition, the results of different sizes of the companies (small sized and large sized companies) indicate that in small sized companies, the role of HRM is not recognized as a critical variable, while in large sized companies, the role of SCI to improve quality and cost are partly ignored. Thus, Vietnamese food manufacturers are recommended to pay more attention to supply chain capabilities, which can help companies improve their competitiveness.

To gain the highest objective function value under a limited investment budget, certain strategies and actions are considered necessarily. In a normal situation for both small sized and large sized companies, to improve the supply chain integration, companies should select suitable suppliers and build close collaboration with them. Implementing effective forecasting software, effective accounting systems, 5S program, quality control method, suitable delivery systems, and efficient maintenance methods are considered beneficial for improving the companies' operations. It was also found that supplier selection and a 5S program are considered suitable for all situations due to their low investment cost.

The findings also suggest different strategies and actions for different sizes of the companies. For small sized companies, Vendor Manage Inventory (VMI) should be implemented to reduce inventory cost. While, for large sized companies, Material Requirements Planning (MRP) System and Enterprise Resource Planning (ERP) should be used for effectively planning and controlling production systems. In addition, proper techniques for improving flexibility are also needed, in order to improve company's competitiveness. HRM should be focused on improving the staff recruiting process, in order to select the best employees for vacant positions.

This study makes significant contributions by providing comprehensive understanding about relationships between SCM practices and business performance, and proposing a systematic methodology to select suitable SCM strategies and actions for the Vietnamese food industry. There are also some limitations and more opportunities for future research. The first limitation of this study is that the study only considers interested factors of supply chain capabilities, competitive advantages, and SCM strategies. Other factors such as innovation and time to market are also competitive advantages of manufacturers. Other related strategies also could be suggested for improving business performance. Further studies in the future can develop a research model by adding other variables as well as other effective strategies. Due to the limit of time and cost, the first survey was conducted in a short period of time (from January to April of 2015), so the data may not cover deeply the characteristics of this industry. In addition, the samples in this study were collected among manufacturing companies listed on the website (www.vn.report), in which not all manufacturing companies were listed. However, non-response bias has shown that it is not such a major problem. Lastly, there are also other industries, which can be seen as large sectors of contribution to the Vietnamese economy, i.e., electrical and electronic industries. Other researchers can also focus on these gaps and make comparison between different case studies, to have a deeper vision on this theme.

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Appendix A
Questionnaire

A.1 Questionnaire to assess the effect of firm's supply chain capabilities and competitive advantages toward business performance in Vietnamese Food industry.

The purpose of this questionnaire is to assess the importance of firm's supply chain capabilities and competitive advantages, as well as evaluate the relationships among various factors that affect the performance of the companies in the food supply chain. This will help to identify the relative importance of these factors towards the success of the companies. The questionnaire is divided into two parts:

Part 1: General Information

1. Company name ....
2. Name of respondent ....
   Position ....
3. Number of employees (persons):
   [ ] < 50 persons [ ] 50-100 persons [ ] 101-200 persons
   [ ] 201-500 persons [ ] 501-1000 persons [ ] > 1000 persons
4. Capital (VND):
   [ ] < 1 billion [ ] 1-10 billion [ ] 11-50 billion
   [ ] 51-100 billion [ ] 101-300 billion [ ] 301-500 billion
   [ ] > 500 billion
5. Net value of fixed assets (VND):
   [ ] < 1 billion [ ] 1-10 billion [ ] 11-50 billion
   [ ] 51-100 billion [ ] 101-300 billion [ ] 301-500 billion
   [ ] > 500 billion
6. Types of product:
   [ ] Meat and meat products [ ] Fresh and processed fruits and vegetables
   [ ] Cereal products [ ] Fishery products
   [ ] Spices and condiments [ ] Milk and milk products
   [ ] Sugar and sweetmeat [ ] Beverage
   [ ] Tea, coffee, cocoa [ ] Oil and fat
   [ ] Pet food products
   [ ] Supplements and other products ....

Part 2: Supply Chain Operations

Please evaluate firm operations according to current level.

Item	Supply Chain Integration	Level of your evaluation (1) Totally disagree	(2) Disagree	(3) Mediocrity	(4) Agree	(5) Totally agree
1	Your firm has a policy to build long-term relationships with key suppliers without changing them too often.					
2	Your firm has close and frequent communication with suppliers.					
3	Your firm has a computer network linking information with suppliers so that the information can be updated constantly.					
4	There is an exchange of important information such as production details, production level, and customer demand between the firm and its suppliers.					
5	Your firm and your suppliers always opt for an improvement and find a way to collaborate in problem solving.					

Item	Supply Chain Operation	Level of your evaluation				
		(1)	(2)	(3)	(4)	(5)
		Totally disagree	Disagree	Mediocrity	Agree	Totally agree
1	The firm has employed effective methods, tools, or systems to manage and control its inventory level/warehouse as the real customer demand can be accurately forecasted.					
2	Your firm is currently utilizing effective production planning and control systems such as Material Requirements Planning (MRP) System, Application and Products in Data Processing (SAP), and Enterprise Resource Planning (ERP) so the production control can be done effectively.					
3	Your firm has suitable methods and tools to manage the transportation routes to minimize the transportation costs under the required delivery time window (dead line).					
4	Your firm always uses the concept of Just-In-Time (JIT) and Lean Manufacturing System to produce the products, as the customer demand is used to drive raw material ordering and production processes.					
5	Your firm has employed an effective system to evaluate the strengths and weakness of each supplier so that the firm can select the suppliers for every material suitably.					

Item	Human Resource Management	Level of your evaluation (1) Totally disagree	(2) Disagree	(3) Mediocrity	(4) Agree	(5) Totally agree
1	Your firm has a capability to recruit and completely fill new staff positions as required by each division.					
2	Your firm can continuously maintain suitable training programs to improve the capability of the staff.					
3	Your firm can maintain capable staffs, as the incentives and benefits provided by the firm are fair and attractive.					
4	Your firm has an open mind and always listens to staff opinions, so a corporative and friendly working environment can be achieved.					
5	Every division of the firm contributes and takes part in all activities to strengthen the collaboration among divisions.					

Item	Competitive Advantages-Quality	Level of your evaluation				
		(1)	(2)	(3)	(4)	(5)
		Totally disagree	Disagree	Mediocrity	Agree	Totally agree
1	Your firm has made the product quality to be the first priority.					
2	Products manufactured from your firm have received certified national or international standards.					
3	Your firm has never received complaints from the customers about the quality of products during the past six months.					
4	Products of your firm have never been returned from the customers as defective units during the past six month.					
5	Your firm has been increasingly recognized for the quality of products from the customers.					

Item	Competitive Advantages-Delivery	Level of your evaluation (1) Totally disagree	(2) Disagree	(3) Mediocrity	(4) Agree	(5) Totally agree
1	Your firm is capable of forecasting and planning for its transportation resources effectively, such as always managing for suitable number of trucks, delivery staffs, etc.					
2	Your firm always delivers its products to customers within the due-date.					
3	Your firm has the ability to ship its products to customers accurately according to the purchasing orders.					
4	Your firm has never had to pay compensation due to the damage caused by the delivery.					
5	Your firm has a systematic system to issue complete and suitable delivered documents with each delivery so that the post-evaluation can be done readily and effectively.					

Item	Competitive Advantages-Flexibility	Level of your evaluation (1) Totally disagree	(2) Disagree	(3) Mediocrity	(4) Agree	(5) Totally agree
1	Production lot/batch sizes can be continuously reduced.					
2	Process set-up or change over time can be gradually reduced.					
3	Process cycle time can be continuously reduced.					
4	Your firm has the ability to quickly adjust its production plan according to urgent customer requirements.					
5	Your firm is capable of adjusting its production system to produce a variety of products.					

Item	Competitive Advantages-Cost	Level of your evaluation				
		(1)	(2)	(3)	(4)	(5)
		Totally disagree	Disagree	Mediocrity	Agree	Totally agree
1	Production cost of your firm can be continuously reduced.					
2	Transportation costs of your firm can be continuously reduced.					
3	Your firm can reduce its waste continuously.					
4	The firm’s inventory level can be continuously reduced.					
5	Your firm always utilizes its staffs effectively so there is no redundant staff.					

Item	Firm performance during the past 5 years	Level of your evaluation				
		Decrease significantly (1)	Decrease (2)	The same (3)	Increase (4)	Increase significantly (5)
1	Market share					
2	Sale revenue					
3	Production capacity					
4	Return on investment					
5	Profit as a percentage of sales					

The end.

Thank you very much for your kind cooperation in filling out your information!

A.2 Questionnaire to evaluate relationships between supply chain capabilities and business strategies

The purpose of this questionnaire is to evaluate relationships between supply chain capabilities and business strategies for building QFD matrix, which is used to suggest the best strategy for the Vietnamese Food Industry.

The questionnaire is divided into two parts, and please fill in your answer in each part.

Part 1: General Information

Name of respondent ....

Position ....

Part 2: Evaluation

Please evaluate your opinion about relationships between each of supply chain capabilities (Supply Chain Integration, Supply Chain Operation, and Human Resource Management) and each of business strategies, or how much each of business strategies explains or is related to each of supply chain capabilities. Definitions of supply chain capabilities are given below:

- ***Supply Chain Integration (SCI):*** refers to the group of capabilities that foster integration and coordination and knowledge sharing among functional-groups in the chain.

- ***Supply Chain Operation Management (SCO):*** refers to the group of capabilities that help the operations and control of systems for manufacturing, inventory management, and distribution of products.

- ***Human Resource Management (HRM)***: refers to the group of capabilities that build the organization performance capacity by raising human capital to ensure that highly capable and enthusiastic people are always available (e.g., recruiting, incentive, training).

Guideline of linguistic terms has been provided to assist your judgment:

	(1)	(2)	(3)	(4)	(5)
Linguistic terms	Very low relationship	Low relationship	Medium relationship	High relationship	Very high relationship

Please mark (X) over the level 1 – 5 of the relationships between each of supply chain capabilities (Supply Chain Integration, Supply Chain Operation, and Human Resource Management) and each of strategies.

Item	Supply Chain Strategy	Factor Evaluation		
		Supply Chain Integration	Supply Chain Operation	Human Resource Management
1	In order to select a suitable supplier and build a long term relationship with them, their strengths and weaknesses are continuously considered through a proper selection method such as the Ranking and Scoring method to select the best supplier to buy each type of material.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
2	Information sharing of customer demand, production level, or inventory status with suppliers and customers should be done electronically through on-line systems, such as Electronic Data Interchange (EDI), so that information can be updated instantly.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
3	The role to inventory replenishment of your firm can be done by your suppliers so that your suppliers take full responsibility, to replenish inventory of your firm both on time and accurately through Vendor Manage Inventory (VMI), thereby inventory cost can be reduced.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
4	Production planning and control should be done by effective systems such as Material Requirements Planning (MRP), and Enterprise Resource Planning (ERP), to assure that required materials are available when needed, so that the production system can be done more effectively.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
5	Proper demand forecasting methods/software should be used to accurately forecast the customer demand in advance, so that production planning can be done more effectively.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
6	Just-In-Time (JIT), in which materials and products are received only as they are needed, should be implemented, so that production flow time as well as response times from suppliers to customers can be reduced, thereby reducing inventory costs.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)

Item	Supply Chain Strategy	Factor Evaluation		
		Supply Chain Integration	Supply Chain Operation	Human Resource Management
7	Implementing both vertical job enlargement (employees are trained and assigned a higher level of responsibility for their job) and horizontal job enlargement (employees are trained and assigned more job duties and responsibilities) should be simultaneously done so that employee skills can be further improved.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
8	Systematic job recruitment should be implemented by carefully planning and using effective interview methods (structured interview, situational judgment tests), to evaluate and select the right candidates, so that empty staff positions can be filled effectively.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
9	Incentive programs such as bonuses, profit sharing, and welfare should be implemented to motivate and improve employee productivity, as well as maintain them with the firm for a long time.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
10	Program of 5S (Seiri – Sorting out, Seiton – Storage, Seiso – Shining the workplace, Seiletsu – Setting standards, and Shitsuke – Sticking to the rule) should be implemented, to improve work the environment, as well as a firm's productivity.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
11	Quality control should be implemented by effective systems/methods such as Statistical Process Control (SPC) or proper sampling plan, so that defective units can be detected before leaking to the customers.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
12	International quality standard such as ISO 9001, ISO 22000, HACCP should be implemented, to ensure that quality is consistently improved, and products consistently meet customer requirements.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)

Item	Supply Chain Strategy	Factor Evaluation		
		Supply Chain Integration	Supply Chain Operation	Human Resource Management
13	Suitable delivery route in Vehicle Routing Problem (VRP) to deliver the products to customers, needs to be calculated by effective software/systems/methods, so that the delivery can be done with shorter delivery time and minimum cost.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
14	Production batch size can be reduced by proper techniques such as Single-Minute Exchange of Die (SMED) or One-Touch Exchange of Die (OTED), as the machine set-up time need to be reduced.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
15	Advanced Manufacturing Systems and Automation should be implemented, so that more automated equipment can replace traditional manual equipment. As a result, the system becomes more reliable and flexible.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
16	Proper accounting systems/software (e.g., QuickBooks Accounting Software) should be done so that all costs can be accurately charged. As a result, the product price can be established more correctly.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
17	Effective maintenance methods such as Preventive Maintenance need to be implemented so that machines and equipment are well maintained and do not breakdown during operation.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)

Thank you very much for your kind cooperation in filling out your information!

A.3 Questionnaire to evaluate criteria used for building business actions and strategies in the Vietnamese food industry

Following the previous work that investigates the relationships between supply chain capabilities and competitive advantages towards business performance, the purpose of this questionnaire is to evaluate criteria, which are considered to build proper business actions and strategies for the Vietnamese food industry.

The questionnaire is divided into two parts, and please fill in your answer in each part.

