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An analysis of the uncertainty factors affecting the sustainable supply of rice production in Thailand

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An Analysis of the Uncertainty Factors Affecting the Sustainable Supply of Rice Production in Thailand

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THESIS CERTIFICATION

I, Phatcharee Toghaw THONGRATTANA, declare that this thesis in fulfilment of the requirements for the award of Doctor of Philosophy, in the Sydney Business School, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institutions.

Phatcharee Toghaw THONGRATTANA
May 2012

ABSTRACT

The production of rice – a staple food for half the world's population – plays an increasingly vital role in providing global food security. Thailand is the world's main rice exporter, and rice cultivation is a dominant industry in the Thai economy; these two factors make Thailand vulnerable to fluctuations in demand and the increasing instability of the natural environment.

A number of studies have attempted to explain how supply chain management practices help firms maintain high supply chain performance in uncertain conditions. However, these relationships have not yet been investigated in the context of the Thai rice supply chain (TRSC). Thus, the main objective of this thesis is to develop a conceptual framework and use it to analyse the impact of uncertainty factors on supply chain management practices and supply chain performance, and the impact of supply chain management practices on supply chain performance in the TRSC.

Evidence from the literature shows that seven uncertainty factors (supply, demand, process, planning and control, competitor behaviour, government policy and climate), three supply chain management practices (strategic purchasing, LEAN principles and customer-relationship management) and two supply chain performance measures (rice quality and efficiency) are relevant in the context of the TRSC. This thesis is the first empirical study to include government policy and climate ambiguity as uncertainty factors in the TRSC.

Data was collected through a mail-out survey of Thai rice-milling and rice-exporting firms and analysed using the partial least square technique. Competitor uncertainty had the greatest negative impact on supply-chain efficiency. The relationship between demand uncertainty and supply chain performance had a significant effect on rice quality. This suggests that managers should consider the need to cope with climate change, specifically through practices such as strategic purchasing. Interestingly, uncertainty in Thai government policies does not influence the management practices or performance of the TRSC.

Finally, this thesis recommends that policy-makers should encourage TRSC members to implement supply chain management practices to improve their performance. However, since most of them are SMEs, this may limit which practices they can feasibly apply. Practitioners should thus consider putting into operation of strategic purchasing in the first instance.

PUBLICATION FROM THE RESEARCH

Thongrattana, PT & Perera, N 2010, 'Perceived Environmental Uncertainty along the Thai Rice Supply Chain: An Empirical Approach', *Operations and Supply Chain Management: An International Journal.* , vol. 3, no. 3, pp. 117-133.

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Thongrattana, PT, Jie, F & Perera, N 2009, *A Conceptual Framework of the Rice Supply Chain in Thailand*: *7th ANZAM Operations, Supply Chain and Services Management Symposium*, Adelaide, Australia.

Thongrattana, PT, Jie, F & Perera, N 2009, *Understanding the Impact of Environmental Uncertainty on Efficiency Performance Indicators of Thai Rice Millers*: *the Australian and New Zealand Marketing Academy Conference*, Melbourne, Australia.

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CHAPTER 1

INTRODUCTION

1.1 Overview

Over the past century, continuing world population increases have raised concerns about food security. Rice, which is consumed by half of the world's population, plays a vital role in addressing these concerns. This presents a challenge to the rice industry in Thailand, the world's biggest rice exporter in 2010, a position it looks to maintain in 2011 (Anonymous 2011). This industry faces difficulties in both supply and demand. On the supply side, rice output is uncertain because its production mainly relies on the natural environment, while its demand is difficult to forecast due to intensely competitive markets and changes in consumer behaviour. Supply chain management, a popular strategy to improve industry performance generally, can also specifically improve the Thai rice supply chain (TRSC).

Many organisations recognise that supply chain practices can improve their performance and bring competitive advantages. A number of studies, such as Paulraj and Chen (2007) and Li (2002), have attempted to explain how supply chain management practices deal with unpredictable factors to maintain high supply chain performance. However, the findings from previous studies on the impact of uncertainty factors on supply chain management practices and performance are inconsistent (Davis 1993; van der Vorst 2000; Li 2002).

Moreover, although many studies investigate the impact of these uncertainty factors, not all results can be applied to the TRSC. Thus, the main objective of this thesis is to investigate the impact of uncertainty factors specifically on the TRSC in terms of its supply chain management practices and performance by using a conceptual framework.

This thesis analyses the TRSC using a conceptual framework to explain the extent and ways in which uncertainty factors affect supply chain management practices and performance in terms of rice quality and efficiency. It investigates the uncertainty inherent in seven uncertainty factors: supply, demand, process, planning and control, competitor behaviour, government policy and climate. This study also examines three supply chain management practices: strategic purchasing; LEAN principles and customer-relationship management.

This chapter provides an overview of the thesis and its organisation. Section 1.2 discusses the research background, which leads to identification of the research problems in Section 1.3. Section 1.4 identifies the research question which guides the research objectives in Section 1.5. Section 1.6 explores the research methodology. Section 1.7 summaries the research contribution of this study. Section 1.8 examines the study's limitations, and Section 1.9 presents the organisation of the rest of the thesis.

1.2 Background of the Research

In the last decade, supply chain management has played an important role in leading companies to succeed in their business goals, to gain competitive advantages and to improve business performance (Fearne, Hughes & Duffy 2001; Cohen & Roussel 2005; Robertson 2006). Extensive studies have focused on how to improve supply chain performance in real-time conditions in an uncertain environment. This uncertainty harms supply chain performance, which in turn influences many companies to adopt proper supply chain management practices to identify and deal with uncertainty factors (Davis 1993).

Uncertainty factors along a supply chain include supply, demand and process uncertainty (Ettlie & Reza 1992; Davis 1993), planning and control uncertainty (Childerhouse & Towill 2004) and competitor uncertainty (Ettlie & Reza 1992). These factors negatively affect supply chain performance (Davis 1993; Bhatnagar & Sohal 2005; Paulraj & Chen 2007) and force organisations to implement supply chain management strategies (Paulraj & Chen 2007). At least one researcher has found, however, that for a sample of surveyed organisations in the United States, customer,

supplier, competitor, and technology uncertainty do not influence supply chain management practices (Li 2002). These inconsistent results motivate this research to investigate the impact of uncertainty factors in supply chain management practices and supply chain performance in agri-food supply chains.

Agri-food supply chains have distinct characteristics. Their demand fluctuates depending on factors such as the world population growth, consumer behavior and intense market competition. Their supply relies on uncontrollable natural forces (Wijnands & Ondersteijn 2006). Therefore, in this unique environment, the impact of uncertainty factors on supply chain management practices and performance cannot necessarily be predicted from previous studies as the characteristics of the supply chain studied have been different from those of the TRSC. Only a few studies have focused on uncertainty factors (supply, demand, process, and planning and control) in food supply chains (van der Vorst 2000). Van der Vorst's (2000) study of food supply chain is based on three case studies and does not use statistical analysis. How uncertainty factors affect supply chain management and performance has not been empirically investigated in agri-food supply chains.

This study focused on the TRSC as the research context for three main reasons:

- The importance of the TRSC;
- The distinctive environment of the TRSC; and
- The significant contribution to the body of knowledge about supply chains and about the Thai rice industry.

The TRSC plays a vital role in both the Thai economy. It creates jobs for around 56 percent of the Thai population (Krasachat 2004), and accounts for approximately 12 percent of Thai GDP (U.S. State Department 2011). This industry has faced challenges on both the supply and the demand side. When considering rice production, rainfall is the climate determinant for the rice crop period and the stability of crop yield (Yoshida 1981); for instance, approximately 77 percent of total rice production was cropped in the wet season, on 86 percent of the annual rice-cultivation area (Parpertchob, Bhandari & Pandey 2005). As seen in Chapter 2, there is evidence that disruptions to the rice flow in this supply chain can seriously affect

the Thai rice industry. The findings of this research could improve the stability and performance of the Thai rice industry and its supply chain members.

The TRSC is important in the international market. The findings of this investigation concern not only the Thai rice industry, but the international rice market as well, in which. Thailand is the largest supplier (Anonymous 2011). As the demand for rice on the world market has continued to grow, other rice- exporting countries such as Vietnam and the Philippines have faced difficulties in rice production due to natural disasters. This raises the demand for Thai rice (IRRI 2007). However, when normal circumstances return, the demand on Thai rice can be expected to return to normal level. To reduce the resulting market turbulence, an examination of the TRSC is worthwhile.

Most previous studies have addressed the impact of environmental uncertainty on supply chain management and supply chain performance in general (Davis 1993; Childerhouse & Towill 2004; Dirk Pieter van & Taco van er 2005; Hsiao 2006; Paulraj & Chen 2007). Only a few studies have focused on food supply chains (van der Vorst 2000), and these are based on a small number of case studies. This gap in academic research highlights the unique nature of supply, process and demand in agri-food supply chains, as opposed to general products or retail supply chains. The rice supply chain is considered as a representative agri-food supply chain in this study.

Table 1.1 lists the main research relating to uncertainty factors, supply chain management practices and supply chain performance.

Table 1-1: The Main Research Linking Uncertainty Factors, Supply Chain Practices and Supply Chain Performance

Authors	**Sources of Uncertainty**	**Performance Measurement**	**Supply Chain Practices**	**Scope/Methodology**
Davis (1993)	Supplier performance, manufacturing process, and demand uncertainty	Cost and customer service (line-items fill rate and delivery delay)	A strategic modeling tool for a decision support system	Case study: Hewlett-Packard
Badri et al.(2000)	Government policy and political environment	Financial performance	Operation strategy	Interview and questionnaire in the UAE
van der Vorst (2000)	Supply, demand and distribution, process, and planning and control	Safety buffer and inventory level	n/a	Food supply chain with three case studies
(Min & Mentzer 2000)	Competitor actions in the role of marketing	Firm's business performance: efficiency and effectiveness	Market information, information sharing, close long-term relationship, and inter-firm cooperation	- The marketing concept influence SCM implement - Conceptual framework development
Petrovic (2001)	Fuzzy demand, lead time and external supplier reliability	Total supply chain cost, inventory level and fill rate	Inventory management strategy	Simulation model, uncertainties are present in fuzzy logic set
Li (2002)	Customer uncertainty supplier uncertainty and technology uncertainty	- SC flexibility - SC integration - Customer responsiveness -Supplier performance - Partnership quality	- Strategic supplier partnership - Customer relationship - Information-sharing -Information quality - Lean system - Postponement	Survey method > 100 employees firms in USA as target sample
van der Vorst & Beulens (2002)	Demand, distribution, process, planning and control uncertainty	n/a	Supply chain redesign strategies	Qualitative methods with three case studies in food supply chain in the Netherlands
Childerhouse and Towill (2004)	Demand, supply, control system, and process uncertainty	Inventory level, cost, market share and profitability	Value-stream analysis	Two case studies (mechanical precision product and construction-sector product)
Reinartz, Krafft et al. (2004)	n/a	Perceptual and objective economic performance e.g. profitability, return on asset	Customer-relationship management process	Primary source from survey in Austria, Germany and Switzerland. Secondary source from objective performance measures
Ondersteijn, Giesen & Huirne (2006)	Economical, political, social and ecological factors.	n/a	Strategic choices: process-control and diversification strategies	Survey method with sample size of 103 Dutch dairy farms
Bhatnagar & Sohal (2005)	Supplier, process, and demand uncertainty	Supply chain competitiveness such as lead time, inventory, time to market, quality, customer service and flexibility	Plant location strategy and manufacturing practices	Survey method with manufacturing operation companies in Asian countries
Hua, Li et al. (2006)	Demand uncertainty	The overall supply chain profit and efficiency	Cooperation between manufacturers and retailers	Mathematical model with probability distribution
Hsiao (2006)	Decision-making uncertainty	Supply chain performance as part of both financial and non-financial performance	n/a	Survey method with sporting-goods retail businesses in Taiwan
Paulraj & Chen (2007)	Supply, demand and technology uncertainty	Supplier and buyer performance, strategic supply management	Strategic purchasing, long-term relationship, inter-firm communication and supplier integration	Survey method in USA

1.3 Identification of the Research Problem

The existing literature has not address the issues of uncertainty factors, supply chain management practices and supply chain performance of the TRSC. These issues will be addressed in this thesis.

- Link between the supply chain management practices and supply chain performance in an agri-food supply chain context.

  In recent year, there has been an impressive accumulation of studies proving that supply chain management plays an important role in improving supply chain performance and competitive ability in terms of cost reduction, product quality, ability to meet customer requirements (Wisner 2005) and competitive advantage (Mentzer et al. 2001) in a variety of case studies. This might be also true specifically for the TRSC. However, no study has been undertaken to confirm that supply chain management practices can improve the performance of the TRSC. Understanding the impact of supply chain management practices on this supply chain performance can give rise to alternative supply chain management practices that entrepreneurs can use to improve the performance of the TRSC or other agri-food supply chains.

- Lack of a framework how uncertainty factors can affect supply chain management practices and performance.

  There are numerous studies on uncertainty factors in a supply chain. They are found that uncertainty factors are the main cause of unstable processes and the reduction of performance efficiency along the supply chain (Davis 1993; Persson 1995). Despite all the extensive efforts employed in earlier research to examine the effect of many uncertainty factors that are supply, demand, process, planning and control, and competitor (Davis 1993; Childerhouse & Towill 2004; van Donk & van der Vaart 2005; Hsiao 2006; Paulraj & Chen 2007) government policy (Badri, Davis & Davis 2000) and climate uncertainty (Thongrattana, Jie & Parton 2011) on supply chain management and performance, no attempt has been made to integrate these into one study. To do this, the research will investigate the conceptual framework underpinning the relationships among uncertainty factors, supply chain management practices and supply chain performance in the context

of TRSC. From the framework, a number of assumption and hypotheses relating to these factors can be identified and tested. Result from such hypothesis testing will facilitate understanding of how the TRSC uses their supply chain management practices to reduce uncertainty factors and improve its performance.

To contribute to the understanding of the TRSC and its context, Chapter 3 will discuss its supply chain members and mapping.

1.4 Research Question and Hypotheses

Though it is widely argued that uncertainty factors generate unstable processes along supply chains which in the end worsen their performance, and in another side they encourages companies to employ highly effective supply chain management (Davis 1993; Childerhouse & Towill 2004), the work of Li (2002) found that some uncertainty factors such supplier, customer, competitor and technology uncertainty are not the driving force for supply chain management practices. According to the previous studies, the relationship between uncertainty factors and supply chain management practices are inconsistent.

Moreover, although the study of van der Vorst (2000) has shown that some uncertainty factors such as supply, demand, process, and planning and control uncertainty factors can reduce the Dutch food supply chain performance. Such studies do not provide a clear picture of the relationships among uncertainty factors, supply chain management practices and performance in the TRSC. Therefore, this thesis explores a number of research questions relating to the relationships among uncertainty factors, supply chain management practices and performance in the TRSC. The main research question is *'To what extent and in what way do uncertainty factors affect supply chain management pracftice and supply chain performance in the Thai rice supply chain (TRSC)?'*

The main research question can be divided into three specific research questions.

1) What are the key uncertainty factors having greatest impact on the performance of the Thai rice supply chain?

2) How do uncertainty factors affect supply chain practices on the upstream side, on the downstream side and in the internal supply chain process in the Thai rice supply chain?
3) How do different supply chain practices in the Thai rice supply chain affect its performance?

The basic hypotheses therefore are:

H1: The higher the level of uncertainty, the lower the level of rice supply chain performance in Thailand.

H2: The higher the level of uncertainty, the higher the level of supply chain practices.

H3: The higher the level of rice supply chain practices, the higher the level of rice supply chain performance.

The development of three main hypotheses will be addressed in Section 4.4.

1.5 Objective of the Research

As mentioned in the first section of this chapter, the main objective of this thesis is to investigate the impact of uncertainty factors on the TRSC in terms of its supply chain management practices and performance by using a conceptual framework. With this main objective, this study aims to achieve the following:

1) To develop a conceptual framework of the uncertainty factors having an impact on supply chain practices and supply chain performance for the Thai rice industry;
2) To establish a conceptual framework of supply chain management practices having an impact on supply chain performance for the Thai rice industry; and
3) To analyse the impact of uncertainty factors on supply chain management practices and supply chain performance, and the impact of supply chain management practices on supply chain performance in the Thai supply chain.

1.6 Methodology

The research process used to answer the research question and to fill the gaps of knowledge is a deductive approach based on a positivistic approach to research. The research, which employs a hypothetico-deductive method based on relative emphasis upon whether theory comes first (Pathirage, Amaratunga & Haigh 2008), follows a seven-step process (Sekaran 2003):

Step 1 – observation. Broad area of research interest identified.

Step 2 – problem identification from the primary gathering of information.

Step 3 – theory formation from a conceptual framework that clearly identifies and labels variables

Step 4 – hypothesizing. A possible explanation to some phenomenon is proposed.

Step 5 – further scientific data collection

Step 6 – data analysis.

Step 7 – deduction. Conclusions are reached by interpreting the results of the data analysis. Hypotheses are substantiated and research questions are answered.

The next chapter presents a review of previous studies relating to the relationships among uncertainty factors, supply chain management practices and performance, in accordance with Step 2. The conceptual framework is developed by considering which uncertainty factors, supply chain management practices and performance measures are relevant to the TRSC.

Based on the nature of the research question as part of a positivist paradigm (Hussey & Hussey 1997), this study uses a quantitative research method to support its focus on the formulation and testing of the hypotheses. Moreover, this study seeks reliability and validity measurement and analysis of a particular concept by statistics (Easterby-Smith 1991; Jean Lee 1992; Saunders 2003; Mangan, Lalwani & Gardner 2004; Veal 2005; Azhdar, Jennifer & Farhad 2006; Cooper 2006). The data-collection method in this study is a mailed questionnaire, since it can best cover the geographical area at a relatively low cost (Sekaran 2003).