Part 1: General Information

1. Company name ....
2. Name of respondent ....
   Position ....

Part 2: Evaluation

Please evaluate your expected investment cost, benefit values, and potential as well as feasibility to implement such actions and strategies. Definitions of these terms are given below:

Investment cost: Estimated investment expense if your firm has to proceed with each action from very low (1) to very high (5) investment cost.

Benefit value: This is the benefit that could gain from implementing such actions. This benefit value can be calculated from the amount of cost reduction if that action can help to reduce the costs, or the amount of increasing revenue if it can help to increase the current sales and hence increase the revenue. High percentage value indicates more costs can be reduced or more revenue can be gained in relation to your current level of costs or revenue.

Feasibility to implement: Providing the benefit and drawback of each action, this is to evaluate the feasibility to implement such actions in your organization.

Guideline of approximate range has been provided to assist your judgment:

Criteria	(1)	(2)	(3)	(4)	(5)
Investment costs (VND)	< 200 million	200 - 500 million	500 million - 2 billion	2 - 5 billion	> 5 billion
Benefit value as revenue increment or cost reduction	None	< 10%	10 - 20 %	20 - 30%	> 30 %
Feasibility to implement	Maybe impossible	Possible with some difficulty	Likely possible	Totally possible	A must, and vital to implement

Please mark (X) over the level 1 – 5 of each criterion (Investment costs, Benefit value, and Feasibility) that matches with your potential expectation.

Item	Supply Chain Strategy	Criteria Evaluation		
		Investment Costs	Benefit Value	Feasibility to implement
1	In order to select a suitable supplier and build a long term relationship with them, their strengths and weaknesses are continuously considered through a proper selection method such as the Ranking and Scoring method to select the best supplier to buy each type of material.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
2	Information sharing of customer demand, production level, or inventory status with suppliers and customers should be done electronically through on-line systems, such as Electronic Data Interchange (EDI), so that information can be updated instantly.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
3	The role to inventory replenishment of your firm can be done by your suppliers so that your suppliers take full responsibility, to replenish inventory of your firm both on time and accurately through Vendor Manage Inventory (VMI), thereby inventory cost can be reduced.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
4	Production planning and control should be done by effective systems such as Material Requirements Planning (MRP), and Enterprise Resource Planning (ERP), to assure that required materials are available when needed, so that the production system can be done more effectively.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
5	Proper demand forecasting methods/software should be used to accurately forecast the customer demand in advance, so that production planning can be done more effectively.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)

Item	Supply Chain Strategy	Criteria Evaluation		
		Investment Costs	Benefit Value	Feasibility to implement
6	Just-In-Time (JIT), in which materials and products are received only as they are needed, should be implemented, so that production flow time as well as response times from suppliers to customers can be reduced, thereby reducing inventory costs.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
7	Implementing both vertical job enlargement (employees are trained and assigned a higher level of responsibility for their job) and horizontal job enlargement (employees are trained and assigned more job duties and responsibilities) should be simultaneously done so that employee skills can be further improved.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
8	Systematic job recruitment should be implemented by carefully planning and using effective interview methods (structured interview, situational judgment tests), to evaluate and select the right candidates, so that empty staff positions can be filled effectively.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
9	Incentive programs such as bonuses, profit sharing, and welfare should be implemented to motivate and improve employee productivity, as well as maintain them with the firm for a long time.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
10	Program of 5S (Seiri – Sorting out, Seiton – Storage, Seiso – Shining the workplace, Seiletsu – Setting standards, and Shitsuke – Sticking to the rule) should be implemented, to improve work the environment, as well as a firm's productivity.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
11	Quality control should be implemented by effective systems/methods such as Statistical Process Control (SPC) or proper sampling plan, so that defective units can be detected before leaking to the customers.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)

Item	Supply Chain Strategy	Criteria Evaluation		
		Investment Costs	Benefit Value	Feasibility to implement
12	International quality standard such as ISO 9001, ISO 22000, HACCP should be implemented, to ensure that quality is consistently improved, and products consistently meet customer requirements.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
13	Suitable delivery route in Vehicle Routing Problem (VRP) to deliver the products to customers, needs to be calculated by effective software/systems/methods, so that the delivery can be done with shorter delivery time and minimum cost.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
14	Production batch size can be reduced by proper techniques such as Single-Minute Exchange of Die (SMED) or One-Touch Exchange of Die (OTED), as the machine set-up time need to be reduced.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
15	Advanced Manufacturing Systems and Automation should be implemented, so that more automated equipment can replace traditional manual equipment. As a result, the system becomes more reliable and flexible.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
16	Proper accounting systems/software (e.g., QuickBooks Accounting Software) should be done so that all costs can be accurately charged. As a result, the product price can be established more correctly.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)
17	Effective maintenance methods such as Preventive Maintenance need to be implemented so that machines and equipment are well maintained and do not breakdown during operation.	(1)	(1)	(1)
		(2)	(2)	(2)
		(3)	(3)	(3)
		(4)	(4)	(4)
		(5)	(5)	(5)

Thank you very much for your kind cooperation in filling out your information!

Appendix B
Two-step procedure of SEM analysis

B.1 Measurement model analysis

The relationships between latent variables and their indicators are tested, to delete the weak relationships and add new strong relationships. The first result, which is before deleting and adding, are shown from Figure B-1 to B-10.

Step 1: Reviewing the chi-square test

The chi-square test provides a statistic test of the null hypothesis that the model fit the data. If the model provides a good fit, the chi-square value will be relative small and the corresponding p value will be relatively large. In the case of accepting fit, the chi-square ratio (X^2/df) should be less than 3.

$$\frac{Chi\text{-}square}{df} = \frac{1{,}599}{712} = 2.25 \qquad \text{(see M1, Figure B-1)}$$

The ratio for the measurement model is 2.25, indicating an acceptable fit.

Step 2: Reviewing the Non-Normed Fit Index and the Comparative Fit Index

The Non-Normed Fit Index, or NNFI, and the Comparative Fit Index, or CFI, are the identification about overall goodness of fit indices. Value over 0.9 on the NNFI and CFI indicate an acceptable fit.

The Comparative Fit Index shown in Figure B-1 (M2) is 0.9027. The Non-Normed Fit Index (M3) is 0.8983, which is less than 0.9, so this value is unacceptable.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	5.4419	
Goodness of Fit Index (GFI)	0.7876	
GFI Adjusted for Degrees of Freedom (AGFI)	0.7554	
Root Mean Square Residual (RMR)	0.0307	M1
Standardized Root Mean Square Residual (SRMR)	0.0486	
Parsimonious GFI (Mulaik, 1989)	0.7190	
Chi-Square	1599.9284	
Chi-Square DF	712	
Pr > Chi-Square	<.0001	
Independence Model Chi-Square	10345	
Independence Model Chi-Square DF	780	
RMSEA Estimate	0.0651	
RMSEA 90% Lower Confidence Limit	0.0609	
RMSEA 90% Upper Confidence Limit	0.0694	
ECVI Estimate	6.2957	
ECVI 90% Lower Confidence Limit	5.8956	M2
ECVI 90% Upper Confidence Limit	6.7266	
Probability of Close Fit	0.0000	
Bentler's Comparative Fit Index	0.9072	
Normal Theory Reweighted LS Chi-Square	1585.5706	
Akaike's Information Criterion	175.9284	
Bozdogan's (1987) CAIC	-3161.1980	M3
Schwarz's Bayesian Criterion	-2449.1980	
McDonald's (1989) Centrality	0.2220	
Bentler & Bonett's (1980) Non-normed Index	0.8983	
Bentler & Bonett's (1980) NFI	0.8453	
James, Mulaik, & Brett (1982) Parsimonious NFI	0.7716	
Z-Test of Wilson & Hilferty (1931)	17.5539	
Bollen (1986) Normed Index Rho1	0.8306	
Bollen (1988) Non-normed Index Delta2	0.9078	
Hoelter's (1983) Critical N	144	

Figure B-1: Output 1 of the measurement model result

Step 3: Reviewing the significance tests for factor loading

The factor loadings are equivalent to path coefficients from latent factors to their indicator variables. Therefore, an insignificant factor loading means that the involved indicator variable is not doing a good job for measuring the underlying factor, and should be reassigned or dropped. The *t*-value explains about the significance of path coefficients from latent factors to their indicator variables. The factor loadings are significant when *t*-values are greater than 1.96 at $p < 0.05$, 2.576 at $p < 0.01$, or 3.291 at $p < 0.001$.

All *t*-values, which are shown in Figure B-2, are greater than 3.219 at $p < 0.001$. The standardized factor loadings are shown in Figure B-3. All standardized factor loadings are higher than 0.6.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
V1         =    0.7123*F1       +  1.0000 E1
Std Err         0.0408 LV1F1
t Value        17.4464
V2         =    0.7733*F1       +  1.0000 E2
Std Err         0.0433 LV2F1
t Value        17.8473
V3         =    0.5161*F1       +  1.0000 E3
Std Err         0.0363 LV3F1
t Value        14.2351
V4         =    0.6830*F1       +  1.0000 E4
Std Err         0.0396 LV4F1
t Value        17.2281
V5         =    0.6270*F1       +  1.0000 E5
Std Err         0.0384 LV5F1
t Value        16.3251
V6         =    0.5968*F2       +  1.0000 E6
Std Err         0.0379 LV6F2
t Value        15.7651
V7         =    0.7607*F2       +  1.0000 E7
Std Err         0.0438 LV7F2
t Value        17.3749
V8         =    0.6808*F2       +  1.0000 E8
Std Err         0.0393 LV8F2
t Value        17.3422
V9         =    0.7986*F2       +  1.0000 E9
Std Err         0.0450 LV9F2
t Value        17.7561
V10        =    0.5685*F2       +  1.0000 E10
Std Err         0.0387 LV10F2
t Value        14.6898
V11        =    0.4971*F3       +  1.0000 E11
Std Err         0.0325 LV11F3
t Value        15.2918
V12        =    0.6402*F3       +  1.0000 E12
Std Err         0.0400 LV12F3
t Value        15.9861
V13        =    0.6248*F3       +  1.0000 E13
Std Err         0.0381 LV13F3
t Value        16.3874
V14        =    0.6168*F3       +  1.0000 E14
Std Err         0.0404 LV14F3
t Value        15.2558
V15        =    0.6091*F3       +  1.0000 E15
Std Err         0.0386 LV15F3
t Value        15.8007
V16        =    0.7698*F4       +  1.0000 E16
Std Err         0.0460 LV16F4
t Value        16.7193
V17        =    0.7258*F4       +  1.0000 E17
Std Err         0.0417 LV17F4
t Value        17.3886
V18        =    0.5791*F4       +  1.0000 E18
Std Err         0.0417 LV18F4
t Value        13.9003
V19        =    0.7063*F4       +  1.0000 E19
Std Err         0.0420 LV19F4
t Value        16.8185
V20        =    0.6592*F4       +  1.0000 E20
Std Err         0.0386 LV20F4
t Value        17.0976
V21        =    0.6459*F5       +  1.0000 E21
Std Err         0.0352 LV21F5
t Value        18.3321
```

```
V22        =    0.4517*F5        +   1.0000 E22
Std Err         0.0377 LV22F5
t Value        11.9950
V23        =    0.4968*F5        +   1.0000 E23
Std Err         0.0361 LV23F5
t Value        13.7435
V24        =    0.5363*F5        +   1.0000 E24
Std Err         0.0427 LV24F5
t Value        12.5565
V25        =    0.6647*F5        +   1.0000 E25
Std Err         0.0365 LV25F5
t Value        18.2159
V26        =    0.5915*F6        +   1.0000 E26
Std Err         0.0482 LV26F6
t Value        12.2793
V27        =    0.5617*F6        +   1.0000 E27
Std Err         0.0435 LV27F6
t Value        12.9278
V28        =    0.5712*F6        +   1.0000 E28
Std Err         0.0488 LV28F6
t Value        11.7094
V29        =    0.4608*F6        +   1.0000 E29
Std Err         0.0371 LV29F6
t Value        12.4102
V30        =    0.4399*F6        +   1.0000 E30
Std Err         0.0326 LV30F6
t Value        13.4804
V31        =    0.7386*F7        +   1.0000 E31
Std Err         0.0399 LV31F7
t Value        18.4894
V32        =    0.6203*F7        +   1.0000 E32
Std Err         0.0412 LV32F7
t Value        15.0457
V33        =    0.4631*F7        +   1.0000 E33
Std Err         0.0390 LV33F7
t Value        11.8800
V34        =    0.5313*F7        +   1.0000 E34     M4
Std Err         0.0361 LV34F7
t Value        14.7059
V35        =    0.6003*F7        +   1.0000 E35
Std Err         0.0380 LV35F7
t Value        15.7873
V36        =    0.7519*F8        +   1.0000 E36
Std Err         0.0391 LV36F8
t Value        19.2238
V37        =    0.8622*F8        +   1.0000 E37
Std Err         0.0425 LV37F8
t Value        20.2755
V38        =    0.6901*F8        +   1.0000 E38
Std Err         0.0392 LV38F8
t Value        17.6209
V39        =    0.6664*F8        +   1.0000 E39
Std Err         0.0367 LV39F8
t Value        18.1508
V40        =    0.6823*F8        +   1.0000 E40
Std Err         0.0386 LV40F8
t Value        17.6823
```

Figure B-2: Output 2 of the measurement model result

```
                        The CALIS Procedure
  Covariance Structure Analysis: Maximum Likelihood Estimation

     Manifest Variable Equations with Standardized Estimates

V1     =   0.8374*F1     +   0.5466 E1
                  LV1F1
V2     =   0.8495*F1     +   0.5276 E2
                  LV2F1
V3     =   0.7291*F1     +   0.6844 E3
                  LV3F1
V4     =   0.8306*F1     +   0.5568 E4
                  LV4F1
V5     =   0.8019*F1     +   0.5975 E5
                  LV5F1
V6     =   0.7816*F2     +   0.6237 E6
                  LV6F2
V7     =   0.8336*F2     +   0.5523 E7
                  LV7F2
V8     =   0.8326*F2     +   0.5538 E8
                  LV8F2
V9     =   0.8452*F2     +   0.5344 E9
                  LV9F2
V10    =   0.7441*F2     +   0.6681 E10
                  LV10F2
V11    =   0.7706*F3     +   0.6373 E11
                  LV11F3
V12    =   0.7943*F3     +   0.6075 E12
                  LV12F3
V13    =   0.8076*F3     +   0.5898 E13
                  LV13F3
V14    =   0.7694*F3     +   0.6388 E14
                  LV14F3
V15    =   0.7881*F3     +   0.6156 E15
                  LV15F3
V16    =   0.8131*F4     +   0.5821 E16
                  LV16F4
V17    =   0.8341*F4     +   0.5516 E17
                  LV17F4
V18    =   0.7149*F4     +   0.6992 E18
                  LV18F4
V19    =   0.8163*F4     +   0.5777 E19
                  LV19F4
V20    =   0.8251*F4     +   0.5650 E20
                  LV20F4
V21    =   0.8686*F5     +   0.4955 E21
                  LV21F5
V22    =   0.6447*F5     +   0.7644 E22
                  LV22F5
V23    =   0.7147*F5     +   0.6994 E23
                  LV23F5
V24    =   0.6680*F5     +   0.7442 E24
                  LV24F5
V25    =   0.8652*F5     +   0.5015 E25
                  LV25F5
V26    =   0.6770*F6     +   0.7360 E26
                  LV26F6
V27    =   0.7041*F6     +   0.7101 E27
                  LV27F6
V28    =   0.6525*F6     +   0.7578 E28
                  LV28F6
V29    =   0.6825*F6     +   0.7308 E29
                  LV29F6
V30    =   0.7265*F6     +   0.6872 E30
                  LV30F6
V31    =   0.8728*F7     +   0.4882 E31
                  LV31F7
V32    =   0.7621*F7     +   0.6474 E32
                  LV32F7
V33    =   0.6395*F7     +   0.7688 E33
                  LV33F7
V34    =   0.7500*F7     +   0.6614 E34
                  LV34F7
V35    =   0.7878*F7     +   0.6160 E35
                  LV35F7
V36    =   0.8836*F8     +   0.4683 E36
                  LV36F8
V37    =   0.9117*F8     +   0.4109 E37
                  LV37F8
V38    =   0.8372*F8     +   0.5469 E38
                  LV38F8
V39    =   0.8530*F8     +   0.5219 E39
                  LV39F8
V40    =   0.8391*F8     +   0.5440 E40
                  LV40F8
```

M5

Figure B-3: Output 3 of the measurement model result

Step 4: Normalized residual matrix

The model provides a good fit to the data when the distribution of normalized residual is centered on zero, symmetrical, and contains no or few large residuals. The distribution of normalized residual of the measurement model is nearly symmetrical and centers near zero, but some residuals are too large (Figure B-4).

Distribution of Asymptotically Standardized Residuals

Each * Represents 3 Residuals

----------Range---------		Freq	Percent	
-5.25000	-5.00000	1	0.12	
-5.00000	-4.75000	2	0.24	
-4.75000	-4.50000	3	0.37	*
-4.50000	-4.25000	1	0.12	
-4.25000	-4.00000	3	0.37	*
-4.00000	-3.75000	4	0.49	*
-3.75000	-3.50000	6	0.73	**
-3.50000	-3.25000	5	0.61	*
-3.25000	-3.00000	9	1.10	***
-3.00000	-2.75000	9	1.10	***
-2.75000	-2.50000	14	1.71	****
-2.50000	-2.25000	15	1.83	*****
-2.25000	-2.00000	30	3.66	**********
-2.00000	-1.75000	26	3.17	********
-1.75000	-1.50000	22	2.68	*******
-1.50000	-1.25000	39	4.76	*************
-1.25000	-1.00000	37	4.51	************
-1.00000	-0.75000	36	4.39	************
-0.75000	-0.50000	45	5.49	***************
-0.50000	-0.25000	60	7.32	********************
-0.25000	0	47	5.73	***************
0	0.25000	78	9.51	**************************
0.25000	0.50000	43	5.24	**************
0.50000	0.75000	38	4.63	************
0.75000	1.00000	28	3.41	*********
1.00000	1.25000	36	4.39	************
1.25000	1.50000	36	4.39	************
1.50000	1.75000	28	3.41	*********
1.75000	2.00000	27	3.29	*********
2.00000	2.25000	16	1.95	*****
2.25000	2.50000	16	1.95	*****
2.50000	2.75000	11	1.34	***
2.75000	3.00000	11	1.34	***
3.00000	3.25000	7	0.85	**
3.25000	3.50000	10	1.22	***

Figure B-4: Output 4 of the measurement model result

Step 5: The Wald test

The Wald test estimates the change in model chi-square that would result from fixing a given parameter at zero. In this case, there is no Wald's test result, which means that there is no suggestion of dropping any parameter.

Step 6: The Lagrange multiplier test

The Lagrange multiplier test estimates the reduction in model chi-square that results from freeing a fixed parameter and allowing it to be estimated. In other words, the Lagrange multiplier estimates the degree to which chi-square would improve if a new factor loading or covariance is added to model.

Rank Order of the 10 Largest Lagrange Multipliers in _GAMMA_

Row	Column	Chi-Square	Pr > ChiSq
V35	F4	37.71198	<.0001
V35	F2	27.22949	<.0001
V32	F8	27.19730	<.0001
V35	F3	25.68372	<.0001
V35	F8	24.00082	<.0001
V32	F5	22.77689	<.0001
V32	F4	22.39162	<.0001
V28	F2	19.85604	<.0001
V28	F3	18.65548	<.0001
V15	F8	18.30063	<.0001

M6

Figure B-5: Output 5 of the measurement model result

The Lagrange multiplier results from Figure B-5 (see M6) suggest adding the relationship between V35 and F4 (Quality). V35 already belongs to F7 (Flexibility), and the relationship between them is considered strong (*t*-value is 15.78 and standardized factor loading is 0.7878) as shown in Figure B-2 (M4) and Figure B-3 (M5). In addition, as can be seen in Figure B-5, V35 is also suggested to measure F2, F8, and F3. So, to reduce complexity in the model, variable V35 should be dropped.

Table B-1: Results of the measurement and revise measurement models of all companies

Model	X^2	df	X^2/df	CFI	NNFI	Lagrange test results	Decision
Measurement model	1,599	712	2.25	0.9072	0.8983	V35 and F4	Remove V35
Revise 1	1,498	674	2.22	0.911	0.9021	V32 and F8	Remove V32
Revise 2	1,416	637	2.22	0.9133	0.9043	V28 and F2	Remove V28
Revise 3	1,305	601	2.17	0.9199	0.9112	V15 and F8	Remove V15
Revise 4	1,213	566	2.14	0.9237	0.9151	V23 and F8	Remove V23
Revise 5	1,115	532	2.10	0.9293	0.9209	V6 and F8	Remove V6
Revise 6	1,044	499	2.09	0.9315	0.9229	-	-

After dropping 6 variables, the values of chi-square, NNFI, CFI, and standardized loadings are improved. The results of final measurement model are shown from Figure B-6 to Figure B-9.

Step 1: Reviewing the chi-square test

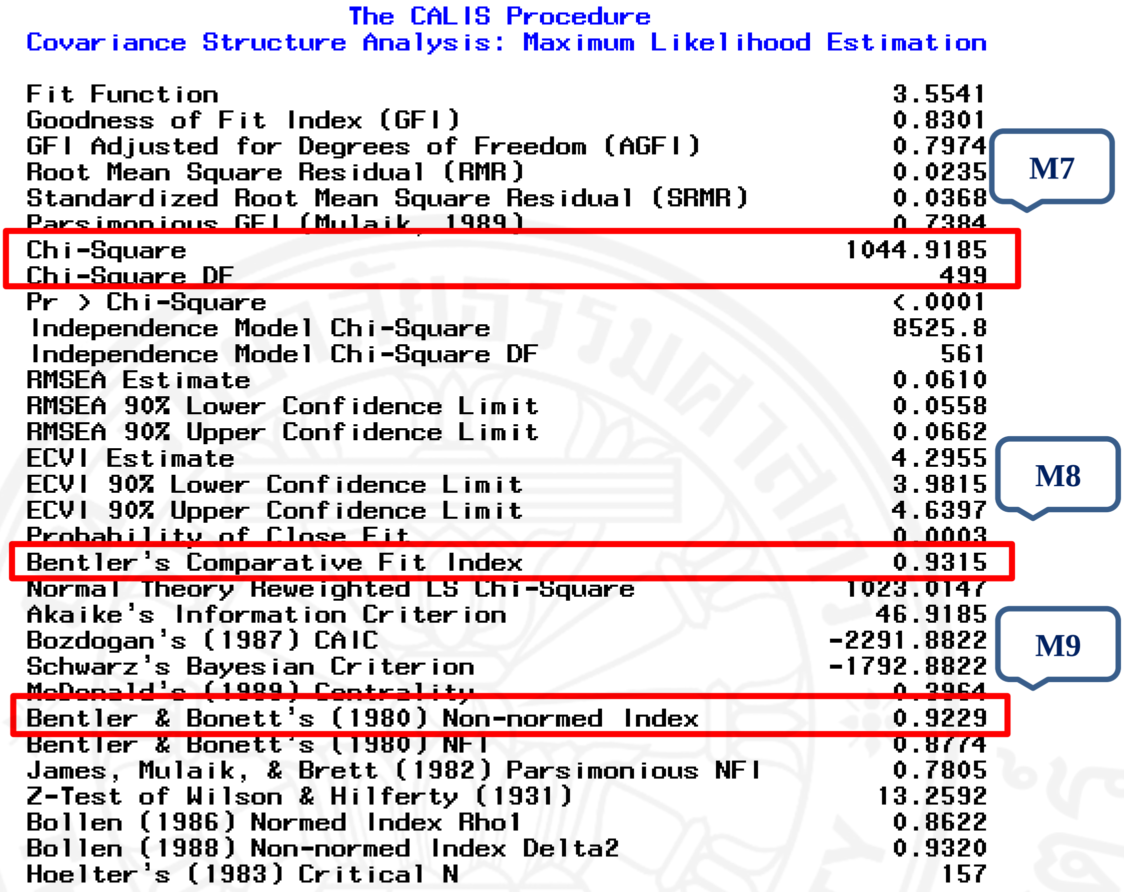
The ratio of chi-square to degree of freedom for the final measurement model is calculated as below:

$$\frac{Chi-square}{df} = \frac{1{,}044}{499} = 2.09 \qquad \text{(see M7, Figure B-6)}$$

The ratio for the final measurement model is 2.09, which is less than 3, so this model provides a good fit to the data.

Step 2: Reviewing the Non-Normed Fit Index and the Comparative Fit Index

The CFI and NNFI shown in Figure B-6 are 0.9315 (M8) and 0.9229 (M9), respectively. These values are greater than 0.9, indicating an acceptable fit between the model and data.



The CALIS Procedure
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Fit Function	3.5541
Goodness of Fit Index (GFI)	0.8301
GFI Adjusted for Degrees of Freedom (AGFI)	0.7974
Root Mean Square Residual (RMR)	0.0235
Standardized Root Mean Square Residual (SRMR)	0.0368
Parsimonious GFI (Mulaik, 1989)	0.7384
Chi-Square	1044.9185
Chi-Square DF	499
Pr > Chi-Square	<.0001
Independence Model Chi-Square	8525.8
Independence Model Chi-Square DF	561
RMSEA Estimate	0.0610
RMSEA 90% Lower Confidence Limit	0.0558
RMSEA 90% Upper Confidence Limit	0.0662
ECVI Estimate	4.2955
ECVI 90% Lower Confidence Limit	3.9815
ECVI 90% Upper Confidence Limit	4.6397
Probability of Close Fit	0.0003
Bentler's Comparative Fit Index	0.9315
Normal Theory Reweighted LS Chi-Square	1023.0147
Akaike's Information Criterion	46.9185
Bozdogan's (1987) CAIC	-2291.8822
Schwarz's Bayesian Criterion	-1792.8822
McDonald's (1989) Centrality	0.3964
Bentler & Bonett's (1980) Non-normed Index	0.9229
Bentler & Bonett's (1980) NFI	0.8774
James, Mulaik, & Brett (1982) Parsimonious NFI	0.7805
Z-Test of Wilson & Hilferty (1931)	13.2592
Bollen (1986) Normed Index Rho1	0.8622
Bollen (1988) Non-normed Index Delta2	0.9320
Hoelter's (1983) Critical N	157

Figure B-6: Output 1 of the final measurement model result

Step 3: Reviewing the significance tests for factor loading

All *t*-values, which are shown in Figure B-7, are greater than 3.291 at $p < 0.001$. The standardized factor loadings are shown in Figure B-8. All standardized factor loadings are higher than 0.6. So, all paths are significant.

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Manifest Variable Equations with Estimates

```
V1         =    0.7114*F1        +  1.0000 E1
Std Err         0.0409 LV1F1
t Value        17.4093
V2         =    0.7728*F1        +  1.0000 E2
Std Err         0.0433 LV2F1
t Value        17.8321
V3         =    0.5156*F1        +  1.0000 E3
Std Err         0.0363 LV3F1
t Value        14.2153
V4         =    0.6835*F1        +  1.0000 E4
Std Err         0.0396 LV4F1
t Value        17.2505
V5         =    0.6277*F1        +  1.0000 E5
Std Err         0.0384 LV5F1
t Value        16.3509
V7         =    0.7676*F2        +  1.0000 E7
Std Err         0.0437 LV7F2
t Value        17.5578
V8         =    0.6888*F2        +  1.0000 E8
Std Err         0.0391 LV8F2
t Value        17.6012
V9         =    0.8010*F2        +  1.0000 E9
Std Err         0.0451 LV9F2
t Value        17.7732
V10        =    0.5670*F2        +  1.0000 E10
Std Err         0.0389 LV10F2
t Value        14.5815
V11        =    0.5010*F3        +  1.0000 E11
Std Err         0.0325 LV11F3
t Value        15.4175
V12        =    0.6387*F3        +  1.0000 E12
Std Err         0.0402 LV12F3
t Value        15.8766
V13        =    0.6153*F3        +  1.0000 E13
Std Err         0.0385 LV13F3
t Value        15.9635
V14        =    0.5924*F3        +  1.0000 E14
Std Err         0.0412 LV14F3
t Value        14.3628
V16        =    0.7676*F4        +  1.0000 E16
Std Err         0.0461 LV16F4
t Value        16.6460
V17        =    0.7277*F4        +  1.0000 E17
Std Err         0.0417 LV17F4
t Value        17.4600
V18        =    0.5789*F4        +  1.0000 E18
Std Err         0.0417 LV18F4
t Value        13.8880
V19        =    0.7069*F4        +  1.0000 E19
Std Err         0.0420 LV19F4
t Value        16.8385
V20        =    0.6583*F4        +  1.0000 E20
Std Err         0.0386 LV20F4
t Value        17.0589
V21        =    0.6474*F5        +  1.0000 E21
Std Err         0.0353 LV21F5
t Value        18.3325
V22        =    0.4427*F5        +  1.0000 E22
Std Err         0.0380 LV22F5
t Value        11.6637
```