The development of the survey instrument in this research follows the principles of questionnaire design suggested by Sekaran (2003) in terms of wording, measurement, and how the questionnaire looks. This includes elements such as a good introduction, well-organised instructions and neat alignment of the questions. After constructing a questionnaire, pre-testing with a group and a redesigning of the questionnaire is required in order to improve the quality of the answers. A number of statistical techniques are employed to test assumptions and hypotheses in the framework. Two main types of statistical techniques are implemented in this study: exploratory and confirmatory data analysis.

The exploratory data analysis includes non-bias testing, non-parametric testing, confirmatory tetrad analysis test (CTA), exploratory factor analysis (EFA) and reliability and validity tests. The confirmatory data analysis includes component-based structural equation modeling specifically, partial least squares. Several software packages such as VisualPLS, PLS-Graph, SPAD-PLS and SmartPLS, can be used to analyse partial least squares. SmartPLS is chosen for this study because it provides user-friendliness and a bootstrap procedure for assessing the significance of parameter estimates (Tenenhausa et al. 2005).

As discussed in Chapter 3, there are three main sectors in the Thai rice supply chain: rice cultivators, millers and marketers/exporters.

Rice millers and exporters were nominated for data collection for this study, for several reasons:

- Rice millers and exporters' activities are related to supply chain management, as they must deal with their suppliers and customers.
- Milling and marketing are two essential sectors of the TRSC as discussed in Chapter 3.
- Commercial rice mills are located across Thailand (Rice Knowledge Bank 2009), and hold the highest inventory of paddy rice and milled rice of all organisation in Thailand. The total milling capacity of all Thai millers is 100 million tonnes of paddy rice per annum (Thai Rice Mills Association 2011)

- Rice exporters are an important supply chain member of TRSC. First, rice exporters must deal with uncertainty demand of the global market (FAPRI 2010). The high competition among other rice export countries in this market leads to uncertainty demand for Thai rice exporters. Second, rice exporters do a brisk trade with international customers, exporting 47% of total rice output (Office of Agricultural Economics 2009)or around 8 to 9 million tonnes worth approximately 200 billion baht ($US 6.5 billion) per year (Anonymous 2010). Third, rice exporters play a vital role in managing the price of Thai rice in the world market as Thai rice is the biggest rice exporter. The price of exported Thai rice is expected to increase by 10 percent in 2011 influenced by high demand in the world market (Thai Rice Mills Association 2010), boosting the industry's profit margin.
- The researcher could access only the address lists of rice-milling and rice-exporting companies, through the Thai Rice Mills Association and Thai Rice Exporters Association respectively. Furthermore, of 30 million people producing rice in Thailand, 16 million are poor and uneducated (Vanichanont 2004), and with poor knowledge of business and management; they might not be able to provide good-quality data and perspective on the supply chain. Mailing a questionnaire to all rice farmers would be unfeasible, and the data from them might be of low quality.
- Unlike rice millers and exporters, rice wholesalers and retailers cannot provide data about particular rice products, as they sell many products at the same time. Moreover, there is no information on specific numbers of rice wholesalers and retailers in Thailand.

The significant contribution of rice millers and rice exporters to the Thai rice industry and the national economy make the improvement of their performance a critical issue.

1.7 Summary of Research Contribution

This thesis provides a number of knowledge contributions. The development and application of a conceptual framework provides a comprehensive examination of uncertainty factors, supply chain management practices and performance in the

TRSC. More specifically, it investigates how uncertainty factors influence supply chain management practices and supply chain performance in the Thai rice industry. This study is innovative in that it is the first to add government policy and climate as uncertainty factors in the TRSC. Overall, the findings from this study make a number of contributions to the body of knowledge about supply chain management.

1) This study is the first to incorporate climate uncertainty in examining supply chain management. Earlier, studies of climate uncertainty examined long-term change in the statistical distribution of weather patterns over a period of time, but not in terms of climate's effects on supply chain management. Adverse climate conditions reflect a trend of slower growth in agricultural production and more rapid growth in demand (Trostle 2008), and can increase the price of paddy rice. This, in turn, increases the raw material cost for rice millers and exporters. The literature clearly shows that climate change plays a vital role in agri-business, and should be one factor for managerial decision-making (Hoogenboom 2000; Trostle 2008). The lack of studies measuring climate uncertainty and its effects on agri-business has created the need to construct a focused, empirical study that can explain the way in which climate uncertainty influences an agricultural supply chain. The findings of this research show that to cope with climate uncertainty, TRSC members need to pay more attention to strategic purchasing, which requires a great deal of collaboration with their suppliers to ensure that the suppliers can provide an adequate amount of paddy rice at the proper price, as well as a strong focus on longer-term ways to mitigate the effects of climate uncertainty.

2) The study of Badri, Davis et al. (2000) addressed the effects of government policy in developing countries on operation strategies and firm performance, but not on a supply chain. Since rice is the dominant agricultural product in Thailand, the Thai Government uses many laws and regulations to govern rice price, production and market (Yao 1997; Department of Internal Trade 2008). However, there has been no study examining government policy uncertainty as a source of uncertainty along the TRSC. Interestingly, in contrast to the findings from previous studies, the results of this study show that government policy uncertainty in Thailand does not influence either the supply chain management practices or the performance of the TRSC. Davis (1993) found that uncertainty factors can play a lesser role in

supply chain performance when identifying and controlling the sources of uncertainty has become a common practice. Thus, in the Thai rice industry, government policy uncertainty may have already familiar to the TRSC members, who may already have developed methods to cope with it.

1.8 Delimitations of Scope and Key Assumptions

The scope and assumptions of this research are explained below:

1) This study focuses only on the rice supply chain in Thailand.
2) Rice supply chain performance measurement focuses on efficiency and rice quality, which in this study are measured subjectively.
3) The populations sampled in this study are rice millers and rice exporters in Thailand.
4) The research methodology and analysis in this study are based on a questionnaire approach.
5) It is assumed that there are no errors in the translation of the questionnaire from English to Thai. The assumption is made that the data from returned questionnaires is appropriate and accurate.
6) The questionnaire does not request confidential or sensitive data requested so as to avoid receiving biased data from respondents.

1.9 The Organisation of the Thesis

Chapter 2 provides a critical evaluation of the literature concerning the fundamentals of supply chain management in agri-food supply chains. It reviews previous studies of strategic purchasing, LEAN principles and customer-relationship management, and discusses generic supply chain and agri-food supply chain performance as a step in investigating the impact of supply chain management practices on supply chain performance. This is followed by a discussion of the uncertainty factors in supply chains, agri-food supply chains, and particular the TRSC. Chapter 3 provides an overview of the global rice scenario, the rice industry and the rice supply chain in Thailand as the context of this study.

Chapter 4 discusses the conceptual framework for depicting the relationships among uncertainty factors, supply chain management and performance that are linked to the development of the research hypotheses and research questions. Chapter 5 describes the research methodology employed in this thesis and the research design, survey-instrument development and data-collection procedure. Chapter 5 also discusses and clarifies the types of constructs in this study as different types of constructs require different methods of statistical analysis.

Chapter 6 sets out the process of the exploratory analysis of the data from the questionnaire; this consists of a non-bias test, non-parametric test, confirmatory tetrad analysis test (CTA) and exploratory factor analysis (EFA). These tests examine the quality of data before proceeding with reliability and validity tests in the next chapter. Prior to testing the hypotheses using structural equation modelling (SEM), Chapter 7 examines the reliability and validity tests according to the types of constructs discussed in Chapter 5.

Chapter 8 compares two types of structural equation modeling: covariance-SEM and partial least square (PLS). The comparison showed that PLS is suitable for testing hypotheses in this study. Therefore, the constructs that meet the requirement of reliability and validity tests in Chapter 7 are assembled for hypothesis testing using SmartPLS software to perform PLS. Chapter 9 discusses the principal findings related to the research questions.

Chapter 10 summarises the study's finding and reviews the results, research contributions, study limitations and recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter surveys previous studies relevant to an investigation of the Thai rice supply chain (TRSC), with the aim of identifying gaps in the knowledge.

Section 2.2 provides a critical evaluation of the literature concerning the fundamentals of supply chain management. Section 2.3 examines literature relating to the three main supply chain management practices (strategic purchasing, the LEAN principles and customer-relationship management) relevant to the TRSC. Section 2.4 reviews supply chain performance measurement in generic supply chains.

Since this study focuses on the TRSC as an agri-food supply chain, Section 2.5 discusses the specific characteristics of agri-food supply chains. Section 2.6 explores agri-food supply chain performance measurement. Section 2.7 presents five uncertainty factors that apply to supply chains in general and to agri-food supply chains in particular (demand, supply, planning and control, process, and competitor uncertainty). Section 2.8 analyses two additional uncertainty factors (governmental policy and climate uncertainty). The chapter concludes with a discussion of the gaps in the literature and how this study will contribute new knowledge that addresses them.

2.2 Fundamentals of Supply Chain Management

Many researchers provide a definition of a supply chain. For example, Lee and Billington (1993, p835) define it as “a network of facilities that perform functions of procurement of material, transportation of material to intermediate and finished products, and distribution of finished products to customers.” Additional definitions of supply chains and supply chain management have been reviewed by Ananda (2004, p24) as provided in Table 2-1. Figure 2-1 shows a generic supply chain from suppliers to end customers.

Table 2-1: Definitions of Supply Chains and Supply Chain Management (Ananda 2004, p24)

Author	Definition
Ronald, Stephen et al. (2000)	The supply chain refers to all those activities associated with the transformation and flow of goods and services, including their attendant information flows, from the sources of raw materials to end users. Management refers to the integration of all these activities, both internal and external to the firm.
Benita (1999)	A supply chain is an integrated process where raw materials are manufactured into final products, then delivered to customers via distribution, retail or both.
Bhaskaran (1998)	A supply chain is a series of manufacturing plants that transform raw materials into finished products.
Frazelle (2002)	A supply chain is a network of enterprises, individuals, facilities and information/ material-handling systems that connect the supplier's supplier to the customer's customer.
Cooper, Lambert et al.(1997)	Supply chain management is the integration of business processes from end user through original suppliers to provide products, services and information that add value for customers.
Tan, Kannan et al.(1999)	Supply chain management is the simultaneous integration of customer requirements, internal processes, and upstream supplier performance.
Simchi-Levi (2003)	Supply chain management is a set of approaches used to effectively integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced in the right quantities and distributed to the right locations at the right time, to minimise system-wide costs while satisfying service-level requirements.
Fawcett (2007)	The design and management of seamless, value-added processes across organisational boundaries to meet the real needs of the end customers

As shown in Figure 2-1, each delivery activity needs an information flow that takes transportation and inventory management into account. Finally, a supply chain usually will retain used products received from end-customers via the suppliers for repairing, recycling or destroying at the end of the product's life cycle (Wisner 2005). In terms of supply chains' horizontal and vertical dimensions, Lambert, Cooper et al. (1998, p2) assert that the horizontal supply chain contains, but is not limited to "2nd tier suppliers, 1st tier suppliers, manufacturer, customers, and then end-users." The vertical supply chain refers to "the number of suppliers and customers within each tier".

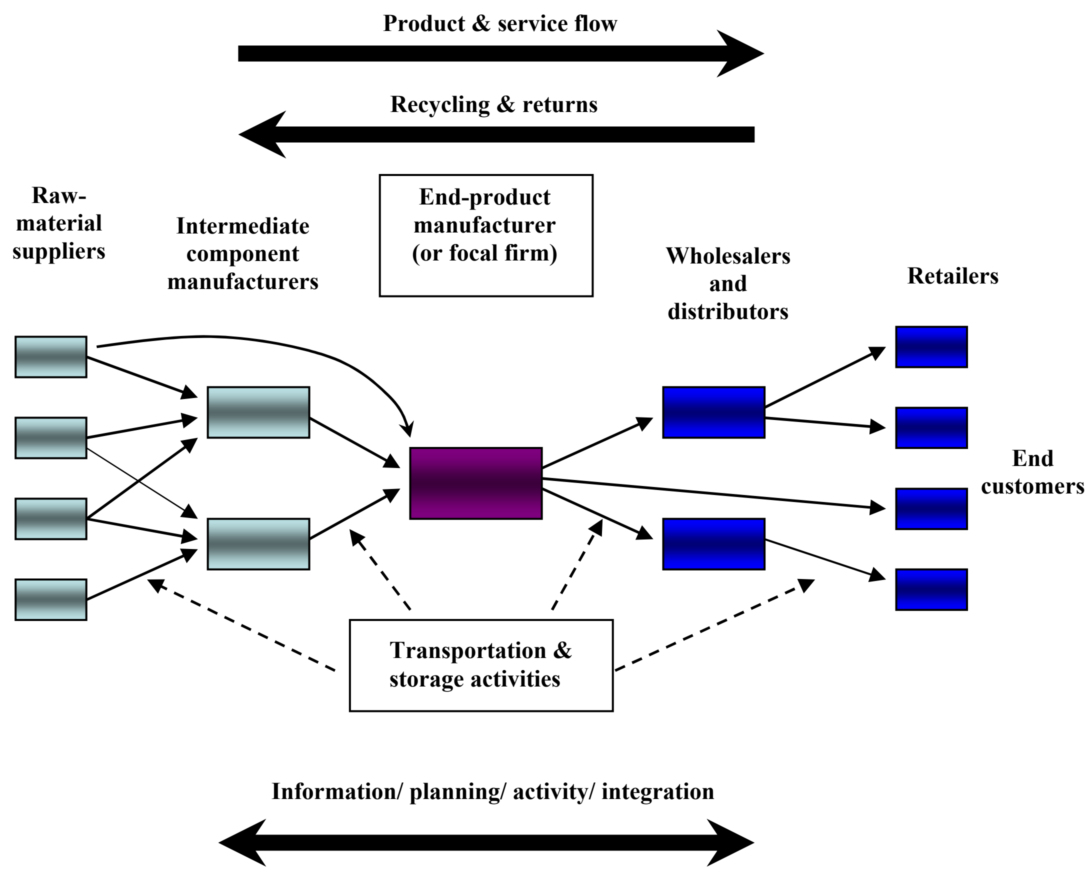


Figure 2-1: A Generic Supply Chain (Wisner 2005, p6)

The objective of supply chain management is "to maximise the overall value generated" (Chopra 2004, p6), and "to increase the competitive advantage of supply chain as a whole, rather than to increase the advantage of any single firm" (Mentzer 2004, p7). Competitive advantage can be achieved through supply chain management (SCM) by seeking each company's internal advantages (Fawcett 2007). A company's internal processes must be managed and coordinated efficiently before the company seeks cooperation with other participants in the supply chain. SCM can increase flexibility towards the customers' wishes, provide quicker and more precise delivery times and foster greater customer loyalty. This results in increased sales, fewer backorders, reduced total costs and motivated and focused vendors (Jespersen & Skjott-Larsen 2005).

Joel (2003) asserts that there are two important elements in SCM: supplier management and customer relationships. Their significance lies in the fact that they correlate and affect the performance of supply chain management and the firm as a whole. Chen and

Paulraj (2004) propose three main supply chain practices in an internal supply chain: purchasing, production and distribution (Figure 2-2).

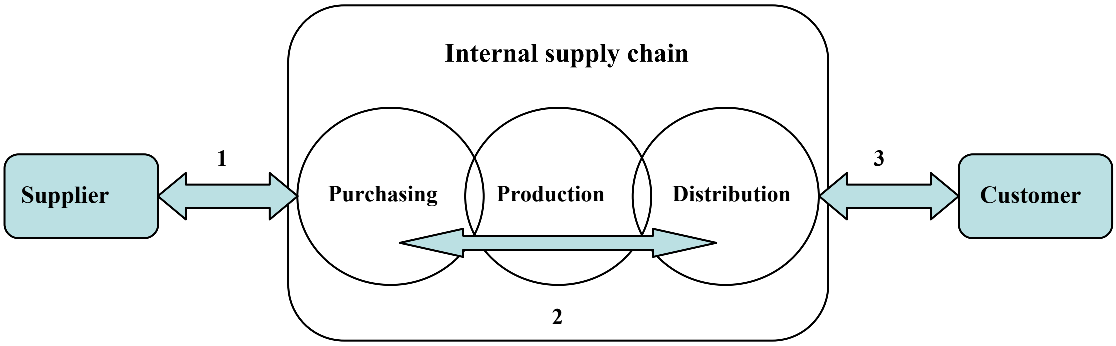


Figure 2-2: An Illustration of SCM in a Firm's Supply Chain (Chen & Paulraj 2004)

"Purchasing" refers to the business process that involves a supplier for acquiring goods or services to accomplish the enterprise's goals. "Distribution" refers to the process of delivering a product or service to end customers. "Production" refers to producing goods for use or sale in a process that requires collaboration with the purchasing and distribution processes (Chen & Paulraj 2004). Wisner (2005) adds integration activities as an additional element in supply chain management, further breaking this element down into supplier management or purchasing; operation or demand management; distribution or transportation/inventory management; and coordination/integration activities.

A lack of supply chain integration creates 'the bullwhip effect', which Chopra (2004) describes as happening when a small disturbance generated by a customer produces successively larger disturbances at each upstream stage in the supply chain, as shown in Figure 2-3. Its effects create excessive safety stock along the supply chain due to a lack of information sharing and communication in the supply chain (Li 2007).