```
V24       =    0.5173*F5        +  1.0000 E24
Std Err        0.0433 LV24F5
t Value       11.9555
V25       =    0.6683*F5        +  1.0000 E25
Std Err        0.0365 LV25F5
t Value       18.3091
V26       =    0.5263*F6        +  1.0000 E26
Std Err        0.0500 LV26F6
t Value       10.5194
V27       =    0.5018*F6        +  1.0000 E27
Std Err        0.0452 LV27F6
t Value       11.0975
V29       =    0.4899*F6        +  1.0000 E29
Std Err        0.0367 LV29F6
t Value       13.3324
V30       =    0.4681*F6        +  1.0000 E30
Std Err        0.0323 LV30F6
t Value       14.5013
V31       =    0.7098*F7        +  1.0000 E31
Std Err        0.0420 LV31F7
t Value       16.8894
V33       =    0.4688*F7        +  1.0000 E33
Std Err        0.0394 LV33F7
t Value       11.9025
V34       =    0.5148*F7        +  1.0000 E34
Std Err        0.0372 LV34F7
t Value       13.8585
V36       =    0.7524*F8        +  1.0000 E36
Std Err        0.0391 LV36F8
t Value       19.2479
V37       =    0.8618*F8        +  1.0000 E37
Std Err        0.0425 LV37F8
t Value       20.2625
V38       =    0.6902*F8        +  1.0000 E38
Std Err        0.0392 LV38F8
t Value       17.6270
V39       =    0.6669*F8        +  1.0000 E39
Std Err        0.0367 LV39F8
t Value       18.1773
V40       =    0.6810*F8        +  1.0000 E40
Std Err        0.0386 LV40F8
t Value       17.6344
```

Figure B-7: Output 2 of the final measurement model result

```
                     The CALIS Procedure
  Covariance Structure Analysis: Maximum Likelihood Estimation

      Manifest Variable Equations with Standardized Estimates

V1       =    0.8363*F1      +  0.5482 E1
                    LV1F1
V2       =    0.8491*F1      +  0.5282 E2
                    LV2F1
V3       =    0.7285*F1      +  0.6851 E3
                    LV3F1
V4       =    0.8314*F1      +  0.5556 E4
                    LV4F1
V5       =    0.8028*F1      +  0.5962 E5
                    LV5F1
V7       =    0.8413*F2      +  0.5406 E7
                    LV7F2
V8       =    0.8426*F2      +  0.5385 E8
                    LV8F2
V9       =    0.8478*F2      +  0.5303 E9
                    LV9F2
V10      =    0.7421*F2      +  0.6702 E10
                    LV10F2
V11      =    0.7768*F3      +  0.6297 E11
                    LV11F3
V12      =    0.7926*F3      +  0.6098 E12
                    LV12F3
V13      =    0.7955*F3      +  0.6059 E13
                    LV13F3
V14      =    0.7390*F3      +  0.6737 E14
                    LV14F3
V16      =    0.8109*F4      +  0.5852 E16
                    LV16F4
V17      =    0.8365*F4      +  0.5480 E17
                    LV17F4
V18      =    0.7146*F4      +  0.6995 E18
                    LV18F4
V19      =    0.8171*F4      +  0.5765 E19
                    LV19F4
V20      =    0.8240*F4      +  0.5665 E20
                    LV20F4
V21      =    0.8707*F5      +  0.4917 E21
                    LV21F5
V22      =    0.6319*F5      +  0.7751 E22
                    LV22F5
V24      =    0.6443*F5      +  0.7648 E24
                    LV24F5
V25      =    0.8700*F5      +  0.4930 E25
                    LV25F5
V26      =    0.6024*F6      +  0.7982 E26
                    LV26F6
V27      =    0.6290*F6      +  0.7774 E27
                    LV27F6
V29      =    0.7257*F6      +  0.6880 E29
                    LV29F6
V30      =    0.7731*F6      +  0.6342 E30
                    LV30F6
V31      =    0.8388*F7      +  0.5445 E31
                    LV31F7
V33      =    0.6474*F7      +  0.7622 E33
                    LV33F7
V34      =    0.7268*F7      +  0.6869 E34
                    LV34F7
V36      =    0.8842*F8      +  0.4670 E36
                    LV36F8
V37      =    0.9113*F8      +  0.4117 E37
                    LV37F8
V38      =    0.8374*F8      +  0.5466 E38
                    LV38F8
V39      =    0.8538*F8      +  0.5206 E39
                    LV39F8
V40      =    0.8376*F8      +  0.5463 E40
                    LV40F8
```

Figure B-8: Output 3 of the final measurement model result

Step 4: Normalized residual matrix

The distribution of normalized residual is symmetrical and centers near zero (Figure B-9). The results of final measurement model indicate a good fit, so, there is no step 5 and step 6.

```
                        The CALIS Procedure
      Covariance Structure Analysis: Maximum Likelihood Estimation