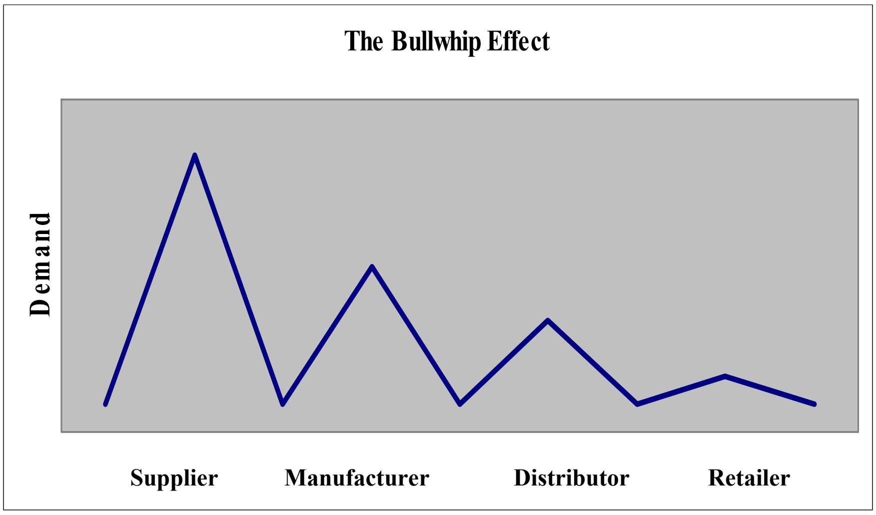


Figure 2-3: The Bullwhip Effect (Fawcett 2007)

In 1996 the Supply-Chain Council defined the Supply Chain Operations Reference (SCOR) model, defining five processes - plan, source, make, deliver and return - that operated in three channels suppliers, firms and customers (Ronald, Stephen & Ashok 2000). The SCOR model is used as a supply chain management diagnostic, benchmarking and process improvement tool by notably successful firms such as Intel, IBM, and 3M (Wisner 2005). Poluha (2007) details the five processes of the SCOR model:

Plan - Processes that adjust the expected resource need to the expected demand condition.

Source - Processes that procure goods and services to meet planned or actual demand.

Make - Processes that transform product to a finished state to meet planned or actual demand.

Deliver - Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management and distribution management.

Return - Processes associated with returning or receiving returned products for any reason. These processes extend into post-delivery customer support.

Supply management, demand management, distribution management and supply chain integration are the four main elements of supply chain management. These elements are reviewed in the following section.

2.2.1 Supply Management

Supply management includes a decision-making process that has three parts: purchasing strategy, which relates to cost, quality, capacity, delivery and service; supplier selection; and supplier management, which involves scrutinising the performance of selected suppliers (Lee, Ha & Kim 2001).

In an increasingly globalised marketplace, manufacturers have access to many suppliers; these relationships can develop into partnerships across the world. Products' increasing technological sophistication and short lead time have forced companies to carefully decide on whether they will use appropriated suppliers or outsourcing. These decision require efficient processes for supplier selection (Aissaoui, Haouari & Hassini 2007). Effective suppliers can offer low-cost labour and raw material, reduce delivery time or add value to products (Rodney & Daniel 2001; Choy & Lee 2002). However, they can bring risk to organisations in terms of integrity and trade-secret security (Cohen & Roussel 2005).

Efficient supplier management can bring benefits of knowledge transference, cost reduction and quality improvement. Close relationship between buyers and sellers that align with supplier management can be win-win strategies (Christopher 2005). Companies often seek to implement a supplier management strategy based on "the concept of partnership and a long-term agreement" (Aissaoui, Haouari & Hassini 2007, p3519). Close relationship management can be divided into four supplier-relationship integrations (Fearne, Hughes & Duffy 2001):

- Quasi-vertical integration, in which partners share costs, risk and profits in a relationship that can cease at the end of an agreed period of time;
- Tapered vertical integration, which involves cooperating backward with suppliers;
- Full vertical integration, when partners join in two or more consecutive stages along the supply chain; and
- Horizontal integration, in which networks that aim to access new markets are integrated.

Managing, monitoring and controlling a large number of supply chain partners are complicated. To reduce the complex network in a supply chain, organisations tend to reduce the number of suppliers to “single sourcing” (Aissaoui, Haouari & Hassini 2007, p3520). However, this practice can bring high risk to the supply chain, which could be broken with the collapse of the single supplier (Christopher 2005). In addition, natural disasters and disruptions can increase risk in agri-food supply chain management when the business has only one supplier (Paul, Richard & Frances 2004).

2.2.2 Demand Management

Demand management is the development of a demand forecast involving the level, timing and composition of demand (Crum & Palmatier 2003). The aim of demand management is to identify, reduce and eliminate the volatility of the customer-demand profile that is the input into the demand planning process (Bolton 1998). Demand management is composed of four elements (Crum & Palmatier 2003): planning demand; communicating demand; influencing demand; and managing and prioritising demand.

Demand planning includes “the processes that an organisation takes to anticipate customer demand and ensure sufficient product is available” (Bolton 1998, p139). Specifically, it involves demand forecasting; inventory management; capacity planning; production planning and scheduling and material requirement planning. Communicating demand is the process of ensuring that supply chain partners receive and understand the demand plan. Influencing demand is related to marketing and selling efforts: for example, product positioning, pricing and promotions. Managing and prioritising demand is the process of matching customer orders and available supply.

Demand management is an important part of supply chain management as customer demand commonly does not remain steady. According to Samson (2001), there are several major causes of changes in demand including price, technology, politics, and acts of nature. It can lead to misalignment between the supply chain and customers. Demand management implementation can improve forecast accuracy, increase supply chain visibility, reduce supply chain costs and improve customer service levels (Bolton 1998).

Forecasting techniques should be used to estimate uncertainty demand before matching supply and demand. Forecasting methods can be either qualitative or quantitative; each is appropriate for different demand patterns (Wisner 2005). Accuracy is influenced by the choice of the forecasting technique, the number of forecast products and the forecast horizon (Andries & Gelders 1995). The accuracy of forecasting customer demand leads to effective demand management, enabling flexible logistic planning and scheduling (Wisner 2005). To employ an appropriate demand management strategy, Cohen (2005) suggests that companies should be aware of the requirements and profitability of customers because different customer segments have different requirements.

2.2.3 Distribution Management

Distribution management is a part of logistics that is related to both physical and information flow (Rushton, Croucher & Baker 2006). Distribution management is concerned "with the management of the physical movement of products from the factory to the consumer through different distribution channels involving transportation, warehousing, inventory, information system, order processing and documentation" (Kapoor & Kansal 2004, pix). Logistics and distribution uses human and material resources that can affect a national economy; for example, logistics and distribution represents 10 to 15 percent of the GDP of North America, European, and Asia/Pacific economies (Rushton, Croucher & Baker 2006).

Reduction in the total cost along the supply chain can be achieved by focusing on logistics costs (Bolton 1998). For example, in the food and drink industry, overall logistics costs account for approximately 14 percent of sales turnover (Rushton, Croucher & Baker 2006). Reducing logistics costs could noticeably cut the total supply chain cost.

Distribution channels consists of the people and organisations involved in the transfer of products (Kapoor & Kansal 2004). The channels may be operated by manufacturers, wholesalers, retailers or third-party logistics service providers (Rushton, Croucher & Baker 2006). The third-party logistics service providers are one type of outsourcing that provides reliable delivery and short turnaround and delivery times. Businesses use third-party logistics service providers to distribute the right raw materials, materials and/or

finished goods at the right time to the right place (Jieming, Han Swee & Seah Kiat 2002).

The inventory and warehouse management functions within logistics control the amount of inventory. Inventory should be held at the appropriate level to meet customers' service requirements and expectations (Rushton, Croucher & Baker 2006). Many companies cannot avoid uncertainty in regard to customer needs and external suppliers; inventory and warehouse policies are created to mitigate the negative impact of such uncertainty (Heath & Danks 2003).

Perishable products require different inventory policies from non-perishable, due to the need to consider deterioration rate and obsolescence date. For example, according to six case studies, perishable commodities could be sold about 50 percent more quickly than non-perishable commodities. Thus, most supermarkets need a high frequency of delivery of perishables. To reduce waste, researchers have proposed inventory control rules for goods that can deteriorate. For example, direct delivery from suppliers can achieve lead-time reduction. Substitute demand can replace deteriorated goods with other more costly ones with a longer shelf life. Sellers can also apply a policy of small assortment in term of high periodic demand for specific perishable goods (van Donselaar et al. 2006).

2.2.4 Supply Chain Integration

Supply chain integration aims "to remove all walls among entire activities involved with material and information flow which are purchasing, material control, production, sales and distribution in supply chains" (Naylor, Naim & Berry 1999, p110). Integrating the activities in the supply chain allows companies to eliminate redundancies, decrease error costs and lead time, and increase efficiency (Wisner 2005).

To accomplish supply chain integration, businesses work from a baseline material flow to implement functional integration, internal integration and external integration (Stevens 1989), as illustrated in Figure 2-4. Wisner (2005) points out that this implementation can involve such activities as:

1) Identifying critical supply chain trading partners;

2) Reviewing and establishing supply chain strategies;
3) Aligning supply chain strategies with key supply chain process objectives;
4) Developing internal performance measures for key process effectiveness;
5) Assessing and improving internal integration of key supply chain processes;
6) Developing supply chain performance measures for key processes;
7) Assessing and improving external process integration and supply chain performance;
8) Extending process integration to second-tier supply chain partners; and
9) Reevaluating the integration model annually.

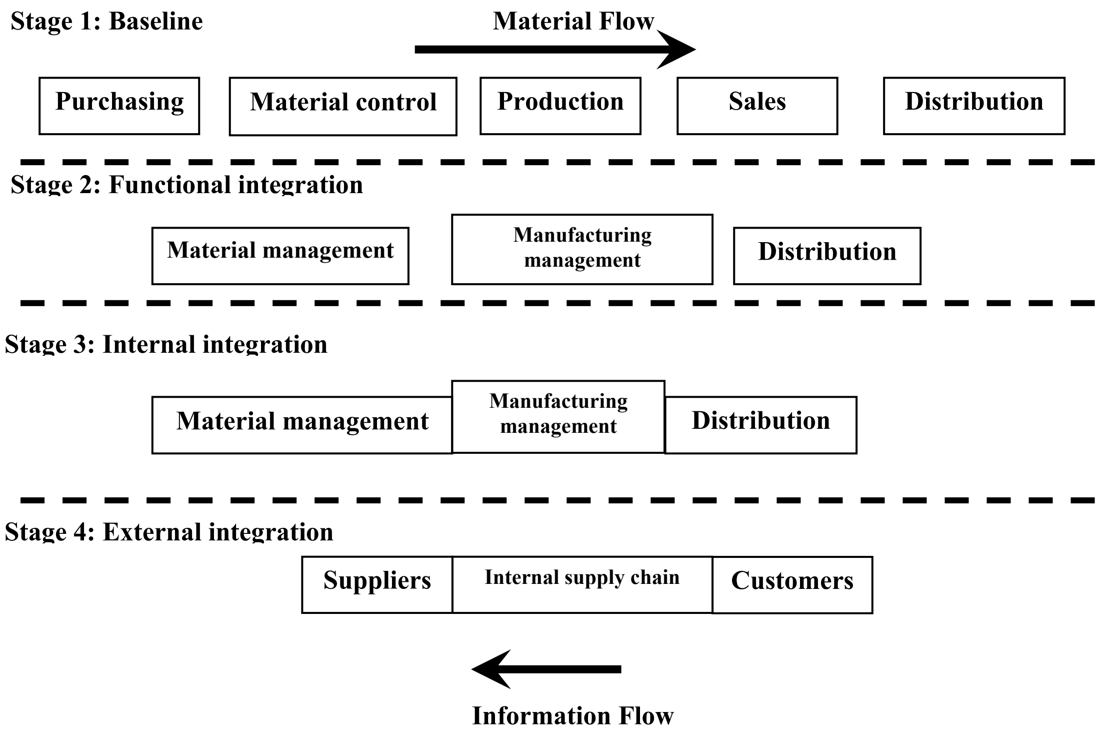


Figure 2-4: Supply Chain Integration (Stevens 1989)

Wisner (2005) also point out that the supporting conditions for this integration are training and preparedness; the existence of willing and competent trading partners; trust; and organisational cultures that can change to accommodate the integration. Obstacles may also obstruct the integration process: failure to see the big picture within the whole supply chain; inability to share partner information in real time; unwillingness to work together; lack of knowledge and skill to implement the integration; and inability to control bullwhip effects.

In the European food industry, demand and supply planning integration is implemented to accomplish value chain efficiency (Ferrer 2003; Gattorna 2003). However, global businesses can find it more difficult than local businesses to integrate supply chains. Particularly, communications among core processes (such as production and marketing) and among partners have become a vital factor in achieving supply chain integration in international business (Rodney & Daniel 2001).

As Chapter 4 will show, this study develops a conceptual framework consisting of three main constructs: supply chain management practices, supply chain performance and uncertainty factors. The following section provides a comprehensive literature review of these constructs.

2.3 Supply Chain Management Practices

Supply chain management practices can be defined as the activities that contribute to the planning and control of material and information flows both within an organisation and between an organisation and its external supply chain members (Cooper, Lambert & Pagh 1997; Fisher 1997). A large proportion of the research on strategic supply chain management suggest the adoption of alternative practices to deal with uncertain situations, characteristics of products and what "drives forward a company's strategic objective" (Cohen & Roussel 2005, p11). Figure 2-5 shows the components of the theory behind strategic supply chain management.

Before selecting a strategy to manage supply chains, organisations should recognise the nature of their products (as described in Table 2-2), including whether they are functional – in other words, connected with the physical functions of the supply chain – or innovative – connected with the market-mediation function (Fisher 1997). Organisations can implement market-responsive supply chains by deploying excess buffer capacity, deploying significant buffer stocks for innovative products (Porter 1985; Fisher 1997), or applying a combination of both strategies (Porter 1985).

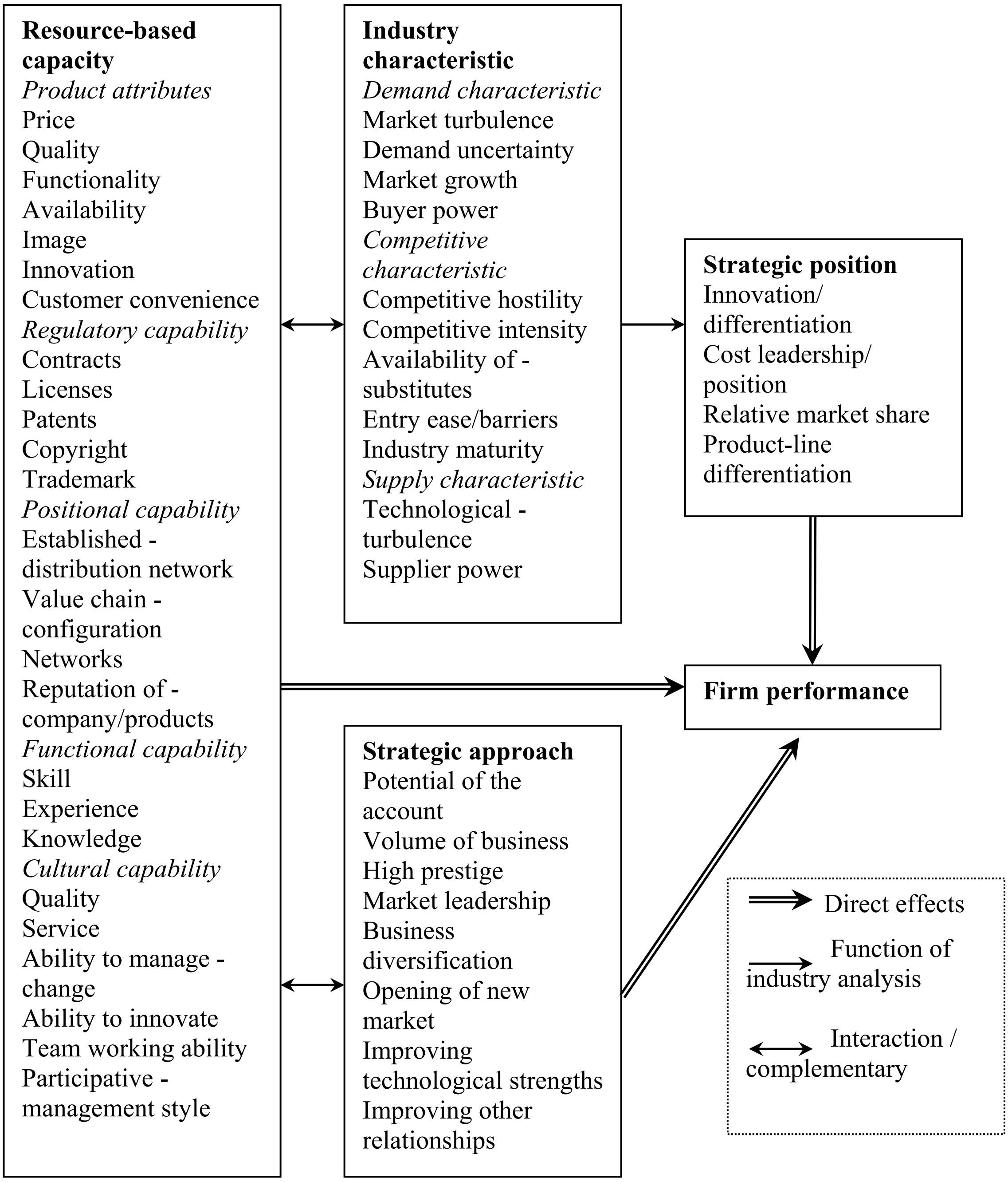


Figure 2-5: The Link Between Strategic Theory and Firm Performance (Fawcett 2007)

Table 2-2: Functional and Innovative Products: Difference in Demand (Fisher 1997)

Aspects of Demand	Functional Products	Innovative Products
Prediction	Predictable	Unpredictable
Product life cycle	More than 2 years	3 months to 1 year
Contribution margin	5% to 20%	20%-60%
Product variety	Low (10 to 20 variants per category)	High (often millions of variants per category)
Average margin of error in the forecast at the time production is committed	10%	40% to 100%
Average stock out rate	1% to 2%	10% to 40%
Average forced end-of-season markdown as percentage of full price	0%	10% to 25%
Lead time required for made-to-order product	6 months to 1 year	1 day to 2 weeks

The next section describes, and Figure 2-2 shows, the three main supply chain practices - purchasing, production and distribution; these involve suppliers, production and customers (Chen & Paulraj 2004).