         Distribution of Asymptotically Standardized Residuals

                    Each * Represents 3 Residuals

----------Range---------      Freq     Percent

  -4.00000     -3.75000          1        0.17
  -3.75000     -3.50000          1        0.17
  -3.50000     -3.25000          2        0.34
  -3.25000     -3.00000          3        0.50   *
  -3.00000     -2.75000          3        0.50   *
  -2.75000     -2.50000          6        1.01   **
  -2.50000     -2.25000         10        1.68   ***
  -2.25000     -2.00000         18        3.03   ******
  -2.00000     -1.75000         16        2.69   *****
  -1.75000     -1.50000         19        3.19   ******
  -1.50000     -1.25000         26        4.37   ********
  -1.25000     -1.00000         29        4.87   *********
  -1.00000     -0.75000         30        5.04   **********
  -0.75000     -0.50000         39        6.55   *************
  -0.50000     -0.25000         45        7.56   ***************
  -0.25000            0         34        5.71   ***********
         0      0.25000         75       12.61   *************************
   0.25000      0.50000         37        6.22   ************
   0.50000      0.75000         34        5.71   ***********
   0.75000      1.00000         32        5.38   **********
   1.00000      1.25000         30        5.04   **********
   1.25000      1.50000         26        4.37   ********
   1.50000      1.75000         14        2.35   ****
   1.75000      2.00000         15        2.52   *****
   2.00000      2.25000         14        2.35   ****
   2.25000      2.50000          7        1.18   **
   2.50000      2.75000          9        1.51   ***
   2.75000      3.00000          6        1.01   **
   3.00000      3.25000          3        0.50   *
   3.25000      3.50000          2        0.34
   3.50000      3.75000          3        0.50   *
```

Figure B-9: Output 4 of the final measurement model result

Step 7: Indicator reliability

The reliability of an indicators indicates the percent of variation in the indicator that is explained by the factor that it is supposed to measure (Long, 1983). All indicator reliabilities can be seen in Figure B-10 (M10).

Squared Multiple Correlations

M10

	Variable	Error Variance	Total Variance	R-Square
1	V1	0.21745	0.72349	0.6994
2	V2	0.23108	0.82837	0.7210
3	V3	0.23511	0.50094	0.5307
4	V4	0.20866	0.67587	0.6913
5	V5	0.21732	0.61134	0.6445
6	V7	0.24326	0.83243	0.7078
7	V8	0.19381	0.66832	0.7100
8	V9	0.25095	0.89248	0.7188
9	V10	0.26222	0.58371	0.5508
10	V11	0.16496	0.41598	0.6034
11	V12	0.24145	0.64940	0.6282
12	V13	0.21966	0.59831	0.6329
13	V14	0.29162	0.64254	0.5462
14	V16	0.30681	0.89603	0.6576
15	V17	0.22730	0.75690	0.6997
16	V18	0.32102	0.65610	0.5107
17	V19	0.24882	0.74859	0.6676
18	V20	0.20482	0.63812	0.6790
19	V21	0.13367	0.55281	0.7582
20	V22	0.29486	0.49083	0.3993
21	V24	0.37706	0.64462	0.4151
22	V25	0.14339	0.59001	0.7570
23	V26	0.48636	0.76336	0.3629
24	V27	0.38461	0.63645	0.3957
25	V29	0.21569	0.45567	0.5267
26	V30	0.14743	0.36652	0.5978
27	V31	0.21232	0.71610	0.7035
28	V33	0.30459	0.52434	0.4191
29	V34	0.23674	0.50180	0.5282
30	V36	0.15793	0.72402	0.7819
31	V37	0.15155	0.89423	0.8305
32	V38	0.20299	0.67937	0.7012
33	V39	0.16536	0.61017	0.7290
34	V40	0.19726	0.66106	0.7016

Figure B-10: Output 5 of the final measurement model result

Step 8: Composite reliability and variance extracted

The composite reliability identifies the indicators measuring a given factor while the variance extracted identifies the amount of variance that is captured by factor in relation to the amount of variance due to measurement error. The minimal acceptable level of composite reliability and variance extracted are 0.6 and 0.5, respectively. The results of composite reliability and variance extracted are shown in Table B-2.

Table B-2: Composite reliability and variance extracted estimate of each latent variable

Constructs and Indicators	Standardized Loading	Indicator Reliability	Error Variance	Composite Reliability	Variance Extracted Estimate
	L_i	${L_i}^2$	$1-{L_i}^2$ or $Var\ (E_i)$	$\frac{(\sum L_i)^2}{(\sum L_i)^2+\sum Var\ (E_i)}$	$\frac{\sum {L_i}^2}{\sum {L_i}^2+\sum Var\ (E_i)}$
F1 (SCI)				0.9060	0.6591
V1	0.8363	0.6994	0.3006		
V2	0.8491	0.7210	0.2790		
V3	0.7285	0.5307	0.4693		
V4	0.8314	0.6912	0.3088		
V5	0.8082	0.6532	0.3468		
Total	4.0535	3.2955	1.7045		
F2 (SCO)				0.8909	0.6718
V7	0.8413	0.7078	0.2922		
V8	0.8426	0.7100	0.2900		
V9	0.8478	0.7188	0.2812		
V10	0.7421	0.5507	0.4493		
Total	3.2738	2.6872	1.3128		
F3 (HRM)				0.8591	0.6041
V11	0.7768	0.6034	0.3966		
V12	0.7962	0.6339	0.3661		
V13	0.7955	0.6328	0.3672		
V14	0.7390	0.5461	0.4539		
Total	3.1075	2.4163	1.5837		
F4 (QU)				0.8998	0.6429
V16	0.8109	0.6576	0.3424		
V17	0.8365	0.6997	0.3003		
V18	0.7146	0.5107	0.4893		
V19	0.8171	0.6677	0.3323		
V20	0.8240	0.6790	0.3210		
Total	4.0031	3.2146	1.7854		
F5 (DE)				0.8449	0.5824
V21	0.8707	0.7581	0.2419		
V22	0.6319	0.3993	0.6007		
V24	0.6443	0.4151	0.5849		
V25	0.8700	0.7569	0.2431		
Total	3.0169	2.3294	1.6706		

Constructs and Indicators	Standardized Loading	Indicator Reliability	Error Variance	Composite Reliability	Variance Extracted Estimate
	L_i	${L_i}^2$	$1 - {L_i}^2$ or $Var\ (E_i)$	$\frac{(\sum L_i)^2}{(\sum L_i)^2 + \sum Var\ (E_i)}$	$\frac{\sum {L_i}^2}{\sum {L_i}^2 + \sum Var\ (E_i)}$
F6 (FL)				0.7788	0.5824
V26	0.6024	0.3629	0.6371		
V27	0.6290	0.3956	0.6044		
V29	0.7257	0.5266	0.4734		
V30	0.7731	0.5977	0.4023		
Total	2.7302	1.8829	2.1171		
F7 (CO)				0.7840	0.5503
V31	0.8388	0.7036	0.2964		
V33	0.6474	0.4191	0.5809		
V34	0.7268	0.5282	0.4718		
Total	2.2130	1.6510	1.3490		
F8 (BP)				0.9371	0.7488
V36	0.8842	0.7818	0.2182		
V37	0.9113	0.8305	0.1695		
V38	0.8374	0.7012	0.2988		
V39	0.8538	0.7290	0.2710		
V40	0.8376	0.7016	0.2984		
Total	4.3243	3.7441	1.2559		

Remarks:
L_i is standardized factor loading for indicator variable *i*
$Var\ (E_i)$ is error variance associated with the indicator variables *i*

From Table B-2, the composite reliability and the variance extracted estimate of all factors greater than the requirement of 0.6 and 0.5, respectively.

Step 9: Convergent validity

Convergent validity is used to measure the similarity or convergence between the indicators measuring the same construct. Convergent validity is demonstrated when the correlations between these indicators are statistically significant (greater than twice their standard errors).

Table B-3 indicates that the coefficients for all items are far greater than twice their standard errors. In addition, all coefficients are large and strongly significant at $p < 0.01$. Thus, these results provide strong evidence to support convergent validity for these items.

Table B-3: Convergent validity for all items

Indicators	Factor Loading	Standard Error	Twice of Standard Error	*t*-value
V1	0.7114	0.0409	0.0818	17.4093
V2	0.7728	0.0433	0.0866	17.8321
V3	0.5156	0.0363	0.0726	14.2153
V4	0.6835	0.0396	0.0792	17.2505
V5	0.6277	0.0384	0.0768	16.3509
V7	0.7676	0.0437	0.0874	17.5578
V8	0.6888	0.0391	0.0782	17.6012
V9	0.8010	0.0451	0.0902	17.7732
V10	0.5670	0.0389	0.0778	14.5815
V11	0.5010	0.0325	0.0650	15.4175
V12	0.6387	0.0402	0.0804	15.8766
V13	0.6153	0.0385	0.0770	15.9635
V14	0.5924	0.0412	0.0824	14.3628
V16	0.7676	0.0461	0.0922	16.6460
V17	0.7277	0.0417	0.0834	17.4600
V18	0.5789	0.0417	0.0834	13.8880
V19	0.7069	0.0420	0.0840	16.8385
V20	0.6583	0.0386	0.0772	17.0589
V21	0.6474	0.0353	0.0706	18.3325
V22	0.4427	0.0380	0.0760	11.6637
V24	0.5173	0.0433	0.0866	11.9555
V25	0.6683	0.0365	0.0730	18.3091
V26	0.5263	0.0500	0.1000	10.5194
V27	0.5018	0.0452	0.0904	11.0975
V29	0.4899	0.0367	0.0734	13.3324
V30	0.4681	0.0323	0.0646	14.5013
V31	0.7098	0.0420	0.0840	16.8894
V33	0.4688	0.0394	0.0788	11.9025
V34	0.5148	0.0372	0.0744	13.8585
V36	0.7524	0.0391	0.0782	19.2497
V37	0.8618	0.0425	0.0850	20.2625
V38	0.6902	0.0392	0.0784	17.6270
V39	0.6669	0.0367	0.0734	18.1773
V40	0.6810	0.0386	0.0772	17.6344

Step 10: Discriminant validity

Discriminant validity is demonstrated when the correlations between different indicators measuring different constructs are relatively weak. There are three possible methods to test the discriminant validity.

1. Chi-square difference test: This measurement model can be analyzed by the significance of change in the chi-square value when setting the covariance between each pair of latent variables to be 1. If chi-square's difference between the measurement model and the discriminant model is significant, the model is supported to give the discriminant validity.

In our measurement model, the strongest correlation between factors occurs at the correlation between F1 (SCI) and F8 (BP) (see M11, Figure B-11), so it is set to be 1.

Correlations Among Exogenous Variables

Var1	Var2	Parameter	Estimate
F1	F2	CF1F2	0.82085
F1	F3	CF1F3	0.79326
F2	F3	CF2F3	0.89390
F1	F4	CF1F4	0.81632
F2	F4	CF2F4	0.91029
F3	F4	CF3F4	0.90432
F1	F5	CF1F5	0.72309
F2	F5	CF2F5	0.80096
F3	F5	CF3F5	0.82612
F4	F5	CF4F5	0.84270
F1	F6	CF1F6	0.68847
F2	F6	CF2F6	0.70244
F3	F6	CF3F6	0.71041
F4	F6	CF4F6	0.67852
F5	F6	CF5F6	0.73831
F1	F7	CF1F7	0.85451
F2	F7	CF2F7	0.84645
F3	F7	CF3F7	0.77242
F4	F7	CF4F7	0.79277
F5	F7	CF5F7	0.73779
F6	F7	CF6F7	0.74225
F1	F8	CF1F8	0.91202
F2	F8	CF2F8	0.87224
F3	F8	CF3F8	0.84457
F4	F8	CF4F8	0.90167
F5	F8	CF5F8	0.83708
F6	F8	CF6F8	0.71027
F7	F8	CF7F8	0.90350

M11

Figure B-11: Output 6 of the final measurement model result

Then, the discriminant model is analyzed. Figure B-12 shows the result of the discriminant model of F1 and F8.

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Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	3.8246
Goodness of Fit Index (GFI)	0.8182
GFI Adjusted for Degrees of Freedom (AGFI)	0.7837
Root Mean Square Residual (RMR)	0.0243
Standardized Root Mean Square Residual (SRMR)	0.0378
Parsimonious GFI (Mulaik, 1989)	0.7293
Chi-Square	1124.4342
Chi-Square DF	500
Pr > Chi-Square	<.0001
Independence Model Chi-Square	8525.8
Independence Model Chi-Square DF	561
RMSEA Estimate	0.0652
RMSEA 90% Lower Confidence Limit	0.0601
RMSEA 90% Upper Confidence Limit	0.0703
ECVI Estimate	4.5582
ECVI 90% Lower Confidence Limit	4.2275
ECVI 90% Upper Confidence Limit	4.9190
Probability of Close Fit	0.0000
Bentler's Comparative Fit Index	0.9216
Normal Theory Reweighted LS Chi-Square	1110.4650
Akaike's Information Criterion	124.4342
Bozdogan's (1987) CAIC	-2219.0535
Schwarz's Bayesian Criterion	-1719.0535
McDonald's (1989) Centrality	0.3470
Bentler & Bonett's (1980) Non-normed Index	0.9120
Bentler & Bonett's (1980) NFI	0.8681
James, Mulaik, & Brett (1982) Parsimonious NFI	0.7737
Z-Test of Wilson & Hilferty (1931)	14.7328
Bollen (1986) Normed Index Rho1	0.8520
Bollen (1988) Non-normed Index Delta2	0.9222
Hoelter's (1983) Critical N	146

M12

Figure B-12: Output of the discriminant model of F1 and F8

The chi-square of final measurement model is 1,044.9185 and df is 499.

The chi-square of discriminant model (see M12, Figure B-12) is 1,124.4342 and df is 500.

The difference in chi-square between two models: 1,124.4342 - 1,044.9185 = 79.5157

The difference in df between two models: 500 - 499 = 1

The critical chi-square value of 1 degree of freedom different ($p < 0.01$) is 6.6349. The chi-square difference value is greater than the critical value so this chi-square difference test suggests having the discriminant validity between F1 (SCI) and F8 (BP).

2. Confidence interval test: If the range between the correlation plus and minus twice its standard deviation does not include 1, there is a discriminant validity.

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value
F1	F2	CF1F2	0.82085	0.02597	31.61
F1	F3	CF1F3	0.79326	0.03007	26.38
F2	F3	CF2F3	0.89390	0.02156	41.45
F1	F4	CF1F4	0.81632	0.02603	31.36
F2	F4	CF2F4	0.91029	0.01780	51.14
F3	F4	CF3F4	0.90432	0.02020	44.77
F1	F5	CF1F5	0.72309	0.03504	20.64
F2	F5	CF2F5	0.80096	0.02898	27.64
F3	F5	CF3F5	0.82612	0.02840	29.09
F4	F5	CF4F5	0.84270	0.02486	33.90
F1	F6	CF1F6	0.68847	0.04200	16.39
F2	F6	CF2F6	0.70244	0.04152	16.92
F3	F6	CF3F6	0.71041	0.04255	16.70
F4	F6	CF4F6	0.67852	0.04300	15.78
F5	F6	CF5F6	0.73831	0.03932	18.78
F1	F7	CF1F7	0.85451	0.02795	30.58
F2	F7	CF2F7	0.84645	0.02926	28.93
F3	F7	CF3F7	0.77242	0.03709	20.83
F4	F7	CF4F7	0.79277	0.03340	23.73
F5	F7	CF5F7	0.73779	0.03880	19.02
F6	F7	CF6F7	0.74225	0.04300	17.26
F1	F8	CF1F8	0.91202	0.01534	59.47
F2	F8	CF2F8	0.87224	0.01987	43.89
F3	F8	CF3F8	0.84457	0.02417	34.94
F4	F8	CF4F8	0.90167	0.01662	54.25
F5	F8	CF5F8	0.83708	0.02387	35.07
F6	F8	CF6F8	0.71027	0.03908	18.17
F7	F8	CF7F8	0.90350	0.02247	40.22

M13

Figure B-13: Output of covariance among factors

The correlation between F1 (SCI) and F8 (BP) is highest, which is 0.9120 and its standard error is 0.01534 (see M13, Figure B-13).

Twice standard error = 2*0.01534 = 0.03068

Lower bound = 0.9120 - 0.03068 = 0.88134

Upper bound = 0.912 + 0.03068 = 0.9427

The range of lower bound and upper bound is 0.88134 and 0.9427, which does not include 1, so there is the discriminant validity between F1 (SCI) and F8 (BP).

3. Variance extracted test: If the variance extracted estimates of both factors, which have the strongest correlation pair exceeding the square of correlation, there is discriminant validity.

In this test, the correlation of F1 (SCI) and F8 (BP) is 0.9120, the square of this correlation is 0.8317. The variance extracted estimates are calculated and shown in Table B-2, in which the variance extracted estimates is 0.6591 for F1 (SCI) and 0.7488 for F8 (BP).

This is fail to support the discriminant validity between F1 (SCI) and F8 (BP). However, the discriminant validity between F1 (SCI) and F8 (BP) is still expected to occur because of the results of the chi-square difference test and confidence interval test.

Finally, results of the final measurement model indicate a good fit between the model and data. All factors are successfully measured by their remaining indicators.

B.2 Theoretical model analysis

After the relationships between latent variables and their indicators are analyzed in the measurement model, the theoretical model is developed to analyze the relationships between latent variables themselves.

Step 1: Reviewing the chi-square test

The ratio of chi-square to degree of freedom for the theoretical model is calculated as below:

$$\frac{Chi\text{−}square}{df} = \frac{1{,}044}{493} = 2.12 \qquad \text{(see M14, Figure B-14)}$$

The ratio of chi-square to degree of freedom for the theoretical model is 2.12, indicating an acceptable fit.

Step 2: Reviewing the Non-Normed Fit Index and the Comparative Fit Index

The CFI and NNFI shown in Figure B-14 are 0.9307 (M15) and 0.9211 (M16), which are greater than 0.9. So this model provides an acceptable fit.

```
                    The CALIS Procedure
     Covariance Structure Analysis: Maximum Likelihood Estimation

     Fit Function                                                 3.5541
     Goodness of Fit Index (GFI)                                  0.8301
     GFI Adjusted for Degrees of Freedom (AGFI)                   0.7949
     Root Mean Square Residual (RMR)                              0.0235
     Standardized Root Mean Square Residual (SRMR)                0.0368
     Parsimonious GFI (Mulaik, 1989)                              0.7295
     Chi-Square                                                1044.9185
     Chi-Square DF                                                   493
     Pr > Chi-Square                                              <.0001
     Independence Model Chi-Square                                8525.8
     Independence Model Chi-Square DF                                561
     RMSEA Estimate                                               0.0617
     RMSEA 90% Lower Confidence Limit                             0.0565
     RMSEA 90% Upper Confidence Limit                             0.0669
     ECVI Estimate                                                4.3418
     ECVI 90% Lower Confidence Limit                              4.0270
     ECVI 90% Upper Confidence Limit                              4.6868
     Probability of Close Fit                                     0.0001
     Bentler's Comparative Fit Index                              0.9307
     Normal Theory Reweighted LS Chi-Square                    1023.0201
     Akaike's Information Criterion                              58.9185
     Bozdogan's (1987) CAIC                                   -2251.7603
     Schwarz's Bayesian Criterion                             -1758.7603
     McDonald's (1989) Centrality                                 0.3924
     Bentler & Bonett's (1980) Non-normed Index                   0.9211
     Bentler & Bonett's (1980) NFI                                0.8774
     James, Mulaik, & Brett (1982) Parsimonious NFI               0.7711
     Z-Test of Wilson & Hilferty (1931)                          13.4230
     Bollen (1986) Normed Index Rho1                              0.8605
     Bollen (1988) Non-normed Index Delta2                        0.9313
     Hoelter's (1983) Critical N                                     155
```

M14

M15

M16

Figure B-14: Output 1 of theoretical model result

<u>Step 3: Reviewing the significance tests for factor loading</u>

The factor loadings are equivalent to path coefficients from latent factors to other latent factors. Therefore, an insignificant factor loading means that the relationship between these factors is relatively slow, and should possibly be dropped. The *t*-values explain about the significance of path coefficients from latent factors to other latent factors. The factor loadings are significant when *t*-values are greater than 1.96 at $p < 0.05$, 2.576 at $p < 0.01$, or 3.291 at $p < 0.001$. Figure B-15 shows that there are many *t*-values less than 1.96, which indicate insignificant relationships.