2.3.1 Strategic Purchasing

Both long- and short-term purchasing strategy aligned with a firm's goals should be included in its planning for collaboration within the buyer-supplier relationship (Handfield 1993; Chen, Paulraj & Lado 2004; Paulraj & Chen 2007). This strategy increases reliance on collaborative alliances between suppliers and customers (Carter et al. 2000). It also strengthens the purchasing function and its role in supporting the corporate strategy of firms (Freeman & Cavinato 1990; Ellram & Carr 1994). Strategic purchasing is achieved throughout the four stages shown in Table 2-3 (Freeman & Cavinato 1990).

Table 2-3: Purchasing Emphases Throughout the Range of Strategic Setting (Freeman & Cavinato 1990, p8)

Purchasing Attributes	**Stage I Basic Financial Planning**	**Stage II Forecast Based Planning**	**Stage III Externally Oriented Planning**	**Stage IV Strategic Management**
Concept of the field	Buying	Purchasing	Procurement	Supply
Concept of strategy	Better price on next buy	Maintain favorable price/ cost variances	Support line of business	Entrepreneurial team member
Expectation	Minimisation of costs	Cost minimisation Cost avoidance Cost reduction Purchase for quality	Contributions through value analysis Value engineering	Involved in product development and line of business management Line of business results
Management approach	Reactive	Reactive but plan for future	Fit department in with plan from rest of firm	Positive proactive
Major activities	Process requisition into purchase orders and contracts	Management of the buying function Make process efficient	Fit buying cycle to the business-product cycle	Manage commercial relationship for the firm Source for long term
Range of products	MRO (maintenance, repair and operations) items Office goods	Raw materials MRO items Office goods	Capital goods Raw materials MRO items Office goods Outsourcing management	Suggestion source firms to purchase Suggest product changes in line with market opportunities and future constrains
Budgetary approach	Cost center	Cost center Planning for future	Supply chain management Shape future of department for line of business	True supply management Partner in change
Management style	Clerical/ reactive	Managerial Forecasting	Managerial Planning	Team member
Key personal skills	Task-oriented	Some management	Managerial Strong interpersonal Strong analytical	Purchasing decisions are business decision
Concerns	Conformance to norms Process problems	Basic managerial issues Concern with power regarding scope, back-door buying, headcount centralisation, etc.	Supply chain management	Shape of function not important, result and output are the keys

Strategic purchasing has been developed to be one part of supply chain management by involving supply-base integration, supplier partnership, information sharing, long-term

relationship (Carr & Pearson 1999; Paulraj & Chen 2005; Paulraj, Chen & Flynn 2006), integration of strategic planning processes (Cousins & Spekman 2005; Paulraj, Chen & Flynn 2006) and support for the corporate strategy of the firm and other strategic functions (Ellram & Carr 1994). There are three distinct types of purchasing strategy (Ellram & Carr 1994, p10):

1) Specific strategic purchasing employed by purchasing function;
2) Purchasing that support other strategies and goals of the firm; and
3) Purchasing administered at top management level as a strategy.

Purchasing strategy is important for a firm (Spekman, Kamauff & Salmond 1994) as it can lead to better products (Paulraj & Chen 2005), higher financial performance (Carr & Pearson 1999; Carr & Pearson 2002; Chen, Paulraj & Lado 2004; Paulraj, Chen & Flynn 2006), higher operational performance (Chen & Paulraj 2004; Paulraj, Chen & Flynn 2006), more value added to products (Russell & Thukral 2003) and a competitive advantage (Porter 1985; Spekman, Kamauff & Salmond 1994). Moreover, strategic purchasing supports supply through supplier responsiveness (Carr & Smeltzer 1999), customer responsiveness (Chen, Paulraj & Lado 2004), buyer-supplier communication, close relationship with a limited number of suppliers and long-term buyer-supplier relationships (Carr & Pearson 1999; Carr & Smeltzer 1999; Chen, Paulraj & Lado 2004). In summary, the higher the level of strategic purchasing, the higher the supply chain performance (Paulraj, Chen & Flynn 2006). The clear benefits of an effective purchasing function have meant that in many firms it has shifted from being a clerical activity to being strategic (Freeman & Cavinato 1990; Johnson et al. 2002).

These benefits suggest that strategic purchasing could be usefully implemented in the rice industry. Whether it can improve supply chain performance and deal with uncertainty factors in the TRSC requires further investigation.

2.3.2 LEAN principles

LEAN manufacturing, first developed by Toyota in the 1950s, is defined as "developing a value stream to eliminate all (seven) wastes" (Naylor, Naim & Berry 1999, p108): the production of goods not yet ordered, waiting, rectifying mistake, excess processing, excess movement, excess transport and excess stock (Japan Management Association

1985; Shingo 1989; Bicheno 1994). The core characteristics of the LEAN production model include (Oliver et al. 1994, pS54):

- Team-based work organisation, in which flexible, multi-skilled operators take a high a degree of responsibility for work within their areas.
- Active shopfloor problem-solving structures, central to *kaizen* or continuous-improvement activities.
- Manufacturing operations that force the correction of problems and lead to low inventories; the management of quality by prevention rather than detection and subsequent correction; small numbers of direct workers, and small-batch, just-in-time production.
- High-commitment human-resource policies that encourage a sense of shared destiny within a firm.
- Close, shared-destiny relationships with suppliers, typically in the context of much smaller supply bases.
- Cross-functional development teams.
- Retailing and distribution channels that provide close links to the customer and permit a make-to-order strategy.

To achieve LEAN manufacturing, many tools were developed such as 5S, Just in Time (JIT), Total Quality Management (TQM), low-inventory flexible manufacturing and close relationships with suppliers and customers (Levy 1997). LEAN manufacturing has been successful in improving efficiency and performance and reducing cost by eliminating wastes in Toyota's production system and those of its suppliers such as Autoliv (Cohen & Roussel 2005). LEAN manufacturing has since been implemented by other industries around the world. For example, in the aerospace industry, LEAN manufacturing helped the Airbus company achieve the most efficient delivery of new products for market in 1998 (Mark 1999). LEAN implementation has improved flow, flexibility and quality within Chinese manufacturing sector (Taj & Morosan 2011). Australian companies have used LEAN manufacturing to achieve increased flexibility, shorter manufacturing cycles, greater market sensitivity, higher productivity, stronger focus on performance, improved supplier bonds and transformation from being reactive to being proactive (Sohal & Egglestone 1994).

During the 1990s, the concept of LEAN manufacturing evolved “LEAN principles” (Helper 1996): specifying value by specific products; identifying the value stream for each product; making value flow without interruption; letting the customer pull value from the producer; and pursing perfection. LEAN principles are measured in terms of concepts such as faster throughput times for in-bound, work in progress (WIP) and out-bound material; smaller manufacturing batch sizes; shorter set-up and changeover times and greater “up time”; greater schedule stability; and lower rework and rectification costs (Jina, Bhattacharya & Walton 1997).

LEAN principles were then applied to particular core processes such as supply (John-Paul & Susan 1997; Yen Chun 2003), logistics and distribution (Jones, Hines & Rich 1997; Teo Chung 1998; Karlin 2006; Linda 2006; Andreas & Matthias 2007), warehousing (Sobanski 2009), planning (Pool, Wijngaard & van der Zee 2011) and product development (MartÃ-nez & Farris 2009).

Value chain analysis (VCA), which is based on LEAN principles was first developed by Hines and Rich (1997) as a new strategic and operational approach to “the data capture, analysis, planning and implementation of effective change within the core cross-functional or cross-company processes required to achieve a truly LEAN enterprise” (Hines et al. 1998, p25). Food value chain analysis (FVCA) was initially adapted from VCA by Simons, Francis et al. (2004) and applied mainly in the UK red-meat industry by Taylor and Simons (2004). FVCA is intensely focused on customer value (Womack & Jones 1996) which is in turn linked to supply chain effectiveness with “cost efficient distribution, quality and consistency, value for money, delivery on time/in-full and strategic reserve” (Zokaei & David 2006, p151).

LEAN principles are not necessarily appropriate for all organisations. They are particularly suitable for the manufacturing of products with predictable demand, low product variety, long product life-cycles and stable markets (Cox & Chicksand 2005). For example, organisations making a large variety of products at low volume will struggle to manage production using LEAN principles (Jina, Bhattacharya & Walton 1997).

Global supply chains also face expensive difficulties in applying LEAN principles (Levy 1997). These can include logistic problems such as longer lead times, higher inventories, more expensive transportation and greater errors in demand forecasting (Curtin 1987; Levy 1997). Geographical separation does not allow intensive face-to-face contact for product and process design, engineering and quality assurance, which hinders the development of relationships among supply chain partners as well as the implementation of LEAN principles (Cox & Chicksand 2005).

2.3.3 Customer-Relationship Management (CRM)

Customer-relationship management (CRM) can be divided into two categories: strategic and operational (Richards & Jones 2008). Strategic CRM has been defined as using insightful customer information to develop relationships with customers by understanding their needs and expectations (Winer 2001; Dull et al. 2003). Developing the right products and services will attract a higher level of customer satisfaction, retain profitable customers in the long term (Winer 2001; Dull et al. 2003) and attain customer equity (Richards & Jones 2008). Moreover, CRM can improve flexibility and responsiveness by integrating between CRM and supplier relationship management (Choy, Lee & Lo 2002). Operational CRM is defined narrowly as the processes and information technologies that build better customer relationships (Richards & Jones 2008).

CRM has become an important strategy because information technologies such as the internet allow customers to compare the quality and price of products from different sellers. This circumstance increases customers' power (Chen & Popovich 2003), making good customer relationships all the more crucial. Winer (2001) asserts that firms can strategically foster these relationships using a number of techniques, including customer service, frequency/loyalty programs, customisation, rewards programs and community building. In contrast, Payne & Frow (2005) state that CRM is implemented not strategically, but at an operational level, using five processes: strategy development, value creation, multi-channel integration, performance assessment and information management. Whether it is considered strategically or operationally, CRM requires a balance of cooperation among people, processes and information technology (Chen &

Popovich 2003). Importantly, in terms of improving customer equity through value, brand and relationship, CRM value drivers are necessary (Richards & Jones 2008).

Some studies such as Gartner (2003) explore unsuccessful CRM implementation in the real business world: in these cases, CRM does not result in profitable value compared with the cost of implementing it (Srinivasan & Moorman 2005); this has in some cases been due to misunderstandings that CRM is implemented only with information technology, internet or software packages (Richards & Jones 2008).

2.4 Supply Chain Performance Measurement Systems

Performance measurement is a vital operation for improving business. Performance measurement preaches that "you cannot improve what you cannot measure" (Wisner 2005, p433). In other words, awareness in supply chain performance measurement is necessary for improvement initiatives, process management and positioning for competitive advantages (Gattorna 2003; Walters 2003). Nuthall (2003, pp248-9) affirms that the benefits of performance measurement lead to effective management of supply chains along with human resources and communication. Furthermore, performance measures encourage organisations to improve their performance and create innovations that allow them to obtain competitive advantages in the market place.

To discern accurate supply chain performance, the outcomes of measuring have to be visible and fully understood by all partners across the supply chain before continuous improvement in performance can be achieved (Wisner 2005). The aim of performance measurement is to recognise performance gaps among service levels. Identifying performance gaps allows companies to fill the gaps and enhance supply chain performance (Choy et al. 2007) using cost-based information, financial statistics and accounting data applied first to monitor business performance and then to improve supply chain performance (Gattorna 2003; Walters 2003). However, Wisner, Leong et al. (2005) argue that this system tends to be short-term-oriented due to inaccurate output caused by the difficulty of analysing independent and share cost in many departments throughout the supply chain. Parker (2000) asserts another drawback: that performance measurement is insular and inward-looking, and excludes qualitative factors (such as time, quality and flexibility).

Consequently, a world-class performance-measurement system was introduce by Wisner and Fawcett (1991). It is based on monitoring 'what is important to the customer' and looks at the capability areas shown in Table 2-4.

Table 2-4: World Class Performance Measures (Wisner 2005, p441)

Capability area	**Examples of performance measures**
Quality	Number of defects per unit produced Number of product returns per unit sold Lead time from defect detection to correction
Cost	Scrap or spoilage losses per work center Average inventory turnover Average setup time
Flexibility	Average number of labour skills Average production-lot size Number of customised services available
Dependability	Average service response time or product lead time Percentage of delivery promises kept Average number of days late per shipment
Innovation	Annual investment in R&D Percentage of automated processes Number of new product or service introductions

Supply chain performance measurement systems examine specific performances along the entire supply chain and among all partners to ensure that supply chain strategy can contribute to value creation for end customers (Wisner 2005). The world-class performance measurement system was adopted from the Supply Chain Operations Reference (SCOR) model. Ballou (2000, pp752-3) asserts that the SCOR model is a better measure of supply chain performance and provides an explanation of performance measures and software requirements. The first of its three levels, shown in Table 2-5, presents an overview of the supply chain performance measures. The second and third levels present the process categories and elements (Meyr, Rohde & Stadtler 2002).

Table 2-5: SCOR's Level 1 Metrics (Supply Chain Council 2002, p6)

External, Customer-facing			**Internal-facing**	
Reliability	Responsiveness	Flexibility	Cost	Assets
Delivery performance	Order fulfillment lead time	Supply chain response time	Total supply chain management cost	Cash-to-cash cycle time
Perfect order fulfillment		Production flexibility	Value-added productivity	Inventory days of supply
Fill rate			Warranty cost	Asset turns
			Cost of goods sold	

There are several performance measures: activity-based costing (ABC), balanced scorecards, economic value added (EVA), multi-criteria analysis (MCA), life cycle analysis (LCA), data envelopment analysis (DEA) and the SCOR model. Each method has both advantages and disadvantages, as summarised in Table 2-6.

Table 2-6: Advantages and Disadvantages of Methods to Assess Supply Chain Performance (Aramyan et al. 2006, p53)

Method	**Advantages**	**Disadvantages**
Activity-based costing (ABC)	Gives more than just financial information Recognises the changing cost behaviours of different activities	Costly data collection Difficult to collect initially required data Difficult to determine appropriate and acceptable cost drivers
Balanced scorecards	Balanced view of performance Include financial and non-financial factors Top-level strategy and middle-management actions are clearly connected and appropriately focused	Not a quick fix Complete implementation should be staged
Economic value added (EVA)	Considers the cost of capital Allows projects to be viewed separately	Computation difficulties Difficult to allocate value among divisions
Multi-criteria analysis (MCA)	A participatory approach to decision-making Enables decision-maker to learn more about the problems Suitable for problem where monetary value of the effects are not readily available	Information requirement to derive the weights can be considerable Implicit weights can lead to unexplained results
Life-cycle analysis (LCA)	Allows the establishment of a comprehensive baseline of information on a product's or processor's resource requirement Allows the identification of areas where the greatest reduction of environmental burdens can be achieved Possibility to assess the cost and environment effects associated with the life cycle of a product or process	Data-intensive methodology Lack of confidence in the methodology
Data envelopment analysis (DEA)	All inputs and output are included Generate detailed information about the efficient firms within the sample Does not require a parametric specification of a functional form	Deterministic approach Data-intensive
SCOR model	Takes into account the performance of the overall supply chain Balanced approach Performance of the supply chain in multiple dimensions	Does not attempt to describe every business process or activity Does not explicitly address training, quality, information technology or administration

2.5 Agri-Food Supply Chains

The definition of a food supply chain is “a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of fresh products, industrial food productions, services and/or information from a source to customer” (Hsiao, van der Vorst & Omta 2006, p137). A reverse supply chain in agricultural products means the delivery of food products from customers to farmers (a product recall) because of contaminated products, public health risks, non-compliance with legislation, or a faulty claim on a label (Meuwissen et al. 2006). The unique characteristics of agri-food that can affect on the design of a supply chain are “biological agricultural production relating to uncontrollable natural forces, perishability of products and environmental concerns” (Wijnands & Ondersteijn 2006, p8).

Aramyan, Ondersteijn et al.(2006) categorise agri-food supply chains into two types: a fresh-food product supply chain, such as those for fresh vegetables and fruit; and a processed-food product supply chain such as those for canned products. The members of a food supply chain are farmers, processors, distributors and retailer, while NGOs, governments and shareholders are stakeholders in the chain. Furthermore, there is more than one supply chain in the food supply chain network (FSCN) because food companies prefer to maintain their own identity and autonomy. Therefore, an individual company can have a different position and role in each supply chain (van der Vorst 2006).