```
                 Covariance Structure Analysis: Maximum Likelihood Estimation

                          Latent Variable Equations with Estimates        M17

F4       =    0.0306*F5      + -0.0186*F6      + 0.00224*F7     +  0.1284*F1
Std Err       0.2366 PF4F5      0.1849 PF4F6     0.3323 PF4F7      0.2436 PF4F1
t Value       0.1293           -0.1008           0.00675           0.5270

     +  0.3863*F2      +  0.4736*F3      +  1.0000 D4
        0.3621 PF4F2      0.3357 PF4F3
        1.0666            1.4107

F5       =    0.3933*F4      +  0.2243*F6      +  0.0398*F7     + -0.0180*F1
Std Err            0 PF5F4      0.1618 PF5F6          0 PF5F7      0.1851 PF5F1
t Value            .            1.3860                .           -0.0971

     + 0.00857*F2      +  0.2998*F3      +  1.0000 D5
        0.2951 PF5F2      0.2899 PF5F3
        0.0291            1.0341

F6       =   -0.0886*F4      +  0.1372*F5      +  0.1364*F7     +  0.1079*F1
Std Err            0 PF6F4           0 PF6F5          0 PF6F7      0.1814 PF6F1
t Value            .                 .                .            0.5946

     +  0.0504*F2      +  0.2283*F3      +  1.0000 D6
        0.2960 PF6F2      0.2804 PF6F3
        0.1704            0.8142

F7       =   -0.0553*F4      +  0.0330*F5      +  0.1710*F6     +  0.4363*F1
Std Err            0 PF7F4      0.2357 PF7F5      0.1814 PF7F6     0.1974 PF7F1
t Value            .            0.1401            0.9429           2.2100

     +  0.4380*F2      + -0.1154*F3      +  1.0000 D7
        0.3120 PF7F2      0.3247 PF7F3
        1.4040           -0.3555

F8       =    0.4123*F4      +  0.2730*F5      + -0.1469*F6     +  0.4400*F7
Std Err       0.4125 PF8F4      0.2407 PF8F5      0.1947 PF8F6     0.3576 PF8F7
t Value       0.9996            1.1340           -0.7545           1.2306

     +  0.3836*F1      + -0.1108*F2      + -0.0612*F3      +  1.0000 D8
        0.2631 PF8F1      0.4149 PF8F2      0.3587 PF8F3
        1.4579           -0.2671           -0.1706
```

Figure B-15: Output 2 of theoretical model result

```
                     The CALIS Procedure
   Covariance Structure Analysis: Maximum Likelihood Estimation

          Latent Variable Equations with Standardiz      es

F4     =   0.0272*F5    + -0.0120*F6    + 0.00219*F7     +                + 0.4252*F2
               PF4F5          PF4F6           PF4F7             PF4F1          PF4F2

             + 0.4005*F3    + 0.3484 D4
                  PF4F3

F5     =   0.4421*F4    +  0.1622*F6    +  0.0437*F7    + -0.0215*F1    + 0.0106*F2
               PF5F4          PF5F6           PF5F7          PF5F1          PF5F2

             + 0.2850*F3    + 0.4857 D5
                  PF5F3

F6     =  -0.1377*F4    +  0.1898*F5    +  0.2068*F7    +  0.1781*F1    + 0.0863*F2
               PF6F4          PF6F5           PF6F7          PF6F1          PF6F2

             + 0.3002*F3    + 0.6168 D6
                  PF6F3

F7     =  -0.0567*F4    +  0.0301*F5    +  0.1128*F6    +  0.4750*F1    + 0.4943*F2
               PF7F4          PF7F5           PF7F6          PF7F1          PF7F2

             + -0.1001*F3   + 0.4320 D7
                  PF7F3

F8     =   0.3482*F4    +  0.2050*F5    + -0.0798*F6    +  0.3624*F7    + 0.3440*F1
               PF8F4          PF8F5           PF8F6          PF8F7          PF8F1

             + -0.1030*F2   + -0.0437*F3    + 0.2380 D8
                  PF8F2          PF8F3
```

M18

Figure B-16: Output 3 of theoretical model result

Step 4: Reviewing R^2 values for the latent endogenous variables

The results in Figure B-17 (M19) show that the independent variables accounted for 94% of the variance in business performance factor, 81% of the variance in cost factor, 62% of the variance in flexibility factor, 76% of the variance in delivery factor, and 88% of the variance in quality factor. All of R^2 values are greater than requirement level of 60%.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
13	V14	0.29161	0.64270	0.5463
14	V16	0.30683	0.89634	0.6577
15	V17	0.22731	0.75711	0.6998
16	V18	0.32101	0.65628	0.5109
17	V19	0.24882	0.74885	0.6677
18	V20	0.20483	0.63834	0.6791
19	V21	0.13366	0.55298	0.7583
20	V22	0.29486	0.49094	0.3994
21	V24	0.37700	0.64471	0.4152
22	V25	0.14340	0.59016	0.7570
23	V26	0.48631	0.76346	0.3630
24	V27	0.38461	0.63653	0.3958
25	V29	0.21569	0.45574	0.5267
26	V30	0.14745	0.36660	0.5978
27	V31	0.21234	0.71629	0.7036
28	V33	0.30458	0.52445	0.4192
29	V34	0.23672	0.50193	0.5284
30	V36	0.15794	0.72426	0.7819
31	V37	0.15156	0.89461	0.8306
32	V38	0.20299	0.67963	0.7013
33	V39	0.16537	0.61038	0.7291
34	V40	0.19726	0.66122	0.7017
35	F4	0.06432	0.52980	0.8786
36	F5	0.09892	0.41932	0.7641
37	F6	0.08337	0.21915	0.6196
38	F7	0.09407	0.50395	0.8133
39	F8	0.04208	0.74305	0.9434

M19

Figure B-17: Output 4 of theoretical model result

Step 5: Normalized residual matrix

The distribution of normalized residual is shown in Figure B-18. It is symmetrical and centers on zero.

```
The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Normalized Residuals

Each * Represents 6 Residuals

----------Range---------      Freq      Percent

 -1.75000     -1.50000           2         0.34
 -1.50000     -1.25000           3         0.50
 -1.25000     -1.00000           9         1.51   *
 -1.00000     -0.75000          32         5.38   *****
 -0.75000     -0.50000          55         9.24   *********
 -0.50000     -0.25000          81        13.61   *************
 -0.25000            0         128        21.51   *********************
        0      0.25000         106        17.82   *****************
  0.25000      0.50000          75        12.61   ************
  0.50000      0.75000          51         8.57   ********
  0.75000      1.00000          22         3.70   ***
  1.00000      1.25000          16         2.69   **
  1.25000      1.50000           6         1.01   *
  1.50000      1.75000           4         0.67
  1.75000      2.00000           3         0.50
  2.00000      2.25000           0         0.00
  2.25000      2.50000           1         0.17
  2.50000      2.75000           0         0.00
  2.75000      3.00000           0         0.00
  3.00000      3.25000           1         0.17
```

Figure B-18: Output 5 of theoretical model result

Step 6: The Wald test

The result of Wald test shown in Figure B-19 (M20) recommends dropping parameter PF4F7 (M19), which is a path from F7 (cost) to F4 (quality). As can be seen in Figure B-15 (M17) and Figure B-16 (M18), standardized path coefficient of the relationship between these factors is 0.002 and *t*-value is 0.0067, which shows very weak relationship between F4 and F7. So, this path should be dropped from the model.

Stepwise Multivariate Wald Test

M20

Parameter	------Cumulative Statistics----- Chi-Square	DF	Pr > ChiSq	--Univariate Incr Chi-Square	Pr
PF4F7	6.83341E-6	1	0.9979	6.83341E-6	0.9979
PF5F2	0.0001204	2	0.9999	0.0001136	0.9915
PF5F1	0.00140	3	1.0000	0.00128	0.9715
VARD8	0.00401	4	1.0000	0.00261	0.9593
PF4F5	0.00701	5	1.0000	0.00300	0.9563
PF4F6	0.00885	6	1.0000	0.00184	0.9658
PF6F2	0.01225	7	1.0000	0.00340	0.9535
PF8F3	0.01711	8	1.0000	0.00487	0.9444
PF7F5	0.02339	9	1.0000	0.00627	0.9369
VARD6	0.03485	10	1.0000	0.01146	0.9147
CF2F3	0.04844	11	1.0000	0.01359	0.9072
CF1F3	0.05773	12	1.0000	0.00929	0.9232
VARF3	0.06950	13	1.0000	0.01177	0.9136
VARD4	0.08750	14	1.0000	0.01800	0.8933
VARD7	0.11468	15	1.0000	0.02718	0.8690
VARD5	0.14674	16	1.0000	0.03206	0.8579
PF8F2	0.19468	17	1.0000	0.04795	0.8267
PF6F1	0.25327	18	1.0000	0.05858	0.8087
PF4F1	0.31498	19	1.0000	0.06171	0.8038
PF7F3	0.39355	20	1.0000	0.07857	0.7792

Figure B-19: Output 6 of theoretical model result

The measures of goodness-of-fit for all models are shown in Table B-4.

Table B-4: Goodness of fit of all models

Model	X^2	df	X^2/df	NNFI	CFI
Null model	8,525.8	561	15.20	-	-
Uncorrelated model	3,294.8849	527	6.25	0.6301	0.6525
Measurement model	1,044.9185	499	2.09	0.9229	0.9315
Full maintained model	1,044.9185	493	2.12	0.9211	0.9307
PF4F7 path deleted	1,044.9185	494	2.12	0.9214	0.9308
PF5F2 path deleted	1,044.9186	495	2.11	0.9218	0.931
PF7F5 path deleted	1,044.9185	496	2.11	0.922	0.9311
PF4F5 path deleted	1,044.9185	497	2.10	0.9223	0.9312
PF5F1 path deleted	1,044.92	498	2.10	0.9226	0.9313
PF4F6 path deleted	1,044.9195	499	2.09	0.9229	0.9315
PF6F7 path deleted	1,044.9198	500	2.09	0.9232	0.9316
PF5F6 path deleted	1,044.9269	501	2.09	0.9235	0.9317
PF7F4 path deleted	1,044.9664	502	2.08	0.9238	0.9318
PF8F3 path deleted	1,045.121	503	2.08	0.9241	0.9319
PF5F7 path deleted	1,045.7519	504	2.07	0.9243	0.932
PF6F2 path deleted	1,046.622	505	2.07	0.9245	0.932
PF6F4 path deleted	1,047.9415	506	2.07	0.9246	0.932
PF6F3 path deleted	1,049.122	507	2.07	0.9247	0.9319
PF7F3 path deleted	1,050.3924	508	2.07	0.9248	0.9319
PF8F2 path deleted	1,051.8436	509	2.07	0.9249	0.9318
PF8F6 path deleted	1,054.7511	510	2.07	0.9248	0.9316

After deleting 17 insignificant paths, goodness-of-fit indices indicate an acceptable fit of the structural model to the data as shown from Figure B-20 to Figure B-24.

Step 1: Reviewing the chi-square test

The ratio of chi-square test to degree of freedom for the final theoretical model is calculated as below:

$$\frac{Chi-square}{df} = \frac{1{,}054}{520} = 2.07 \qquad \text{(see M21, Figure B-20)}$$

The ratio of chi-square test to degree of freedom for the final theoretical model is 2.07, which is less than 3. This model provides a good fit to the data.

Step 2: Reviewing the Non-Normed Fit Index and the Comparative Fit Index

The CFI and NNFI shown in Figure B-20 are 0.9316 (M23) and 0.9248 (M24), respectively, indicating a good fit between model and data.

```
                    The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function                                              3.5876
Goodness of Fit Index (GFI)                               0.8285
GFI Adjusted for Degrees of Freedom (AGFI)                0.7999
Root Mean Square Residual (RMR)                           0.0242
Standardized Root Mean Square Residual (SRMR)             0.0379
Parsimonious GFI (Mulaik, 1989)                           0.7531
Chi-Square                                             1054.7511
Chi-Square DF                                                510
Pr > Chi-Square                                           <.0001
Independence Model Chi-Square                             8525.8
Independence Model Chi-Square DF                             561
RMSEA Estimate                                            0.0603
RMSEA 90% Lower Confidence Limit                          0.0551
RMSEA 90% Upper Confidence Limit                          0.0654
ECVI Estimate                                             4.2440
ECVI 90% Lower Confidence Limit                           3.9292
ECVI 90% Upper Confidence Limit                           4.5890
Probability of Close Fit                                  0.0006
Bentler's Comparative Fit Index                           0.9316
Normal Theory Reweighted LS Chi-Square                 1034.8577
Akaike's Information Criterion                           34.7511
Bozdogan's (1987) CAIC                                -2355.6063
Schwarz's Bayesian Criterion                          -1845.6063
McDonald's (1989) Centrality                              0.3973
Bentler & Bonett's (1980) Non-normed Index                0.9248
Bentler & Bonett's (1980) NFI                             0.8763
James, Mulaik, & Brett (1982) Parsimonious NFI            0.7966
Z-Test of Wilson & Hilferty (1931)                       13.1505
Bollen (1986) Normed Index Rho1                           0.8639
Bollen (1988) Non-normed Index Delta2                     0.9320
Hoelter's (1983) Critical N                                  159
```

M21

M22

M23

M24

M25

Figure B-20: Output 1 of final theoretical model result

Step 3: Reviewing the significance tests for factor loading

The standardized factor loadings are shown in Figure B-21. All *t*-values, shown in Figure B-22, are greater than 1.96 at $p < 0.05$. So, all paths are significant at 95% significant level.