Three main characteristics of demand in agri-food supply chains are variability of consumer demand; misalignment of demand and activities along the chain; and poorly managed daily demand. Consumer demand has a pattern of seasonal or unpredictable demand. Misalignment of demand and activity along the chain is caused by forecast demand that is exaggerated by staffs at retail stores and inventory-control algorithms; and by supply-side effects such as product yield, batch size and inventory level rather than by real customer demand. Poorly managed daily demand is a vital characteristic of demand in this supply chain that results from uncertain consumer behaviours. Some causes of poor daily demands are, for instance, complexity of procedures for handling demand information; inconsistency and inaccuracy in data; problems in sharing

consumer demand data; forecast proliferation; timeliness of order transmission; lack of on-shelf availability data; and disconnection between agricultural production and consumer demand. (Taylor & Fearne 2006)

In the last 10 years, the characteristics of food supply chains have made them more complicated to manage (Hsiao, van der Vorst & Omta 2006). Furthermore, increased international trade of food has created issues of food safety and its interaction with government policies increasing the complexity of the FSCN (Walther & Spengler 2005).

2.6 Agri-Food Supply Chain Performance Measurement

Key performance indicators (KPIs) for agri-food supply chains are similar to generic supply chains. Table 2-7 gives an example of logistic KPIs for an agri-food supply chain. Figure 2-8 shows the four types of performance indicators for an agri-food supply chain: efficiency, flexibility, responsiveness and food quality (Luning, Marcelis & Jongen 2002; Aramyan et al. 2006; Aramyan et al. 2007).

Table 2-7: Example of Logistic KPIs for Food-Chain Networks on Three Hierarchical Levels (van der Vorst 2006, p20)

Level	Performance Indicator	Explanation
Supply-chain network	Product available on shelf	Presence of a large assortment and no stock outs
	Product quality	Shelf life of remaining product
	Responsiveness	Order cycle time of supply chain
	Delivery reliability	Meeting guaranteed delivery times
	Total supply chain cost	Sum of all organisations' costs in the supply chain
Organisation	Inventory level	Quantity of product in store
	Throughput time	Time needed to perform chain of business processes
	Responsiveness	Flexibility of the organisation
	Delivery reliability	% orders delivered on time and in the right quantity
	Organisation's total cost	Sum of all process costs in the specific organisation
Process	Responsiveness	Flexibility of the process
	Throughput time	Time needed to perform the process
	Process yield	Outcome of the process
	Process cost	Cost incurred when executing the process

Figure 2-6 shows that the indicators of efficiency, flexibility and responsiveness differ from the supply chain performance indicators discussed in the previous section only in that they are specifically concerned with product safety and health, and environmental aspects (Aramyan et al. 2007).

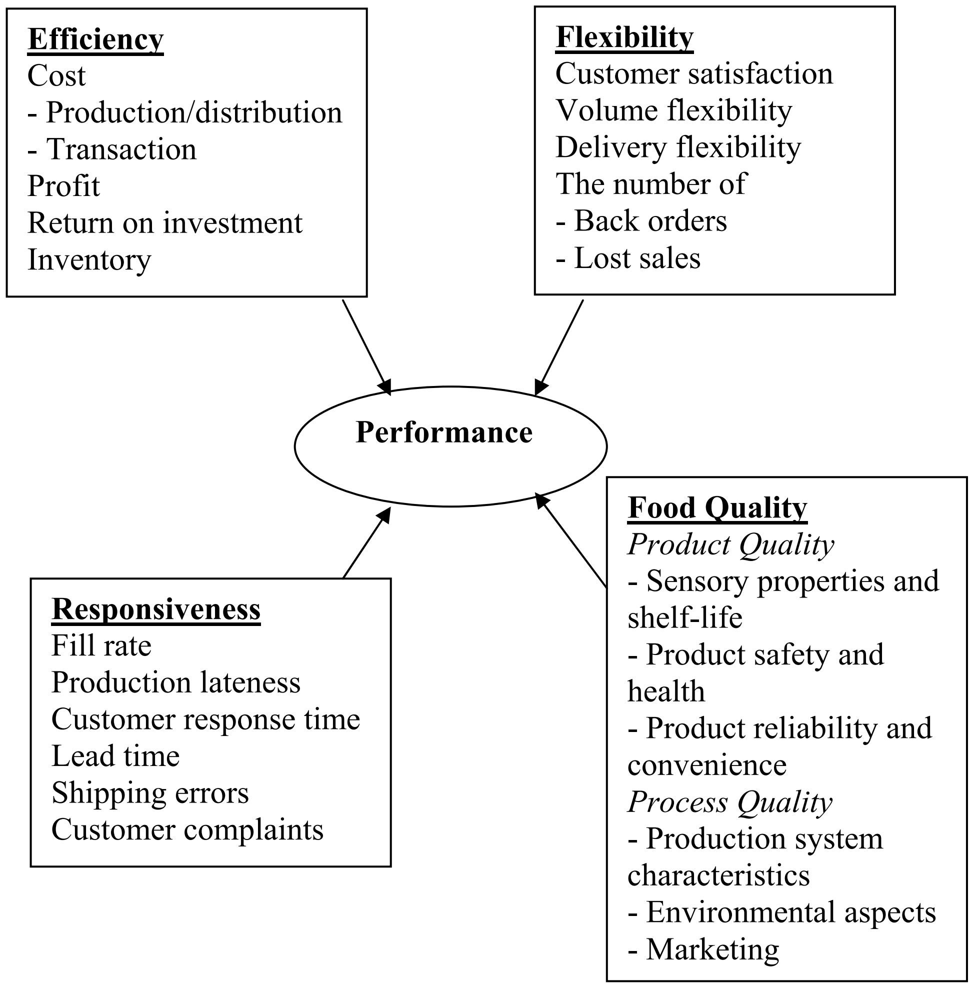


Figure 2-6: Agri-Food Supply Chain Performance Categories and Indicators (Aramyan et al. 2006; Aramyan et al. 2007)

2.7 Uncertainty Factors in Supply Chains and Agri-food Supply Chains

Uncertainty refers to "the unpredictability of environmental or organisational variables that have an impact on corporate performance" (Miller 1993, p694). Rapid change in the economy, market, resources, products and technology is creating much uncertainty in the current business world. Organisations are challenged in their ability to handle this fluctuating environment. In addition, a variety of uncertainty factors affect different organisations in different ways.

The definition of environmental uncertainty in organisation theory is: “an inability to assign probability as to the likelihood of future events, a lack of information about cause-effect relationship and an inability to predict accurately what the outcomes of a decision might be” (Duncan 1972, p318). Uncertainty can affect both an organisation’s internal environment (organisational personnel, functions and levels) and its external environment (customers, suppliers, competitors, socio-politics and technology) (Duncan 1972).

Since a supply chain is a network of enterprises (Frazelle 2002), the environments mentioned by Duncan (1972) apply to all supply chain members. Organisations’ external factors, such as customers and suppliers, can be viewed as the internal factors of a supply chain as a whole.

For supply chains, just as for the organisations that comprise them, “the complex and dynamic interactions between supply chain entities lead to considerable uncertainty in planning” (Bhatnagar & Sohal 2005, p444). Environmental uncertainty plagues supply chain performance in three main areas: suppliers, manufacturing and customers (Davis 1993). Bhatnagar and Sohal (2005) confirm Davis’s (1993) findings that supply chain uncertainty (in other words, supply, process and demand uncertainty) have a significantly negative effect on supply chain performance as measured by lead time, inventory level, time to market, quality, customer service and flexibility. Childerhouse & Towill (2004) speak of an “uncertainty circle”, in which inventory levels, costs, market share and profitability can be harmed by the four factors of demand, supply, control and process. In contrast, Wilding (1998) considers that dynamic conditions experienced by supply chains are caused by deterministic chaos, parallel interactions and demand amplification.

Deterministic chaos in a supply chain means that past partner behaviour is never repeated, which then leads the system to be less predictable. Parallel interactions in a supply chain occur when customers can source their requirements from other suppliers instead of low-performing suppliers in the same tier of a supply chain network. However, the good suppliers also face uncertain requirements transferred from the poor suppliers. Demand amplification means that demand changes according to annual or seasonal cycles (Wilding 1998).

Environmental uncertainty, exacerbated by the lack of information, knowledge and ability, can lead supply chain managers to perceive decision-making uncertainty in term of unpredictable outcomes (Duncan 1972). Decision-making uncertainty (DMU) between retailers and suppliers has been found to negatively affect both financial and non-financial performance along a supply chain (Hsiao 2006). Simulations have suggested that uncertain transportation creates fluctuating inventory levels, thus reducing supply chain performance (Wilson 2007). Environmental uncertainty is one of the external factors that drive supply chain management (Li 2002). The different levels of uncertainty force organisations to manage different levels of integrative practices as summarised in Table 2-8.

Table 2-8: A Framework for Integration for Firms with Shared Resources and Different Uncertainty Levels (adapted from van Donk & van der Vaart (2005, p101))

Supply chain uncertainty	**Risk**	**Impact**	**Integrative practices**
Low volume, low six/specification	Low	Necessity to integrate is absent	Mainly restricted to physical flow, simple operating procedures
High volume, low six/specification	Low and limited keeping stock	Supplier has difficulty in capacity planning, buyers are reluctant to make commitments	Stock, practices to improve physical flow
Low volume, high six/specification	High	High risks of obsolescence, capacity requirements stable, broad scope and high level of integration is necessary	Capacity reservation or buyer-focused operations enables broad scope and high volume
High volume, high six/specification	Very high and real challenge	Stocks and capacity reservations are not feasible options, shared resources as important barrier	Information exchange crucial, supplier orchestrates the links with buyers

An agri-food supply chain has unique characteristics with sources of uncertainty factors that are different from those of other supply chains. Jack and Adrie (2002, p415) state that the sources of uncertainty for food supply chains can be “perishability of products, variable harvest and production yields and the huge impact of weather conditions on customer demand and production.” These equate closely with the more general sources of uncertainty - supply, demand and distribution, process, and planning and control - which fluctuate with respect to quantity, quality and time (van der Vorst 2000).

This specific sources of uncertainty in agri-food supply chains can be divided into five generic sources (van der Vorst & Beulens 2002):

1) Inherent characteristics that relate to high variability in demand, production time and process outcome, and supply; examples include weather conditions and traffic congestion.
2) Supply chain configuration, or the infrastructure related to long-distance delivery of food from supplier to customers.
3) Supply chain control structures, which include decision-making policies and forecasting.
4) Supply chain information systems, which become a source of uncertainty when there is a lack of accurate and up-to-date information.
5) Supply chain organisation structure, which refers to human behaviours in the decision-making process, company culture and division of responsibility and authority.

These study considers seven distinct factors (Badri, Davis & Davis 2000; van der Vorst 2000; Li 2002; Paulraj & Chen 2007) that aggravate uncertainty in agri-food and retail supply chains. Two of these factors - government policy and climate uncertainty - are examined for the first time in this study. The details of each uncertainty factor are discussed in the next sections.

2.7.1 Demand Uncertainty

This section considers demand uncertainty in generic and agri-food supply chains.

2.7.1.1 Demand Uncertainty in Generic Supply Chains

Demand uncertainty is defined as “the extent of the change and unpredictability of the customers’ demands and tastes” (Li 2002, p27). This factor can refer to the uncertainty of customer requirements in regard to quantity, product types and time (Childerhouse & Towill 2004). Such changes in customer demand generates swings of capacity, resources and inventory (Wilding 1998). Uncertain volume, variety and variability of customer demand can also increase risk in a supply chain, and force supply chain

members to practise integration by sharing resources among partners (van Donk & van der Vaart 2005).

The information revolution has improved the ability of customers to access a wide range of products and pricing information. This produces a higher level of product and price knowledge for customers, which creates conditions in which demand can change quickly (Bolton & Dwyer 2003; Fawcett 2007). In other words, high-performance organisations face uncertainty in customer demand when customers transfer their ordering from low-performing organisations (Wilding 1998). The unpredictability of customer requirements puts stress on the scheduling decision-making process and causes volatility in production planning (Childerhouse, Disney & Towill 2008). Even when end-customer demand is relatively stable, variations in the perception of this demand can cause exaggeration in a supply chain (Wilding 1998); this exaggeration in known as the bullwhip effect (Fawcett 2007).

2.7.1.2 Demand Uncertainty in Agri-Food Supply Chains

Demand uncertainty also occurs in an agri-food supply chain. For example, demand typically varies each day of the week: low on weekdays, higher on the weekends (Taylor & Fearne 2006). In an agri-food chain, demand uncertainty is the combination of unpredictability of general demand together with uncertainty of demand for specific varieties of the product (van der Vorst 2000). The real variability of consumer demand is clearly important because when food products is out of stock, customers will instead purchase other available food products. Suppliers strive not to be out of stock when customers want to buy their food products (Taylor & Fearne 2006; Fawcett 2007).

Historical data from 2002 to 2010 shows that demand for Thai rice from international customers is unstable (FAPRI 2010). Thai rice exports are expected to grow; however, there is intense competition on the world rice market from other rice-exporting countries, such as Vietnam and the Philippines. This competition leads to uncertainty in the demand for Thai rice. In contrast, demand from domestic customers is quite stable (FAPRI 2010). This study considers demand uncertainty as an important factor in the TRSC (Section 3.5)

2.7.2 Supply Uncertainty

This section considers supply uncertainty in generic and agri-food supply chains.

2.7.2.1 Supply Uncertainty in Generic Supply Chains

Supply uncertainty is defined as "the extent of change and unpredictability of the suppliers' product quality and delivery performance" (Li 2002, p28). Supply is related to the delivery of raw or packed materials in time, in the right amount and according to the right specifications (quality or price) (van der Vorst 2000). Supply uncertainty - uncertainty of the quantity, quality or lead time of raw materials to be delivered to manufacturers (Davis 1993; Childerhouse & Towill 2004) - happens because supplier performance is low and unstable (Davis 1993). Uncertain arrival time of raw materials will slow or even stop a production line (Shin, Collier & Wilson 2000; Li 2002); faced with this risk, supply chain members tend to hold safety stock to reduce idle time in their production and to lessen back orders (Davis 1993). This increases the overall production cost and total supply chain cost, pressures that can cause an organisation to lag behind its competitors (Shin, Collier & Wilson 2000).

2.7.2.2 Supply Uncertainty in Agri-food Supply Chains

The supply side of agri-food supply chains is agricultural production which depends to some extent on uncontrollable natural forces and environmental concerns, including droughts and floods, and environmental concerns (Wijnands & Ondersteijn 2006). Supply can fluctuate dramatically in each crop season, complicating the management of inventory planning and control (Hsiao, van der Vorst & Omta 2006).

Many factors contribute to variation in the quality and quantity of the rice supply in Thailand. For example, during the 1990s, the Thai government encouraged rice farmers to grow more profitable legumes instead of rice (Yao 1999). Genetic improvements in rice varieties can increase rice production (Slaton, Moldenhauer & Gibbons 2001). Today, rice supply in Thailand tends to increase because the rice-cultivation area is expanding. However, rice yields have been uncertain over the last five years, perhaps because of uncertain weather and global warming which has led to drought and flood in some cultivated areas (Office of Agricultural Economics 2007). The moisture content of

rice paddies depends on the amount of rainfall during harvesting. Paddy-rice quality may be lower if paddy rice is harvested at either high or low moisture levels (Huitink & Siebenmorgen 2001).

The supply of rice to the international rice market is extremely concentrated. The top 10 exporting countries supply more than 90 percent of total rice exports (Calpe 2004). Thailand is the main rice exporter to the world rice market (Anonymous 2011). Consequently, the level of supply uncertainty in the TRSC plays a vital role in the world rice market.

2.7.3 Process Uncertainty

This section considers process uncertainty in generic and agri-food supply chains.

2.7.3.1 Process Uncertainty in Generic Supply Chains

Process uncertainty is related to production-system uncertainty in that it concerns the availability of adequate capacity to produce a particular product, or the availability of sufficient raw materials (van der Vorst 2000). Process uncertainty can vary depending on the maturity and capability of production processes (Lockamy et al. 2008). This uncertainty can be caused by low manufacturing performance or by the nature of material flow (Davis 1993). In the manufacturing process, there is also the unpredictability of broken machines and variable repair time. Such low manufacturing performance can cause uncertainty in the whole supply chain, as it disrupts order-cycle times and causes difficulties in meeting customer time requirements (Childerhouse & Towill 2004). Uncertainty in the manufacturing network is caused by the complexity of material flow for a complicated product. This can create uncertainty in the processing of the final product, and then in shipment to customers (Davis 1993). Process maturity can increase the level of process capability, thus reducing uncertainty and improving supply chain performance (Lockamy et al. 2008).

2.7.3.2 Process Uncertainty in Agri-Food Supply Chains

Process uncertainty in an agri-food supply chain is similar to that in a generic supply chain. However, the nature of agricultural processes is distinct from manufacturing processes. Agricultural processing involves many stages that take place over an extended growing period. For example, crop production involves seeding, pesticide application and harvesting. It can be uncertain because of unpredictable growing conditions such as weed and insect control (Slaton 2001), production yield (Weninger & Zhao 2002) and climate conditions (Nguyen 2002). In a food supply chain, process uncertainty affects quality, quantity and production time (van der Vorst 2000).

Rice cropping has five steps: land preparation, crop establishment, harvesting, post harvesting (threshing, drying and cleaning) and storage (TRFRP 2006). Each member of the supply chain must deal with different processes. Rice farmers must deal with land preparation, crop establishment and harvesting. Rice millers must deal with the milling process, storage and quality control as well as the packing process, while rice exporters must deal with storage, quality control and packing. Milling process is uncertain as, for example, rice milling is done by a large number of small rice mills using inefficient machinery (Ninh 2003). The above processes are uncertain and can affect the TRSC performance. Moreover, environmental factors affecting grain and milling yield vary each year (Slaton, Moldenhauer & Gibbons 2001).

2.7.4 Planning and Control Uncertainty

Planning and control uncertainty is essentially similar for generic and agri-food supply chains since this uncertainty relates to information management.

Planning and control uncertainty is related to the planning and communication structure needed to provide correct and on-time information about such issues as inventory level, production capacity and customer orders (van der Vorst 2000). Information is crucial to operational control for planning and management: the higher the quality of information input, the higher the quality of managerial decision-making (Gorry & Morton 1989). Poor control systems, such as wrong decision rules or incomplete information, introduce uncertainty into the supply chain (Childerhouse & Towill 2004). Inaccurate information

about customer demand and production capacity cause supply chain members to miss customer requirements, which affects on-time customer deliveries (Davis 1993).
In a food supply chain, van der Vorst (2000) concludes that uncertainty in planning and control occurs when there is instability in availability, accuracy and throughput time of information related to operational control. The use of information technology and processing capability can deal effectively with uncertainty in the environment, the partnership and the task (Bensaou 1997); conversely, its lack can exacerbate the consequences of uncertainty. In Chinese agribusiness, for example, many shortcomings occur in agricultural products owing to a lack of data consistency and poor shared data. This is a barrier to China's agricultural trade in the international market (Sun, Wang & Li 2007).

The current study is the first to determine whether planning and control uncertainty affects the Thai rice industry, as reflected in availability accuracy and throughput times, and the use of IT tools by the supply chain members.

2.7.5 Competitor Uncertainty

This section considers competitor uncertainty in generic and agri-food supply chains.

2.7.5.1 Competitor Uncertainty in Generic Supply Chains

Competitor behavior uncertainty refers to the unpredictability of competitor actions such as reducing product price or the time to market, or increasing product quality and variety (Li 2002). In any organisation, the competitor is a crucial external factor that can introduce perceived environmental uncertainty into organisations, harming their performance (Duncan 1972). Therefore, competitor analysis was developed to reveal competitors' behaviours and strategies to support the implementation of sustainable competition. Since competitors' behaviours and strategies have the potential to change an industry, this technique can presage the adverse effect of vague competitor behaviours (Porter 1980).

Competitor focus is a component of market orientation that can improve market share when the competitive structure is intense and customers are powerful (Heiens 2000). In

the context of market orientation, any actions by competitors that attract customers should be reviewed (Slater & Narver 1994; Han, Kim & Srivastava 1998). Intense competition in either domestic or international markets and rapid changes in technology can force competitors to take unpredictable actions to gain a higher market share (Mentzer, Min & Zacharia 2000). Such competitor actions have both direct and indirect effects on the business performance of organisations along the entire supply chain (Min & Mentzer 2000). Thus, competitor behaviour is considered an important uncertainty factor in a supply chain.

2.7.5.2 Competitors Uncertainty in Agri-Food Supply Chains

Competitor action in agribusiness also introduces uncertainty when there is strong competition in the market. Many factors contribute to this intensely competitive market. For example, the entry of China into the World Trade Organisations in 2001 intensified competition in agricultural markets, as China has a better opportunity to tap international agricultural resources, while other countries also can access Chinese agricultural resources (Sun, Wang & Li 2007). This situation has forced organisations to introduce products or service that can attract more customers.

The international rice market is intensely competitive. There are only a few important, and strongly competitive, key players, such as Thailand and Vietnam. Most rice-producing countries introduce some barriers to international rice trade such as import protection, domestic support and export-promotion policies (Jayne 1993; Nielsen 2002). To survive in these situations, rice-exporting countries must introduce unique products (such as low prices for Vietnamese rice) that can maintain market share (Nielsen 2002). The Thai domestic rice market is steady because government policies such as price protection stabilise it (David & Huang 1996).

In addition to the five uncertainty factors discussed above, two uncertainty factors are also present in the TRSC; they are reviewed in the next section.

2.8 Additional Uncertainty Factors in the Rice Supply Chain in Thailand

As the agri-food supply side relies on climate conditions, this is considered to be one potential uncertainty factor in agri-food supply chains. The impact of climate change on agricultural production both from a historic and a predictive point of view has been widely examined within the context of world agriculture (Darwin et al. 1995).

Another source of uncertainty is government policy. Especially in developing countries, government policies can be unpredictable and turbulent (Badri, Davis & Davis 2000). Specifically, Thai government policy with respect to the rice supply chain is uncertain and can have a severe impact on the rice industry. This section discusses these two uncertainty factors (government policy and climate uncertainty) relating to the TRSC.

2.8.1 Government Policy Uncertainty

Laws, regulations and government administrative procedures and policies affect firms' profitability margins by changing their costs or revenues and introducing uncertainty into the supply chain (Badri, Davis & Davis 2000). Government regulation can provide both risks and benefits to business. However, unpredictable government policies force business decision-makers to receive risks in investment (Marcus 1981). Governments influence regional development in agricultural production, and their approaches have changed remarkably over the years (Crosthwaite 2004). For example, the changes in government policy in the Philippine agri-industry have led to uncertain copra production, hurting the economic performance of the copra market (Mendoza & Farris 1992). Unpredictable government policy also forces organisation to adopt any strategies they can to handle this uncertainty (Badri, Davis & Davis 2000).

Most Asian governments view rice as a strategic commodity because of its importance in the diet of the poor, as well as to the employment and income of farmers (Bran & Bos 2005). In Thailand, almost 50 percent of Thais in rural areas are involved in agricultural activities (IRRI 2007). The agricultural sector accounts for approximately 12 percent of Thai GDP (U.S. State Department 2011), and rice is among the top five products exported from Thailand to the world market (World Bank 2009).

The objectives of rice policies around the world vary from country to country and from time to time. During the 1980s several countries in Asia strictly adhered to a policy of rice self-sufficiency. However, during the 1990's, Indonesia and China started to rely upon rice imports to meet their rice requirements. Vietnam has imposed a steady presence among the leading exporters together with Thailand and the USA. India may be the next rising star among the rice exporters (Goletti & Minot 1997). Conversely, when the price of rice doubled in the first half of 2008, India’s government prohibit exports of non-basmati rice in February 2008 and imposing export tariffs on basmati rice in April 2008. This is because they concern about food shortages. This policy could increase domestic supplies and lower domestic prices (Clarkson & Kulkarni 2011). These made the international rice market very dynamic.

The aims of Thai government policies are to sustain paddy prices at a reasonably high level, secure competitive advantages in the international market, and alleviate the poverty of farmers (Nielsen 2002). The Thai government predominantly uses four types of policy instrument: a rice procurement program, which intervenes in the marketing and procurement of paddy and milled rice; rice exports under government-to-government arrangement; a paddy-mortgage scheme for the country as a whole and for specific upcountry areas; and credit assistance (FAO 2009).

Although the Thai government has intervened in rice production and rice trading (Roumasset & Setboonsarng 1988) – for example, mandating a reduction in rice capacity (Yao 1999) – such intervention have not benefitted farmers in the ways that the government expected (Yao 1997; Yao 1999). Therefore, the government has shifted to supporting rice farmers in extending their production for export. The Paddy Rice Mortgage Scheme is the main law involving the paddy rice trade in Thailand. The government annually sets the standard price of paddy rice by purchasing it from farmers. If private millers want paddy rice from farmers, they need to purchase it at a higher standard price. The standard price of paddy rice each year is unpredictable, as it is set against the world’s rice market, the real cost of rice production and current political issues (Department of Internal Trade 2008). However, during the rice season of 2009/2010, the Thai National Rice Policy Committee replaced the current Paddy Rice Mortgage Scheme (Thai National Rice Policy Committee 2009) by approving a new rice policy program that guarantees the price of paddy rice. The purpose of this policy is

the same as the Paddy Rice Mortgage Scheme, but its procedures differ. In 2009, the competitiveness of Thai rice was predicted to worsen owing to the impact of this government intervention program (FAO 2009). A drop of 17 percent in Thai rice exports over the previous year was predicted in 2009, as it was expected that Thai rice would lose market share to cheaper rice from other countries (FAO 2009).

2.8.2 Climate Uncertainty

Climate directly and indirectly affects most agricultural and socio-economic systems, including land-use planning, level of agricultural yield, consistency in yield and agricultural infrastructure. Especially in developing countries, the agricultural system is primarily dependent on rainfall, and highly vulnerable to climate uncertainty (Darwin et al. 1995; Ogallo, Boulahya & Keane 2000). Climate uncertainty refers to the unpredictability of serious weather events in Thailand such as drought, flooding and temperature. These events can lead to decreased rice yields, rice supply shock, delay time of paddy rice to market or transportation disruption (Cruz et al. 2007).

Historical data provides evidence that Thailand's cultivated rice areas are vulnerable to drought and flood. In 1919, for example, 43.4 percent of the cultivated rice area failed totally due to drought; in 1942, 34.3 percent of the cultivated rice area failed due to floods (Yoshida 1981). In March 2011, drought harmed over 100 million *rai* (16 million hectares) across the country (Thai Rice Mills Association 2011). This risk can be reduced by water management, crop management, a change in cropping techniques and the introduction of a crop calendar and improved seed varieties (Chinvanno 2003-2004).

Climate change in Thailand is predicted to affect water resources, rainfall and flooding levels. By 2100, several international climate models predict that there will be an increase in incidents of floods in Thailand (three to six times in a period of 100 years, as opposed to the one in 100 years previously seen) (Yoshida 1981). The rice yield might drop by 20 percent by 2040 in many Thai provinces such as Thung Kula, Chaing Rai, Sakon Na Khon, Sa Kaew and Khon Kaew (Sukin 2004). Therefore, rice supply chain performance can be affected by uncertain rice supply and interrupted rice flow. However, the impact of climate change on rice production in Kula Ronghai Field was

also estimated: in the future, climate change will not significantly affect on rice yield in Tung Kula field, if farmers adopt recent cropping initiatives (Chinvanno 2003-2004).

Climate change is commonly believed to be driven by increase in CO_2 in the atmosphere. Within Thailand, while climate change is predicted to have only a small impact on agriculture production yields in Khon Kaen province, climate trends are currently leading to slightly larger yields from rain-fed rice production in Chaing Rai, Sakonnakorn Ubonratchathani and Sakaeo provinces in Thailand (Matthews & Wassmann 2003; Buddhaboon, Kongton & Jintrawet 2004; Chinvanno et al. 2006).

2.9 A Critical Assessment of the Relevant Literature

The relevant literature includes a great variety of contributions, as well as some gaps.

1) Relationships among uncertainty factors, supply chain management practice and supply chain performance in the TRSC.

   Most previous studies have addressed the impact of supply, demand, process, planning and control, and competitor uncertainty on strategic supply chain management as well as the performance of supply chains in general (Davis 1993; Childerhouse & Towill 2004; van Donk & van der Vaart 2005; Hsiao 2006; Paulraj & Chen 2007). However, the findings from their studies are inconsistent. For example, a case study of the Hewlett-Packard Company using a strategic modeling tool for a decision-support system shows that supplier performance, manufacturing process and demand uncertainty lessen the organisation's performance (Davis 1993). Conversely, in a study of US companies with more than 100 employees, survey results show that customer, supplier and technology uncertainty do not influence supply chain management practices and performance (Li 2002). Therefore, uncertainty factors affect the supply chain management practices and performance of different organisations in different ways. Three case studies of Dutch food supply chains confirm that supply, demand, distribution, process and planning and control uncertainty affect their performance and supply chain design strategies (van der Vorst 2000). However, it is based on only three case studies and does not use any statistical analysis. Moreover, there has been no attempt to empirically study the impact of those uncertainty factors on particular agri-food

supply chains. The current study specifically considers the rice supply chain in Thailand. Not all results from previous studies can be applied to the TRSC, as the characteristics of the Thai rice industry differ from those of the contries examined in other studies. This is a gap in academic research as a clear comprehensive framework illustrating the relationships between uncertainty factor and the TRSC has not been developed to date.

2) The government policy is considered as an uncertainty factor in the TRSC.

The effect of government administrative procedures and policies on firms' performance has been widely studies in different views, including change their costs or revenues (Badri, Davis & Davis 2000), providing both risks and benefits to business (Marcus 1981), and hurting the economic performance of their market (Mendoza & Farris 1992). These efforts contributed useful knowledge about applying any strategies to avoid adverse effects of this factor on their business. However, as discussed in Section 2.8.1, the government policy uncertainty lacks integrated view in the existing supply chain management view. That can lead to overlooking some critical aspects and value in supply chain performance.

The literature concerning the Thai rice industry points out that government policy is another source of uncertainty in this industry. The high uncertainty introduced by government policy can reduce organisations' performance (Badri, Davis & Davis 2000) and force them to implement different strategies to cope (Marcus 1981; Gert 2005). The effect of government policies on organisations' perspective has been vigorously investigated in the literature. Nevertheless, there has been no in-depth study into government policy uncertainty specific to the TRSC.

3) The climate is considered as an uncertainty factor in the TRSC.

The literature clearly shows that weather conditions have enormous effects - both direct and indirect - on crop production (Hodges 1991; Peter 1991; Darwin et al. 1995; Hoogenboom 2000; Ogallo, Boulahya & Keane 2000). The impact of climate change on both historical and predicted agricultural production has been widely examined, not only globally (Darwin et al. 1995) but in specific countries such as the Philippines (Lansigan, de los Santos & Coladilla 2000), China (Matthews et al. 1997; Hui, Xiubin & Guenther 2004; Fengmei et al. 2007; Wei et al. 2007; Xiu et al.

2007), Taiwan (Chang 2002), India (Matthews et al. 1997; Saseendran et al. 2000; Aggarwal & Mall 2002) and Thailand (Matthews et al. 1997; Prapertchob, Bhandari & Pandey 2005; Office of Agricultural Economics 2007). This climate variability harms business performance, interrupt supply chain flow, and short supply. Therefore, it should be one uncertainty factor that managers critically consider to handle it properly.

Nevertheless, the effects of this factor on any agri-food supply chains have not been examined using empirical analysis. Therefore, the link between climate uncertainty and the rice supply chain in Thailand in terms of affecting its supply chain practices and performance should be examined.

2.10 Chapter Summary

This chapter reviewed the literature that provides a theoretical foundation for this research. The literature indicated that identifying and controlling uncertainty factors in a supply chain are necessary to increase the efficiency of the managerial decision-making process and improve supply chain performance. Although adverse conditions cannot always be controlled, their effects can be reduced when organisations are aware of them. In the TRSC, seven uncertainty factors affecting organisations' external and internal environments (supply, demand, process, planning and control, competitor, government policy and climate uncertainty) have been identified. These factors will be investigated in this thesis.

Supply chain management practices are applied in many industries, and have been shown to improve supply chain performance and help organisations gain competitive advantages. They are also employed to deal with uncertainty factors along a supply chain. As supply chain management cannot be a standalone practice, organisations should apply it to manage the supply side, demand side and internal supply chain concurrently. In this study, three supply chain management practices to cope with uncertainty and improve performance — strategic purchasing, LEAN principles and customer-relationship management — will be considered.

The supply chain performance-measurement literature shows the importance of selecting critical indicators that are important to customers such as quality, cost, flexibility, responsiveness and innovation. Though many researchers have discussed various supply chain performance measures, a composite measure of supply chain performance, such as a balance scorecard or SCOR model should be applied. The indicators of efficiency, flexibility, responsiveness and food quality have been developed to apply to agri-food supply chain.

The next chapter will provide and discuss an overview of the TRSC.

CHAPTER 3

THE RICE SUPPLY CHAIN IN THAILAND

3.1 Introduction

This chapter gives a general background of the global rice scenario, and then examines the rice industry and rice supply chain in Thailand. It is divided into five main sections. Section 3.2 reviews in broad terms the global rice scenario, highlighting the roles and importance of rice, and giving an overview of global rice production and trade. Section 3.3 describes the Thai rice industry in terms of stakeholders, and outlines the classifications of rice in Thailand. Section 3.4 explores the crisis that the rice industry in Thailand is currently experiencing, and the problems and opportunities that it brings forth. Section 3.5 provides the first comprehensive description of the Thai rice supply chain (TRSC) in terms of rice supply, rice demand, transportation and inventory management. Lastly, Section 3.6 summarises the uncertainty factors in the rice sector.

3.2 Overview of the Global Rice Scenario

Rice has long been one of the most protected commodities in world trade as it feeds almost half the world population. Consequently, the growth of world population has driven rice to become an extremely important crop under worldwide cultivation (Ito 2004). In fact, an April 2011 report by The Food and Agriculture Organization of the United Nations stated that the world's paddy-rice production for the 2010 season was 699 million tonnes (466 million tonnes on a milled-rice basis), an increase of 2.4 percent over the 2009 season (due mainly to increases in rice production in China and, to a lesser extent, Brazil, Cambodia and Thailand). The global rice consumption in 2011 is expected to increase by 2 percent over 2010, reaching 460 million tonnes (milled-rice basis). This largely reflects rising demand in the expanded world population and the fast-growing economies. However, recently the increase in the rate of global rice production has been higher than that of global rice consumption. Thus, the global rice stock is expected to rise to 139 million tonnes in 2011, the highest since 2002. The rice-exporting countries, especially China, India and the United States, as well as the rice-importing countries,

especially Bangladesh, Indonesia, Sri Lanka and those in the European Union are expected to increase the size of their inventories (FAO 2011).

The international rice market is thin in the sense that the amount of rice traded internationally is just 5 to 7 percent of global rice output. It mainly relies on a few rice-exporting countries such as Thailand and Vietnam. The price of rice in the world market swings (Razzaque & Laurent 2008) because rice production deficit in just a few major exporting countries has major effects on prices (Nielsen 2002). A large number of rice producers are facing the adverse effects of the volatile price of rice, which affect the income and profit of rice farmers (Pitipunya 2005).