```
                    The CALIS Procedure
   Covariance Structure Analysis: Maximum Likelihood Estimation

         Latent Variable Equations with Standardized Estimates

F4     =   0.1470*F1    +  0.4297*F2    +  0.4010*F3    +  0.3578 D4
                  PF4F1          PF4F2          PF4F3
F5     =   0.5102*F4    +  0.3711*F3    +  0.5105 D5
                  PF5F4          PF5F3
F6     =   0.5090*F5    +  0.3178*F1    +  0.6402 D6
                  PF6F5          PF6F1
F7     =   0.1963*F6    +  0.4438*F1    +  0.3344*F2    +  0.4511 D7
                  PF7F6          PF7F1          PF7F2
F8     =   0.2608*F4    +  0.1624*F5    +  0.2665*F7    +  0.3540*F1    +  0.2647 D8
                  PF8F4          PF8F5          PF8F7          PF8F1
```

Figure B-21: Output 2 of final theoretical model result

```
   Covariance Structure Analysis: Maximum Likelihood Estimation

              Latent Variable Equations with Estimates

F4        =   0.1384*F1      +  0.3911*F2      +  0.4759*F3      +  1.0000 D4
Std Err       0.0636 PF4F1      0.1030 PF4F2      0.1282 PF4F3
t Value       2.1768            3.7951            3.7135


F5        =   0.4545*F4      +  0.3924*F3      +  1.0000 D5
Std Err       0.1220 PF5F4      0.1460 PF5F3
t Value       3.7245            2.6881


F6        =   0.3692*F5      +  0.1933*F1      +  1.0000 D6
Std Err       0.0623 PF6F5      0.0501 PF6F1
t Value       5.9276            3.8558


F7        =   0.2980*F6      +  0.4099*F1      +  0.2987*F2      +  1.0000 D7
Std Err       0.1074 PF7F6      0.0857 PF7F1      0.0804 PF7F2
t Value       2.7762            4.7797            3.7125


F8        =   0.3090*F4      +  0.2160*F5      +  0.3218*F7      +  0.3948*F1
Std Err       0.0891 PF8F4      0.0778 PF8F5      0.0914 PF8F7      0.0789 PF8F1
t Value       3.4658            2.7764            3.5213            5.0037
                              +  1.0000 D8
```

Figure B-22: Output 3 of final theoretical model result

Step 4: Reviewing R^2 values for the latent endogenous variables

As can be seen in Figure B-23 (M26), all R^2 values of latent variables are greater than 0.6, accept F6 (0.59). This shows that more than 50% of the variance in the dependent variables are explained by independent variables.

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	V1	0.21697	0.72364	0.7002
2	V2	0.23083	0.82851	0.7214
3	V3	0.23582	0.50100	0.5293
4	V4	0.20820	0.67601	0.6920
5	V5	0.21645	0.61143	0.6460
6	V7	0.23992	0.83262	0.7118
7	V8	0.19141	0.66848	0.7137
8	V9	0.25351	0.89264	0.7160
9	V10	0.26344	0.58380	0.5487
10	V11	0.16503	0.41606	0.6033
11	V12	0.24224	0.64952	0.6270
12	V13	0.22264	0.59842	0.6280
13	V14	0.28916	0.64268	0.5501
14	V16	0.30393	0.89623	0.6609
15	V17	0.22764	0.75708	0.6993
16	V18	0.32202	0.65623	0.5093
17	V19	0.25027	0.74876	0.6658
18	V20	0.20329	0.63827	0.6815
19	V21	0.13290	0.55300	0.7597
20	V22	0.29540	0.49090	0.3983
21	V24	0.37740	0.64466	0.4146
22	V25	0.14276	0.59015	0.7581
23	V26	0.49066	0.76288	0.3568
24	V27	0.39067	0.63592	0.3857
25	V29	0.21246	0.45522	0.5333
26	V30	0.14504	0.36610	0.6038
27	V31	0.20519	0.71498	0.7130
28	V33	0.30397	0.52386	0.4198
29	V34	0.23528	0.50118	0.5305
30	V36	0.15823	0.72351	0.7813
31	V37	0.15032	0.89358	0.8318
32	V38	0.20419	0.67896	0.6993
33	V39	0.16443	0.60978	0.7303
34	V40	0.19809	0.66062	0.7001
35	F4	0.06779	0.52944	0.8720
36	F5	0.10950	0.42011	0.7394
37	F6	0.09061	0.22106	0.5901
38	F7	0.10375	0.50979	0.7965
39	F8	0.05207	0.74326	0.9299

M26

Figure B-23: Output 4 of final theoretical model result

Step 5: Normalized residual matrix

The distribution of normalized residual is nearly symmetrical and centers near zero (Figure B-24).

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 3 Residuals

----------Range---------		Freq	Percent	
-3.75000	-3.50000	2	0.34	
-3.50000	-3.25000	1	0.17	
-3.25000	-3.00000	2	0.34	
-3.00000	-2.75000	3	0.50	*
-2.75000	-2.50000	8	1.34	**
-2.50000	-2.25000	7	1.18	**
-2.25000	-2.00000	15	2.52	*****
-2.00000	-1.75000	16	2.69	*****
-1.75000	-1.50000	20	3.36	******
-1.50000	-1.25000	26	4.37	********
-1.25000	-1.00000	26	4.37	********
-1.00000	-0.75000	28	4.71	*********
-0.75000	-0.50000	43	7.23	**************
-0.50000	-0.25000	47	7.90	***************
-0.25000	0	37	6.22	************
0	0.25000	57	9.58	*******************
0.25000	0.50000	33	5.55	***********
0.50000	0.75000	53	8.91	*****************
0.75000	1.00000	30	5.04	**********
1.00000	1.25000	32	5.38	**********
1.25000	1.50000	27	4.54	*********
1.50000	1.75000	21	3.53	*******
1.75000	2.00000	11	1.85	***
2.00000	2.25000	13	2.18	****
2.25000	2.50000	9	1.51	***
2.50000	2.75000	6	1.01	**
2.75000	3.00000	5	0.84	*
3.00000	3.25000	5	0.84	*
3.25000	3.50000	3	0.50	*
3.50000	3.75000	2	0.34	
3.75000	4.00000	2	0.34	
4.00000	4.25000	2	0.34	

Figure B-24: Output 5 of final theoretical model result

Step 6 and step 8: The Wald test and The Lagrange multiplier test

The Walt test and Lagrange multiplier test do not occur, which means that there is no suggestion to delete or add any path.

Step 7: Chi-square different test

The critical test of the validity of the theoretical approach is the chi-square test comparing the theoretical model (M_t) to the measurement model (M_m). A significant difference between these two models suggests that the theoretical model does not account for relationships between the latent factors that constitute the structural portion of the model.

The chi-square of the measurement model (shown in Figure B-6) is 1,044.9185 and df_m is 499.

The chi-square of the theoretical model (shown in Figure B-20) is 1,054.7511 and df_t is 510.

$M_t - M_m$ = 1,054.7511 – 1,044.9185 = 9.8326

$df_t - df_m$= 510 – 499 = 11

The critical value of chi-square of 11 degree of freedom (p < 0.001) is 31.264. The chi-square difference between two models is less than critical value, so that the chi-square difference test is significant at p < 0.001. Thus, the theoretical model successfully account for the relationships between the latent factors.

Step 9: Parsimony Ratio (PR) and Parsimonious Normed Fit Index (PNFI)

The parsimony of a model refers to its simplicity. The principal of parsimony states that, when several theoretical explanations are equally satisfactory in accounting for some phenomenon, the preferred explanation is the one that is least complicated (the one that makes the fewest assumptions).

One such Index is Parsimony Ratio (PR) (James et al., 1982). The Parsimony Ratio (PR) is easily calculated with the following formula:

$$PR = \frac{df_j}{df_0}$$

where: df_j is the degrees of freedom for the model being studied

df_0 is the degrees of freedom for the null model

The lowest possible value for parsimony ratio is zero, and this value will be obtained for a fully-saturated model in which every V variable is connected to every other V variable by either a covariance or casual path. The upper limit on PR is 1.0, and this value will be obtained for null model in which there is none relationship between any variables.

The null chi-square for the current analysis is 8,525.8 with 561 degrees of freedom (as shown as M22 in Figure B-20). The degrees of freedom of the theoretical model is 510. The Parsimony Ratio (PR) for the theoretical model is calculated as below:

$$PR = \frac{510}{561} = 0.9090$$

This value is used to calculate a second index that also reflects the parsimony of a model, called Parsimonious Fit Index (PNFI). The Parsimonious Fit Index (PNFI) is calculated by using the following formula:

PNFI = (PR)*(NFI)

where: PR is Parsimony Ratio

NFI is Normed Fit Index

The Normed Fit Index (NFI) is a measure of overall fit of a model that may range from zero to 1, with higher values reflecting a better fit. The NFI of the model is 0.8763 (as shown as M25 in Figure B-20). The PNFI for the model can be obtained:

PNFI = 0.9090 * 0.8763 = 0.7966

PNFI is similar to NFI in that the higher values indicate a more desirable model. Like the PR, the PNFI can help in selecting a best model when more than one provides an acceptable fit to the data. Mulaik et al. (1989) indicated that it is possible to have acceptable models with the PNFI in the 0.50.

Step 10: Relative Normed-Fit Index (RNFI)

Relative Normed-Fit Index (RNFI) reflects the fit in just the structural portion of the model, and is not influenced by the fit of the measurement model. The higher values of RNFI (nearer to 1.0) indicate that the hypothesized casual relationships between the structural variables provide a good fit to the data. The RNFI can be calculated as the following formula:

$$RNFI = \frac{F_u - F_j}{F_u - F_m - (df_j - df_m)}$$

where: F_u is the chi-square of the uncorrelated variables model

F_j is the chi-square of the interested model

F_m is the chi-square of the measurement model

df_j is the degrees of freedom of the interested model

df_m is the degrees of freedom of the measurement model

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Fit Function	11.2071
Goodness of Fit Index (GFI)	0.4997
GFI Adjusted for Degrees of Freedom (AGFI)	0.4352
Root Mean Square Residual (RMR)	0.3150
Standardized Root Mean Square Residual (SRMR)	0.4736
Parsimonious GFI (Mulaik, 1989)	0.4694
Chi-Square	3294.8849
Chi-Square DF	527
Pr > Chi-Square	<.0001
Independence Model Chi-Square	8525.8
Independence Model Chi-Square DF	561
RMSEA Estimate	0.1337
RMSEA 90% Lower Confidence Limit	0.1293
RMSEA 90% Upper Confidence Limit	0.1381
ECVI Estimate	11.7322
ECVI 90% Lower Confidence Limit	11.0941
ECVI 90% Upper Confidence Limit	12.3993
Probability of Close Fit	0.0000
Bentler's Comparative Fit Index	0.6525
Normal Theory Reweighted LS Chi-Square	5003.6047
Akaike's Information Criterion	2240.8849
Bozdogan's (1987) CAIC	-229.1511
Schwarz's Bayesian Criterion	297.8489
McDonald's (1989) Centrality	0.0092
Bentler & Bonett's (1980) Non-normed Index	0.6301
Bentler & Bonett's (1980) NFI	0.6135
James, Mulaik, & Brett (1982) Parsimonious NFI	0.5764
Z-Test of Wilson & Hilferty (1931)	41.0354
Bollen (1986) Normed Index Rho1	0.5886
Bollen (1988) Non-normed Index Delta2	0.6540
Hoelter's (1983) Critical N	53

M27

Figure B-25: Output of uncorrelated variables model result

As can be seen in Figure B-25 (M27), the chi-square of the uncorrelated variables model is 3,294.8849. The chi-square and df of the interested model are 1,054.7511 and 510 (see Figure B-20). The chi-square and df of the measurement model are 1,044.9185 and 499 (see Figure B-6).

So, RNFI for the theoretical model is calculated as below:

$$\text{RNFI} = \frac{3{,}294.8849 - 1{,}054.7511}{3{,}294.8849 - 1{,}044.9185 - (510 - 499)} = 1.0005$$

RNFI for the theoretical model is 1.0005. This indicates the fit demonstrated by just the structural portion of the theoretical model, irrespective of how well the latent variables were measured by their indicators. RNFI of 1.0005 indicates a minimally acceptable, although not outstanding fit.

Step 11: Relative Parsimony Ratio (RPR) and the Relative Parsimonious Fit Index (RPFI)

Relative Parsimony Ratio (RPR) can be computed to determine the parsimony of the structural model (Mulaik et al., 1989). RPR for the structural portion of a model range from 0.0 (for the measurement model in which every F variable is related to every other F variable) to 1.0 (for the uncorrelated factors model). The formula for the Relative Parsimony Ratio (RPR) is:

$$RPR = \frac{df_j - df_m}{df_u - df_m}$$

where: df_j is the degrees of freedom of the interested model

df_m is the degrees of freedom of the measurement model

df_u is the degrees of freedom of the uncorrelated variables model

$$RPR = \frac{510 - 499}{527 - 499} = 0.3929$$

The RPR of the theoretical model is 0.3929. This value does not tell whether to accept or reject this model. However, if there are a number of models that are equally acceptable according to other criteria, the model with the higher RPR may be preferred.

RNFI may now be multiplied by the RPR to produce the Relative Parsimonious Fit Index (RPFI). RNFI provides information about the fit in just the structural portion of the model, while RPR provides information about the parsimony of that part of the model. Multiplying them together will provide a single index that simultaneously reflects both the fit and the parsimony in just the structural portion of the model. The Relative Parsimonious Fit Index (RPFI) is computed for the current model as following:

RPFI = (RNFI)* (RPR) = 1.0005 * 0.3929 = 0.3930

Table B-5 shows results for testing structural portion of all models. The first line of the table presents information about the null model in which all variables are completely unrelated to all other variables. The second line of the table presents results for the uncorrelated factors model in which the covariance between all latent variables have been fixed at zero. The third line shows results of measurement model. The fourth to twenty-first lines summarize results from the estimation of the theoretical model and all alternative models.

Table B-5: Goodness of fit and parsimony indices of all models

Model	X^2	df	X^2/df	NFI	NNFI	CFI	PR	PNFI	RNFI	RPR	RPFI
Null model	8,525.8	561	15.20	-	-	-	-	-	-	-	-
Uncorrelated model	3,294.8849	527	6.25	0.6135	0.6301	0.6525	-	-	-	-	-
Measurement model	1,044.9185	499	2.09	0.8774	0.9229	0.9315	-	-	-	-	-
Full maintained model	1,044.9185	493	2.12	0.8774	0.9211	0.9307	0.8788	0.7710	0.9973	-0.2143	-0.2137
PF4F7 path deleted	1,044.9185	494	2.12	0.8774	0.9214	0.9308	0.8806	0.7726	0.9978	-0.1786	-0.1782
PF5F2 path deleted	1,044.9186	495	2.11	0.8774	0.9218	0.9310	0.8824	0.7742	0.9982	-0.1429	-0.1426
PF7F5 path deleted	1,044.9185	496	2.11	0.8774	0.9220	0.9311	0.8841	0.7757	0.9987	-0.1071	-0.1070
PF4F5 path deleted	1,044.9185	497	2.10	0.8774	0.9223	0.9312	0.8859	0.7773	0.9991	-0.0714	-0.0714
PF5F1 path deleted	1,044.92	498	2.10	0.8774	0.9226	0.9313	0.8877	0.7789	0.9996	-0.0357	-0.0357
PF4F6 path deleted	1,044.9195	499	2.09	0.8774	0.9229	0.9315	0.8895	0.7804	1.0000	0.0000	0.0000
PF6F7 path deleted	1,044.9198	500	2.09	0.8774	0.9232	0.9316	0.8913	0.7820	1.0004	0.0357	0.0357
PF5F6 path deleted	1,044.9269	501	2.09	0.8774	0.9235	0.9317	0.8930	0.7836	1.0009	0.0714	0.0715
PF7F4 path deleted	1,044.9664	502	2.08	0.8774	0.9238	0.9318	0.8948	0.7851	1.0013	0.1071	0.1073
PF8F3 path deleted	1,045.121	503	2.08	0.8774	0.9241	0.9319	0.8966	0.7867	1.0017	0.1429	0.1431
PF5F7 path deleted	1,045.7519	504	2.07	0.8773	0.9243	0.9320	0.8984	0.7882	1.0019	0.1786	0.1789
PF6F2 path deleted	1,046.622	505	2.07	0.8772	0.9245	0.9320	0.9002	0.7896	1.0019	0.2143	0.2147
PF6F4 path deleted	1,047.9415	506	2.07	0.8771	0.9246	0.9320	0.9020	0.7911	1.0018	0.2500	0.2504
PF6F3 path deleted	1,049.122	507	2.07	0.8769	0.9247	0.9319	0.9037	0.7925	1.0017	0.2857	0.2862
PF7F3 path deleted	1,050.3924	508	2.07	0.8768	0.9248	0.9319	0.9055	0.7940	1.0016	0.3214	0.3219
PF8F2 path deleted	1,051.8436	509	2.07	0.8766	0.9249	0.9318	0.9073	0.7953	1.0014	0.3571	0.3576
PF8F6 path deleted	1,054.7511	510	2.07	0.8763	0.9248	0.9316	0.9091	0.7966	1.0005	0.3929	0.3931

B.3 Multi-group analysis

The data was divided into two groups by the number of employees. The first group includes 164 companies, which have less than or equal to 200 employees. The other group comprises 138 companies, which have more than 200 employees.

For small sized companies, two paths (from HRM to Delivery and from Delivery to business performance) are insignificant compared to the model of all companies. So, these two paths were dropped during the Wald test. In the final theoretical model, the ratio of chi-square to degree of freedom is 1.55 (795/512) as can be seen in Figure B-26 (M28). The Bentler's Comparative Fit Index (CFI), and Bentler and Bonett's Non-normed Fit Index (NNFI) are 0.9272 (M29, Figure B-26) and 0.9202 (M30, Figure B-26), respectively. All *t*-values are greater than 1.96 at $p < 0.05$ (see Figure B-28). The distribution of residual matrix is normal and symmetrical (see Figure B-29). The results of overall fits and significant paths of small sized companies are shown in Figure B-26, Figure B-27, Figure B-28, and Figure B-29.