3.2.1 Role and Importance of Rice

Rice is crucially important in many countries, as it underpins food security. Moreover, its production and distribution form a major economic sector and the role it plays in traditional culture can be enormous (Fluhr et al. 2011):

Food security means that "all people have access to sufficient food to lead active and healthy lives" (McDonald 2010, p.1). Rice is one of the most important food grains in the world (Wailes 2004): approximately 3 billion people (nearly half the world's population) depend on rice for food security (FAOSTAT Database 2008). Rice provides approximately 21 percent of human energy per capita worldwide (Rice Knowledge Bank 2007). This is particularly true for Asia, where rice consumption accounts for over 30 percent of human energy per capita (Jamora 2010). Therefore, as the world's population continues to grow steadily, rice output should increase proportionately (Rice Knowledge Bank 2007). Any effects on rice production such as declines in land and water resources, or global climate change, could result in long-term damage to food security (Nguyen 2002).

In addition to rice's role in providing food security, rice cultivation is the principal activity and source of income for more than 100 million households in developing countries in Asia, Africa and Latin America (Nguyen 2002). Particularly, Asia has long been dominant in rice production, consumption and trade. More than 92 percent of world rice production, 90 percent of rice consumption and 75 percent of rice surplus for exports

originates in Asia (Sriprasert 2004). Changes in the price of rice directly affect the income of rice producers and, in turn, the economics of developing countries. Thus, governments often seek to control the price of rice to balance effects price changes for both producers and consumers.

Rice plays an important cultural role in many countries (Fluhr et al. 2011). In Asia, many rice farmers spend their lives on rice farms. They sleep on rice straw, drink rice liquor and offer rice to their gods (Greenland 1997). The growth stage of the rice crop marks the passage of time and season. In the languages of China and Japan, the day begins with "morning rice" and ends with "evening rice." In Thailand, “rice is life” (Vanichanont 2004, p.113). It permeates all aspects of the lives of people from all backgrounds. Rice is sung about, particularly in folk songs, and is the subject of various other arts, from poems to paintings to sculptures (Gomez 2001). In China's rural culture, foods made from rice are the basis of festivals such as the Land Opening Festival (Fluhr et al. 2011). In this part of the world, rice is not just a cereal; it is the root of civilisation (Gomez 2001).

3.2.2 Global Rice Production

Figure 3.1 shows the global rice-paddy production and area from 2001 to 2010. During 2002-2008, the global production of rice paddy and area dramatically increased due to production in Asia, particularly in China and India. In the 2009 season, the global production and area dropped from 2008, as major rice producing countries in Asia were affected by unfavorable climatic conditions (FAO 2009). Rice production expanded by 2.4 percent in 2010 and is forecast to rise by 3 percent in 2011 due to increased rice output in China and a recovery in India and expectations of improved weather conditions (FAO 2011). However, climate conditions continue to have important effects on rice output. In 2010, rice output from Africa is expected to increase by 1 percent, whilst Latin America and the Caribbean are forecast to experience some adverse climate conditions that could reduce their rice output by 6 percent (FAO 2011).

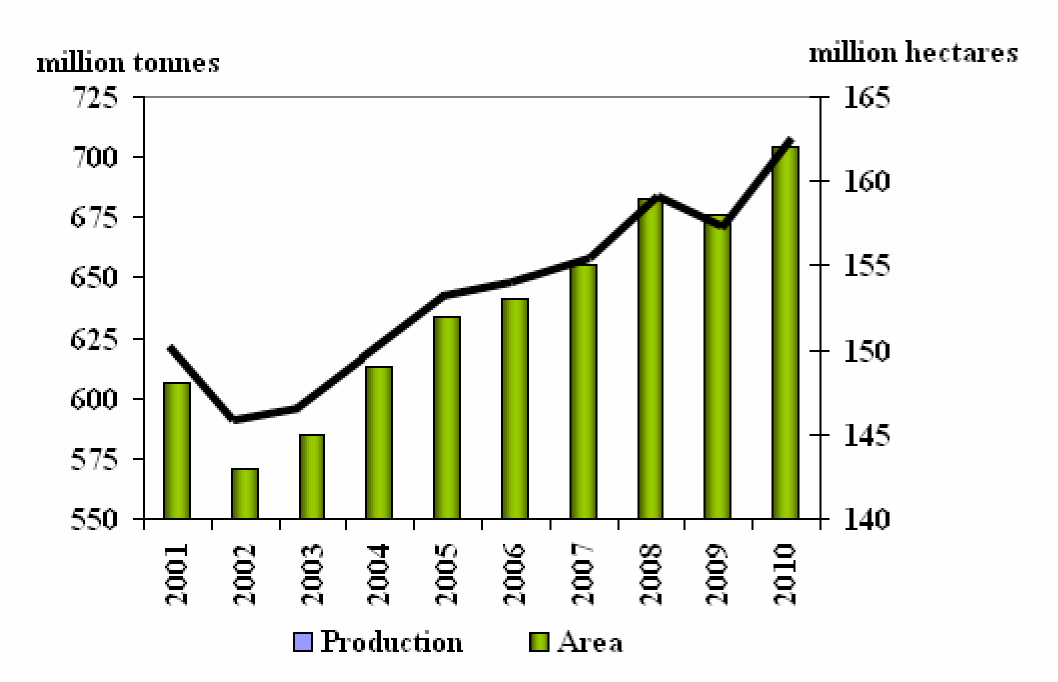


Figure 3-1: The Global Rice Paddy Production and Area from 2001 to 2010 (FAO 2011)

As shown in Table 3-1, global rice production is heavily concentrated in China and India, with these two countries accounting for more than half the total global rice production in 2009. Other Asian countries, such as Indonesia, Bangladesh, Vietnam and Thailand, are also major rice producers (Razzaque & Laurent 2008).

Table 3-1: Major Countries in Global Rice Production and Trade (FAPRI 2009)

Import			Export			Production		
Country	% share	Volume[a]	Country	% share	Volume[a]	Country	% share	Volume[a]
Philippines	6.7	1,848	Thailand	35.9	9,900	China	29.9	129,984
Nigeria	6.6	1,820	Vietnam	17.9	4,936	India	21.7	94,336
Indonesia	5.9	1,627	India	14.6	4,026	Indonesia	8.8	38,256
Saudi Arabia	4.7	1,296	Pakistan	11.2	3,088	Bangladesh	6.4	27,823
Bangladesh	4.2	1,158	United States	9.1	2,509	Viet Nam	5.7	24,780
Iraq	4.1	1,131	Egypt	3.7	1,020	Thailand	4.5	19,563
European Union-27	3.8	1,048	China	3.1	855	Myanmar	3.7	16,085
Brazil	3.5	965	Uruguay	3.1	855	Philippines	2.2	9,564
South Africa	3.5	965	Argentina	2	552	Brazil	1.9	8,260
Iran	3.5	965	Myanmar	0.3	83	Japan	1.9	8,260
Malaysia	3.3	910				USA	1.6	6,956
Mexico	2.5	689				Pakistan	1.2	5,217
Ivory Coast	2.5	689				South Korea	1.2	5,217
Japan	1.8	496				Egypt	1	4,347
Canada	1.4	386				Nigeria	0.5	2,174
China - Hong Kong	1.2	331				Sri Lanka	0.5	2,174
Turkey	0.9	248						
Total Volume		27,576			27,576		92.7	434,730

[a] Thoundsand metric tonnes

3.2.3 Global Rice Trade

The definition of the global rice trade in this study follows the study of Wailes (2004) and Razzaque and Laurent (2008). The global rice trade is differentiated by type, quality, degree of processing and degree of milling as shown in Table 3-2.

Table 3-2: Terms used in the Global Rice Trade (Wailes 2004, p178; Razzaque & Laurent 2008)

Characteristics	**Definitions**
Grain varieties	- Long-grain varieties are typically longer than 6.2 millimeters. - Medium- and short-grain varieties are 6.2 millimeters or less.
Rice quality	- High quality refers to rice that contains 10 percent or less of broken kernels. - Low quality refers to rice that contains more than 10 percent broken kernels.
Degree of processing	- Paddy rice refers to rice as it is harvested in the field before the husk and bran layer are removed. - Brown rice also called cargo or husked rice, has had the husk removed but retains the bran layer. - Milled rice, also called white rice, has had both the husk and bran layers removed

The fragrant rice varieties, basmati and jasmine are generally considered to be long-grain types but they are marketed and priced in global markets differently from unscented long-grain varieties (Wailes 2004). In the international rice market, 77 percent of trade volume is milled rice, followed by parboiled rice (15 percent), and paddy rice (4 percent). On the whole there is a high demand for higher-grade rice: high- and medium-quality rice accounts for 75 percent of total trade (Razzaque & Laurent 2008).

The international rice market is usually described as “thin, volatile, segmented, and highly distorted” (Razzaque & Laurent 2008, p.15). Rice exports accounted for only around 5.80 percent of global rice production in 2007, and are forecast to achieve only 6.40 percent of global rice production in 2011 (FAPRI 2009). This means that most countries are self-sufficient in rice (Wailes 2004). As can be seen in Table 3-1, exports of rice are heavily concentrated in few countries such as Thailand, Vietnam and India. Thailand is the main rice exporter to the international market (36 percent of worldwide exports). Many countries import rice the 3 to 6 percent share range. The Philippines and Nigeria are the major rice importers (FAPRI 2010). However, those countries’ percent share of rice imports can vary each year depending on their own rice output and climate conditions. Jayne (1993) has summarised the factors that contribute to world rice-price fluctuations:

1) The geographic concentration of world rice production in an area of unstable weather as disscused in Section 2.8.2.
2) Government trade and commodity policies, which are normally assumed to destabilise world prices. Governments tend to stabilise domestic markets by venting supply instability onto the world market.
3) The emerging relationship between the world rice and large swings in the petroleum markets.
4) Low world stockholdings relative to production and the absence of a major factor that stabilises world rice prices through stock and trade policies.

The world rice trade increased dramatically between 2002 and 2008 (Figure 3-2), but fell by 9 percent between 2008 and 2010 (FAO 2011).

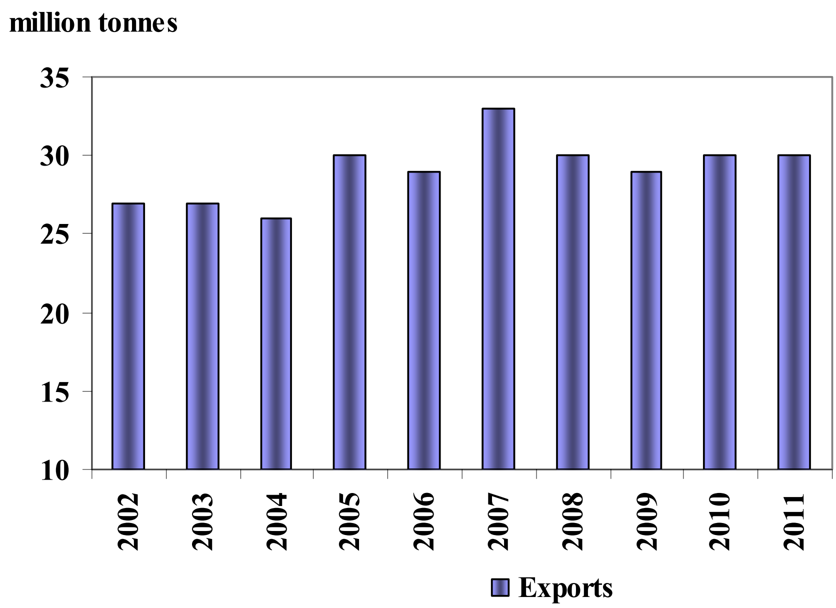


Figure 3-2: Global Rice Trade from 2001 to 2010 (FAO 2011)

3.3 Overview of the Rice Industry in Thailand

Agriculture is the dominant economic activity in rural Thailand (IRRI 2007). The agricultural sector accounts for over 11 percent of Thai GDP (World Bank 2009). The majority of Thai farmers produce rice (Maclean, Dawe & Hettel 2002). Rice-farm families are the backbone of Thailand: rice farmers account for 52 percent (around 30

million) of the Thai population. Rice farms make up over 55 percent of farmland use in Thailand (Clayton 2010). Land under rice cultivation accounted for approximately 68 million *rai* (10 million hectare) in 2010 (Rice Department 2011). The second ranking of planted area was para-rubber cultivation being over 11 million rai (Office of Agricultural Economics 2007). When considering the value of exported agricultural products, the amount of rice, which was exported from 2007 to 2010, was vary from 119 to 196 thousand million baht (Office of Agricultural Economics 2011). Nonetheless, rice is not the highest value of exported agricultural products in Thailand. It is para-rubber and its products. They were exported approximately 126 thousand million baht in 2009 that was the highest value compared with other types of agricultural products (Office of Agricultural Economics 2010).

Like other developing countries, the Thai economy relies mainly on export income. Rice was in the top five agricultural products, in terms of value, exported from Thailand to the world market in 2008 (World Bank 2009). The value of exported rice varied from USD 3,592 to 6,112 million during 2007-2009 (Thai Rice Exporters Association 2011), with an increase of 6 to 7 percent over 2003 (Office of Agricultural Economics 2007). In 2010, the value of Thai rice exported was USD 5,345.2 million (Thai Rice Exporters Association 2011).

There are three main groups of stakeholders of Thai rice industry (Vanichanont 2004):

- **Rice producers**, including farmers and their families, who number 30 million people in Thailand (Maclean, Dawe & Hettel 2002), of whom 16 million are poor (Vanichanont 2004). It is a highly fragmented sector. Most of these producers have poor knowledge of the market and low bargaining power with suppliers and customers.
- **The milling sector** involves about 800 to 1,000 rice-milling companies across the country (Thai Rice Mills Association 2008). It is a fragmented sector made up of small and medium enterprises that primarily serve local customers. The large companies have the power of mass distribution and serve international customers.
- **The marketing sector** involves wholesalers, retailers and exporters. There are approximately 150 to 200 export companies in Thailand (Thai Rice Exporters Association 2008). Those companies hold a very strong position in the Thai rice

industry (Vanichanont 2004). This sector is concentrated and firms have high bargaining power relative to suppliers and strong competition in prices.

The Classification of Rice in Thailand

Rice is classified in Thailand according to a number of criteria: the texture of the rice, its crop season, features of the rice farm and its trading classification. There are two textures of rice: white (amylose) and glutinous (amylopectin).

1) There are two rice crop seasons: rained or major rice (wet season), which is planted during May-July and harvested during November-December, and off-season or minor rice (dry season) (IRRI 1997).
2) Rice farms can be classified into three types: upland rice is cropped in steeply sloped areas; this type of land accounts for 10 percent of the total rice land in Thailand. Lowland rice is grown in about 80 percent of the total rice land in Thailand. Floating rice is grown on the farm land that must be cropped under a metre of water using a special variety of rice (TRFRP 2006).
3) There are four main trading classifications: white, jasmine, parboiled and glutinous rice (TRFRP 2006).

In the Thai rice sector, there are two main paddy rice supply channels. The former is paddy rice purchased directly to millers or merchants. The latter is rice farmers purchasing paddy rice to the government through millers joining the paddy rice mortgage scheme. It is common in developing countries that there are unofficial sale by unauthorised elements. As the government set up the high price of rice, there are some corruptions in the paddy rice mortgage scheme. For example, some farmers and authorised officers cooperate with some millers who join the scheme to mix high quality of rice with low quality of rice, and then put the rice to the scheme. The real quality of rice is not recorded. Moreover, the low quality of rice could come from neighbour countries such as Cambodai that is cheaper than Thai rice (Wongsinchot 2012). This issue can make the government loss a huge buget as the government must sell this low quality of rice cheaper than the mortgage price.

3.4 Overview of SMEs

This section presents an overview of SMEs as they are the main enterprises in TRSC. Then, an overview of SME in Thailand and in the Thai rice industry will be presented in the next sub-section.

SMEs make up 95 percent of all businesses in East Asia (Harvie & Lee 2002). In South-Eat Asia, SME's constitutes around 98 percent of all enterprises (Hayashi 2005). These enterprises are crucial in terms of economics and society contribution. The definitions of SME's vary from country to country, but usually based on the number of employee or the value of assets (Sahakujpicharn 2007). In general, the small enterprises have workers between 5 and 50 (Christodoulou 2009), while the medium enterprises employ workers less than 250 (Hallberg 2000).

The characteristics of SMEs are:

- (i) Independently owned and operated,
- (ii) Closely controlled by owners/managers,
- (iii) Decision-making is primarily done by the owners/managers, and
- (iv) Most of the operating capital is contributed by the owners/managers (ABS 2001).

Therefore, owners or managers play a crucial role in business activities of SME's. The good interpersonal relationship among owners of SME's can encourage their business performance (Sahakujpicharn 2007).

The role played by SME's in any countries is undoubtedly important. SME's have succeeded to develop the numerous developing economics (Park 1995). The study of Sahakujpicharn (Sahakujpicharn 2007) summarises that SME's contribute to:

- (i) individual economics in term of number and output,
- (ii) foundation of industrialisation,
- (iii) job creation,
- (iv) export promotion
- (v) sales, output and value added
- (vi) contribution of SME's to growth, and
- (vii) poverty alleviation.

In East Asia, the profile of SME can be explained in four main messages. First, SMEs (enterprises with fewer than 100 employees) are important to economic growth, and are especially important to jobs and job creation. This message is supported by the study of Sahakujpicharn (2007). About 70 percent of employment growth comes from SMEs in East Asia such as China, Vietnam and Indonesia in the last five to ten years Second, the entrepreneurial engine is developing East Asia seems to be underpowered. This means that the job creating potential of SMEs is less than it could be. Third, internationally, SMEs have more opportunities than ever before, but they seem to be growing only at about the same rate as the international economy. Fourth, SMEs have tended to become more important economically and politically because they employ do many people (Harvie & Lee 2002, p44-45).