```
                     The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function                                            5.1022
Goodness of Fit Index (GFI)                             0.7815
GFI Adjusted for Degrees of Freedom (AGFI)              0.7460
Root Mean Square Residual (RMR)                         0.0306
Standardized Root Mean Square Residual (SRMR)           0.0491      M28
Parsimonious GFI (Mulaik, 1989)                         0.7132
Chi-Square                                            795.9447
Chi-Square DF                                              512
Pr > Chi-Square                                         <.0001
Independence Model Chi-Square                           4460.0
Independence Model Chi-Square DF                           561
RMSEA Estimate                                          0.0596
RMSEA 90% Lower Confidence Limit                        0.0515
RMSEA 90% Upper Confidence Limit                        0.0675
ECVI Estimate                                           6.4741
ECVI 90% Lower Confidence Limit                         5.9910      M29
ECVI 90% Upper Confidence Limit                         7.0251
Probability of Close Fit                                0.0272
Bentler's Comparative Fit Index                         0.9272
Normal Theory Reweighted LS Chi-Square                741.6141
Akaike's Information Criterion                       -228.0553
Bozdogan's (1987) CAIC                              -2304.8531      M30
Schwarz's Bayesian Criterion                        -1792.8531
McDonald's (1989) Centrality                            0.4048
Bentler & Bonett's (1980) Non-normed Index              0.9202
Bentler & Bonett's (1980) NFI                           0.8215
James, Mulaik, & Brett (1982) Parsimonious NFI          0.7498
Z-Test of Wilson & Hilferty (1931)                      7.6256
Bollen (1986) Normed Index Rho1                         0.8045
Bollen (1988) Non-normed Index Delta2                   0.9281
Hoelter's (1983) Critical N                                112
```

Figure B-26: Output 1 of the final theoretical model result of the small sized companies

```
                    The CALIS Procedure
 Covariance Structure Analysis: Maximum Likelihood Estimation

      Latent Variable Equations with Standardized Estimates

F4      =   0.2061*F1     +  0.5047*F2     +  0.3039*F3     +  0.2930 D4
                   PF4F1           PF4F2           PF4F3
F5      =   0.8319*F4     +  0.5550 D5
                   PF5F4
F6      =   0.5408*F5     +  0.2759*F1     +  0.6556 D6
                   PF6F5           PF6F1
F7      =   0.1895*F6     +  0.4533*F1     +  0.3430*F2     +  0.4575 D7
                   PF7F6           PF7F1           PF7F2
F8      =   0.3640*F4     +  0.3589*F7     +  0.3180*F1     +  0.2116 D8
                   PF8F4           PF8F7           PF8F1
```

Figure B-27: Output 2 of the final theoretical model result

of the small sized companies

```
                    The CALIS Procedure
 Covariance Structure Analysis: Maximum Likelihood Estimation

           Latent Variable Equations with Estimates

F4        =   0.1729*F1     +  0.4042*F2     +  0.3526*F3     +  1.0000 D4
Std Err       0.0635 PF4F1     0.1255 PF4F2     0.1653 PF4F3
t Value       2.7241           3.2198           2.1332
F5        =   0.8217*F4     +  1.0000 D5
Std Err       0.0834 PF5F4
t Value       9.8500
F6        =   0.3815*F5     +  0.1613*F1     +  1.0000 D6
Std Err       0.0851 PF6F5     0.0660 PF6F1
t Value       4.4838           2.4453
F7        =   0.3223*F6     +  0.4505*F1     +  0.3255*F2     +  1.0000 D7
Std Err       0.1595 PF7F6     0.1088 PF7F1     0.1014 PF7F2
t Value       2.0209           4.1407           3.2109
F8        =   0.4557*F4     +  0.3792*F7     +  0.3340*F1     +  1.0000 D8
Std Err       0.1052 PF8F4     0.1117 PF8F7     0.0929 PF8F1
t Value       4.3335           3.3939           3.5966
```

Figure B-28: Output 3 of the final theoretical model result

of the small sized companies

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 3 Residuals

----------Range---------		Freq	Percent	
-3.50000	-3.25000	1	0.17	
-3.25000	-3.00000	1	0.17	
-3.00000	-2.75000	2	0.34	
-2.75000	-2.50000	3	0.50	*
-2.50000	-2.25000	6	1.01	**
-2.25000	-2.00000	5	0.84	*
-2.00000	-1.75000	7	1.18	**
-1.75000	-1.50000	18	3.03	******
-1.50000	-1.25000	23	3.87	*******
-1.25000	-1.00000	32	5.38	**********
-1.00000	-0.75000	33	5.55	***********
-0.75000	-0.50000	44	7.39	**************
-0.50000	-0.25000	44	7.39	**************
-0.25000	0	42	7.06	**************
0	0.25000	66	11.09	**********************
0.25000	0.50000	49	8.24	****************
0.50000	0.75000	36	6.05	************
0.75000	1.00000	51	8.57	*****************
1.00000	1.25000	35	5.88	***********
1.25000	1.50000	27	4.54	*********
1.50000	1.75000	20	3.36	******
1.75000	2.00000	10	1.68	***
2.00000	2.25000	11	1.85	***
2.25000	2.50000	9	1.51	***
2.50000	2.75000	6	1.01	**
2.75000	3.00000	5	0.84	*
3.00000	3.25000	4	0.67	*
3.25000	3.50000	0	0.00	
3.50000	3.75000	2	0.34	
3.75000	4.00000	2	0.34	
4.00000	4.25000	0	0.00	
4.25000	4.50000	1	0.17	

Figure B-29: Output 4 of the final theoretical model result of the small sized companies

For large sized companies, two paths (from SCI to Quality and from SCI to Cost) are insignificant compared to the model of all companies. So, these two paths were dropped during the Wald test. In the final theoretical model, goodness-of-fit indices also indicate an acceptable fit of the structural model to the data. The ratio of chi-square to degree of freedom is 1.52 (776/512) as can be seen in Figure B-30 (M31). The Bentler's Comparative Fit Index (CFI) is 0.9358 (see M32, Figure B-30), and Bentler and Bonett's Non-normed Fit Index (NNFI) is 0.9296 (see M33, Figure B-30), all above the desired 0.90 level. All *t*-values are greater than 1.96 at $p < 0.05$ (see Figure B-32). The distribution of residual matrix is normal and symmetrical (see Figure B-33). The results of the overall fit and significant paths of large sized companies are shown in Figure B-30, Figure B-31, Figure B-32, and Figure B-33.

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	5.6685
Goodness of Fit Index (GFI)	0.7574
GFI Adjusted for Degrees of Freedom (AGFI)	0.7181
Root Mean Square Residual (RMR)	0.0282
Standardized Root Mean Square Residual (SRMR)	0.0425
Parsimonious GFI (Mulaik, 1989)	0.6913
Chi-Square	776.5818
Chi-Square DF	512
Pr > Chi-Square	<.0001
Independence Model Chi-Square	4680.4
Independence Model Chi-Square DF	561
RMSEA Estimate	0.0614
RMSEA 90% Lower Confidence Limit	0.0525
RMSEA 90% Upper Confidence Limit	0.0700
ECVI Estimate	7.2959
ECVI 90% Lower Confidence Limit	6.7575
ECVI 90% Upper Confidence Limit	7.9158
Probability of Close Fit	0.0186
Bentler's Comparative Fit Index	0.9358
Normal Theory Reweighted LS Chi-Square	745.8420
Akaike's Information Criterion	-247.4182
Bozdogan's (1987) CAIC	-2258.1721
Schwarz's Bayesian Criterion	-1746.1721
McDonald's (1989) Centrality	0.3834
Bentler & Bonett's (1980) Non-normed Index	0.9296
Bentler & Bonett's (1980) NFI	0.8341
James, Mulaik, & Brett (1982) Parsimonious NFI	0.7612
Z-Test of Wilson & Hilferty (1931)	7.1710
Bollen (1986) Normed Index Rho1	0.8182
Bollen (1988) Non-normed Index Delta2	0.9365
Hoelter's (1983) Critical N	101

M31

M32

M33

Figure B-30: Output 1 of the final theoretical model result

of the large sized companies

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Standardized Estimates

```
F4   =  0.4830*F2    +  0.4685*F3    +  0.3803 D4
            PF4F2           PF4F3
F5   =  0.4372*F4    +  0.4854*F3    +  0.4382 D5
            PF5F4           PF5F3
F6   =  0.4652*F5    +  0.3617*F1    +  0.6259 D6
            PF6F5           PF6F1
F7   =  0.2883*F6    +  0.6502*F2    +  0.4802 D7
            PF7F6           PF7F2
F8   =  0.2167*F4    +  0.2124*F5    +  0.2795*F7    +  0.3449*F1    +  0.2407 D8
            PF8F4           PF8F5           PF8F7           PF8F1
```

Figure B-31: Output 2 of the final theoretical model result

of the large sized companies

Covariance Structure Analysis: Maximum Likelihood Estimation

Latent Variable Equations with Estimates

```
F4        =   0.4916*F2      +  0.5562*F3      +  1.0000 D4
Std Err       0.1468 PF4F2      0.1728 PF4F3
t Value       3.3489            3.2195


F5        =   0.3580*F4      +  0.4719*F3      +  1.0000 D5
Std Err       0.1349 PF5F4      0.1634 PF5F3
t Value       2.6547            2.8890


F6        =   0.3409*F5      +  0.2235*F1      +  1.0000 D6
Std Err       0.0969 PF6F5      0.0802 PF6F1
t Value       3.5177            2.7871


F7        =   0.4139*F6      +  0.5702*F2      +  1.0000 D7
Std Err       0.1476 PF7F6      0.0943 PF7F2
t Value       2.8037            6.0480


F8        =   0.2444*F4      +  0.2925*F5      +  0.3658*F7      +  0.4005*F1
Std Err       0.1124 PF8F4      0.1212 PF8F5      0.1007 PF8F7      0.0905 PF8F1
t Value       2.1738            2.4130            3.6333            4.4278
                                  +  1.0000 D8
```

Figure B-32: Output 3 of the final theoretical model result of the large sized companies

The CALIS Procedure
Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 3 Residuals

----------Range---------		Freq	Percent	
-4.25000	-4.00000	1	0.17	
-4.00000	-3.75000	0	0.00	
-3.75000	-3.50000	0	0.00	
-3.50000	-3.25000	0	0.00	
-3.25000	-3.00000	2	0.34	
-3.00000	-2.75000	2	0.34	
-2.75000	-2.50000	3	0.50	*
-2.50000	-2.25000	6	1.01	**
-2.25000	-2.00000	15	2.52	*****
-2.00000	-1.75000	17	2.86	*****
-1.75000	-1.50000	17	2.86	*****
-1.50000	-1.25000	23	3.87	*******
-1.25000	-1.00000	31	5.21	**********
-1.00000	-0.75000	32	5.38	**********
-0.75000	-0.50000	48	8.07	****************
-0.50000	-0.25000	51	8.57	*****************
-0.25000	0	47	7.90	***************
0	0.25000	73	12.27	************************
0.25000	0.50000	51	8.57	*****************
0.50000	0.75000	42	7.06	**************
0.75000	1.00000	27	4.54	*********
1.00000	1.25000	34	5.71	***********
1.25000	1.50000	15	2.52	*****
1.50000	1.75000	10	1.68	***
1.75000	2.00000	15	2.52	*****
2.00000	2.25000	15	2.52	*****
2.25000	2.50000	6	1.01	**
2.50000	2.75000	3	0.50	*
2.75000	3.00000	5	0.84	*
3.00000	3.25000	2	0.34	
3.25000	3.50000	1	0.17	
3.50000	3.75000	0	0.00	

Figure B-33: Output 4 of the final theoretical model result

of the large sized companies