3.4.1 Overview of SMEs n the Thai Rice Industry

This section presents an overview of SME's in Thailand and especially in the Thai Rice Industry. Most information used in this section derived from Office of Small and Medium Enterprises Promotion under the Ministry of Industry. The definition of Thai SMEs issued by the Ministry of Industry on 2002 emphasises employment and the value of fixes asset. They give the definition of SMEs differently depending on types of sectors as shown in Table 3-3.

Table 3-3: The definition of Thai SMEs in different sectors (Office of Small and Medium Enterprises Promotion 2003).

Sectors	Small enterprise	Medium enterprise
Manufacturing	• Employment not exceeding 50 people • Fixed assets (excluding land) not exceeding THB 50 million	• Employment ranges between 51 and 200 people • Fixed assets (excluding land) exceeding THB 50 million, but less than THB 200 million
Wholesale	• Employment not exceeding 25 people • Fixed assets (excluding land) not exceeding THB 50 million	• Employment ranges between 26 and 50 people • Fixed assets (excluding land) exceeding THB 50 million, but less than THB 100 million
Retail	• Employment not exceeding 15 people • Fixed assets (excluding land) not exceeding THB 50 million	• Employment ranges between 16 and 30 people • Fixed assets (excluding land) not exceeding THB 60 million.
Service	• Employment not exceeding 50 people • Fixed assets (excluding land) not exceeding THB 50 million	• Employment ranges between 51 and 200 people • Fixed assets (excluding land) exceeding THB 50 million, but less than THB 200 million

In Thailand, the number of SME's is approximately 0.67 million, account for 97 percent of all businesses, and employment range from 50 to 80 percent of the work force (Harvie & Lee 2002). About 2.2 million SMEs are the new key driving forces for the overall growth of the economy in Thailand (Office of Small and Medium Enterprises Promotion 2011). In 2010, Thai SMEs contribute around THB 3.7 trillion accounting for 37 percent of Thailand's GDP. In addition, the GDP growth rate of SMEs is 7.9 percent a year. Moreover, the GDP of small-sized enterprises is THB 2.5 trillion that higher than those of medium-sized enterprises. Nevertheless, large-sized enterprises are a growth engine of Thai economy as its growth rate is higher than SMEs' growth rate. When considering the structure of SMEs' GDP, manufacturing sector is the most important sector as it accounts for 32.2 percent of total SMEs' GDP, followed by service sector accounting for 31.6

percent of total SMEs' GDP. This is the same tend as the whole country's GDP structure (Office of Small and Medium Enterprises Promotion 2011).

As this study focuses on the TRSC, its members are found that most of them are SMEs. Most rice farmers are self-employed. Rice millers can be divided into three sizes according to the number of employees. Small-scale mills employ less than 5 people. Medium-scale mills employ less than 10 people, while large-scale mills employ more than 10 people. There are numerous small-scale mills located every local area across the country. They mainly serve local farmers to mill small amount of paddy rice for self-consume (Kalsirisilp 2012). In the marketing sector of rice industry involving wholesalers, retailers and exporters, information on the number of SME is not available as most of them registered in Bangkok and municipality areas. Although the GDP of SME in agriculture sector is not provided, SMEs such as input suppliers of farmers, post-harvesting quality control, transport and storage, and preliminary processors have a potential role to add value to an agriculture supply chain (Zola 2006).

3.5 Crisis in the Thai Rice Industry

The Thai rice industry is currently undergoing crisis in the area of competitiveness and production constraints.

1) Competitiveness

Recently, Thailand's share on the international market has tended to decrease. There is fierce competition in the world market for low-quality rice exports. This issue has raised concerns about the future of rice production in Thailand due to lower production costs borne by its exporting competitors such as Vietnam (Rahman et al. 2009). Beginning in 2005 the more-affordable prices and reinforced quality of Vietnamese rice have increased its market share, especially in the ASEAN market (Jamora et al. 2010). As the aromatic Thai jasmine rice is popular in the world market, Thailand had until relatively recently faced low competition in the high-quality rice market (Rahman et al. 2009). However, jasmine rice has been a target of copying and modifications in the west. In 1990, "Jasmati" rice was first marketed by a company in the United States as possessing the traits of Thai jasmine and Indian basmati rice (Lightbourne 1999). In 2009, a new variety of aromatic rice, known as 'Jazzman' was developed by Louisiana State University's

Agricultural Centre; it has a very similar fragrance, soft grain and quality to Thai jasmine rice (Pratruangkrai 2009; Sha 2009). Such rice is cheaper, and can confuse consumers into believing that it is jasmine rice from Thailand (Tanasugarn 1998).

2) Production constraints

Thailand is facing a shortage of labour in agricultural production. Since Thailand has experienced steady economic growth and gained a position among the newly industrialised nations, more labour for industrial development is required (Ahmad & Isvilanonda 2005). In addition, the income from agriculture fluctuates as its output is unstable. Thus, many farmers in rural areas move to work in the cities or in industries.

Rice yield in Thailand is low compared with other countries such Vietnam and China (FAOSTAT Database 2008): only 66 percent of the world average. This suggests that Thai rice yield can be boosted by improving production process and rice varieties, and controlling some diseases such as neck-blast disease (Rahman et al. 2009), but government agencies are not equipped to play a effective role in promoting such policies. Moreover, climatic problems also affect rice production in Thailand as discussed in Section 2.8.2.

3.6 The Thai Rice Supply Chain (TRSC)

A supply chain consists of all parties (such as suppliers, manufacturers, distributors and retailers) involved, directly or indirectly in fulfilling a customer request (Chopra 2004). The functions that make products and services available to customers are production, delivery and recycling of material (Wisner 2005).

Figure 3-3 illustrates the flow along the TRSC as rice goes from the paddy to the processors to the market. Millers or paddy merchants purchase the largest quantity of rained paddy rice from farmers almost immediately after harvesting in January-Apri; this can lead to a large over-supply of rice. Off-season rice cropped in irrigated area arrives at rice mills during June-September each year (IRRI 2007). After harvesting, drying is the most important process because it can directly affect grain quality and result in losses (Gummert & Rickman 2006). Rice straw is purchased to be animal feed. Rice millers can purchase paddy rice directly from farmers, or indirectly through the Thai government's

Paddy Rice Mortgage Scheme before the rice season of 2009/2010. The price-guarantees scheme for paddy rice replaced the Paddy Rice Mortgage Scheme in 2010 (The Thai National Rice Policy Committee 2009). Farmers receive the subsidy from this policy.

Some paddy rice from farmers who crop rice for their own consumption is milled by small or local rice mills (which generally have a capacity of 1 to 12 tonnes per 24 hours) while some paddy rice from medium to large farms is milled by medium-scale (capacity of 30 to 60 tonnes per 24 hours) or large-scale (capacity of 100 tonnes per 24 hours) mills. The by-product of milling process is broken rice, which is transferred to rice processers, while husk and bran are used for animal feed and fuel production.

The rice supply chain processes have overlaps between the domestic consumption and export markets in milling sector. Some large milling companies supply milled rice to both retailers for the local market and exporters for the international market. Those companies have large-scale mills and ability to operate packing process. Moreover, some of them directly export rice to the international market. Parboiled rice needs specific processes that are soaking, steaming and drying. These steps also make rice easier to process by hand, take less time to cook, improve its nutritional profile, and change its texture (Pillaiyar 1981). There is no the domestic demand for parboiled rice and Thailand exports parboiled rice around 1 million ton a year to Middle East and Africa countries such as Mozambique, Cameroon, Somalia, Nigeria, Saudi Arabia, Italy, Germany, and France (Juliano, Perez & Kaosa-ard 1992).

In general, milled rice is refined and packed for domestic customers by retailers and for international customers by the exporters. Some milled rice is transferred to rice distributors who manage storage systems where the rice is kept before being distributed to retailers or exporters. Domestic demand is met by delivering milled rice through retailers to domestic customers. Some rice for the international market is exported directly, while some goes through exporters for cleaning and repacking (TRFRP 2006). Milled rice stored under the paddy rice mortgage scheme owned by the government is purchased by other governments (G2G), or the government opens bids for the Thai rice exporters. In 2010, the rice stock under this policy is around 5 million tonnes (Bangkok Post 2010).

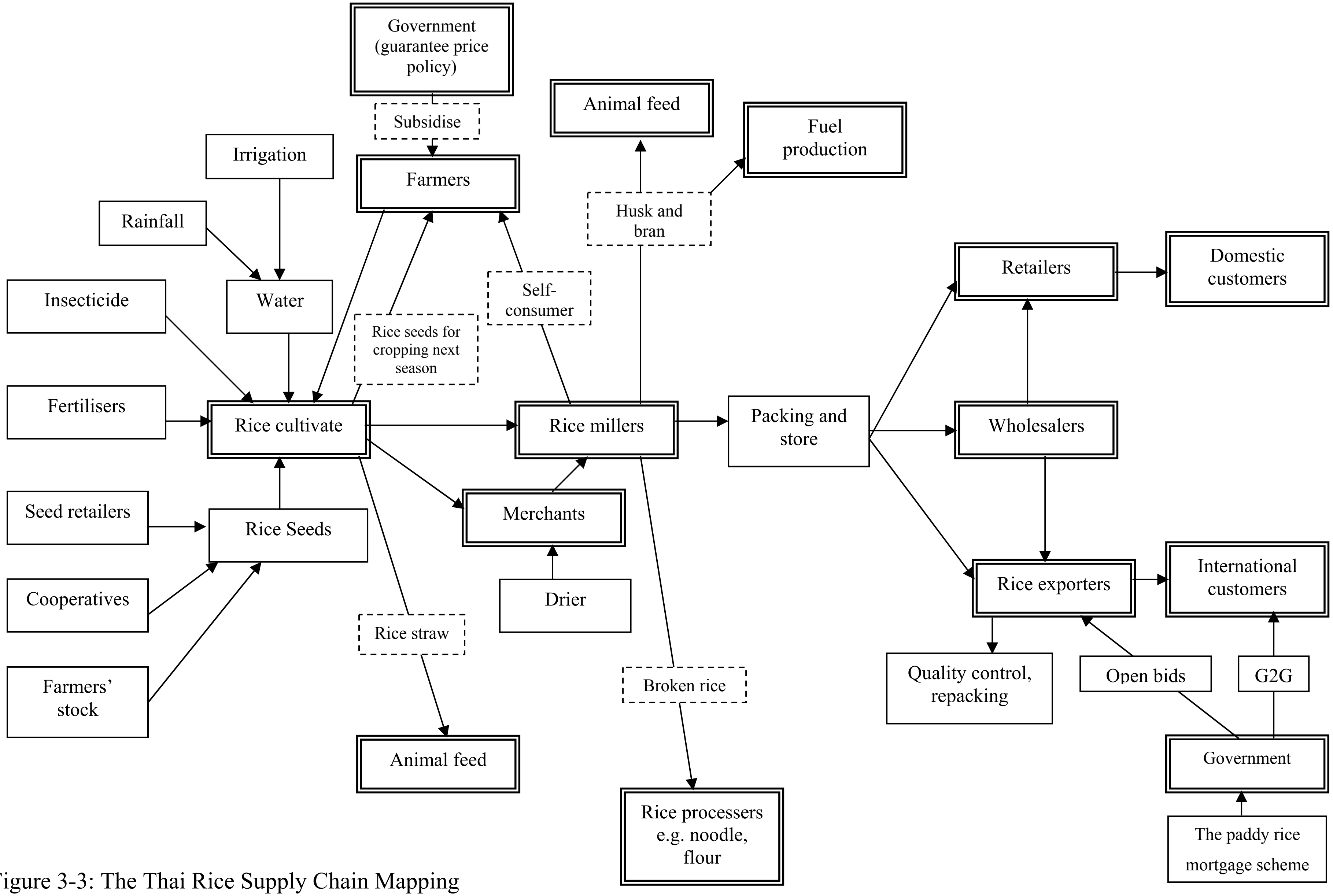


Figure 3-3: The Thai Rice Supply Chain Mapping

3.6.1 Rice Supply

The rice supply side refers to rice production. Rice cropping in Thailand consists of five steps: land preparation, crop establishment, harvesting, post-harvesting (threshing, drying and cleaning) and storage (TRFRP 2006).

There are two main seasons of rice production in Thailand: major (wet) and minor (dry). The period of major rice cropping depends on the amount of rainfall, which can vary from year to year (TRFRP 2006). The minor season occurs in irrigated areas located mainly in the central region of Thailand (Table 3-4. The northeast is the main rice-growing region and the home of the famous jasmine rice. Nevertheless, the central area is more important because it is an intensively cultivated alluvial area during both the major and minor seasons. This area accounts for almost 75 percent of dry-season rice grown under irrigated conditions (IRRI 1997).

Table 3-4: Region, Season and Rice Production in Thailand (IRRI 2007)

Region	Season	Planting	Harvesting	% of total rice land in Thailand
North, northeast and central	Major	May to July	November to December	North: 20% Northeast: 54% Central: 20%
	Minor	December to January	May to June	
South	Major	September to November	March to May	6%
	Minor	April to May	August to September	

The following section examines the rice production environment, the rice yield and the areas under cultivation in Thailand.

3.6.1.1 Rice Production Environments

Rice production environments are described in terms of “topography, soil type, water regime and climate factor” (David 1992, p9) but can be categorised more generally into four types according to water regime: irrigated area, rain-fed lowland, deep-water land and upland or dry land (David 1992). In Thailand, 62 percent of the rice crop area by

production environment was rain-fed land, 27 percent was irrigated, 8 percent was deepwater and only 3 percent was upland (IRRI 1991).

Temperature and solar radiation in different regions are the climate determinant for the rice crop period, productivity and stability, as they affect the growth and development of the rice plant (Yoshida 1981), as summarised in Table 3-5 Unsuitable temperature negatively affects rice growth, cultivation period, efficiency and production rate. Low temperatures (less than 15°C) and high temperatures (more than 40°C), for instance, influence the period of rice growth. Different varieties have different tolerances for low and high temperatures. In addition, sunlight affects rice growth, when the percentage of sunlight decreases, rice grain yield also decrease (Yoshida 1981).

Table 3-5: Temperature and Rainfall Conditions that Affect Crop Period and Productivity and the Stability of Crop Yield (Yoshida 1981, p68)

	Temperate	**Tropics**
Crop period	Temperature in spring 13°C - 20°C	Rainfall
Productivity (rice yield)	Sunlight	Dry season
Stability of crop yield	Temperature Rainfall Sunlight Typhoons	Rainfall (drought or flood) Typhoons

Table 3-6 llustrates the levels of water and temperature appropriate to rice growth. Yoshida (1981) shows that anthesis generally happens during the morning (8 am-1 pm) in tropical weather, and in the afternoon in lower temperatures. The length of ripening is dramatically affected by temperature. Ripening takes approximately 30 days, for example, in the typical environment. On the other hand, it requires 65 days in low temperatures. Low temperature can cause “failure to germinate, delayed seeding emergence, stunting, leaf discoloration, panicle exertion, delayed flowering, high spikelet sterility, delayed heading, and irregular maturity” (Yoshida 1981, p.77). Meanwhile, high temperatures, particularly those greater than 35°C, lead to high percentages of spikelet sterility, affecting growth stages (vegetative, reproductive anthesis and ripening). Sunlight dramatically affect the reproductive and ripening stages: less sunlight results in reduced

spikelet numbers and percentage of filled spikelets which in turn can reduce grain yield (if they were originally higher than 5 tonnes per hectare) (Yoshida 1981).

Table 3-6: Levels of Water and Temperature Appropriate to Rice Growth (adopted from Yoshida 1981, pp2-16)

Stage	**Water**	**Temperature**	**Other factors**
Dormancy	Rain frequently during harvesting	High (49-50 °C)	High treatment duration (4-10 days)
Germination	30-40 % water contenting of the seed	- The length of incubation (2 days at 27-37 °C) - No germination at 8 and 45 °C	Variety differences
Seeding in first week - Growth efficiency - Growth rate After first week		-Very sensitive to temperature (22-31 °C) - Positively correlated with high temperature (more than 15 °C and less than 40 °C) - Less influence	- Variety - Seed history - Agricultural management - 5-6 pp, oxygen (after the appearance of coleoptiles)

3.6.1.2 Rice Yield and Cultivated Area

Rice yield in Thailand depends on both controllable and uncontrollable factors. The uncontrollable factors are climate conditions and soil fertility (as discussed in the previous section) while the controllable factors include, for example, seed, fertiliser, insecticide, irrigation and water management (Sriswasdilek 1990). Generally, rice yield also fluctuates depending on the varieties of rice, seasonality and environment (Yoshida 1981), diseases, soil factors, physiological opportunities and insect infestation (David 1992).

Figure 3-4 shows that the amount of rice-planted land fluctuates greatly, but has tended to increase from approximately 10 to 11 million hectares during 2000-2011, leading Thai farmers to produce about 20 million tonnes of paddy rice in 2011 (FAPRI 2010). Under the Arkansas Global Rice Model, the average percentage of annual rice production increased by 1.54 (FAPRI 2008). However, Figure 3-4 shows that there are some crises happening such as in 2003. The harvested area was increases in year 2003 but rice output was decreased. It shows that rice yield in 2003 was harmed. The mega flood in Thailand at the end of year 2011 could damage the 6 million tonnes of rice paddy in an initial estimate. Thus, the rice output lunching in the beginning of year 2012 will be decreased by 20 percent (Phoonphongphiphat 2011).

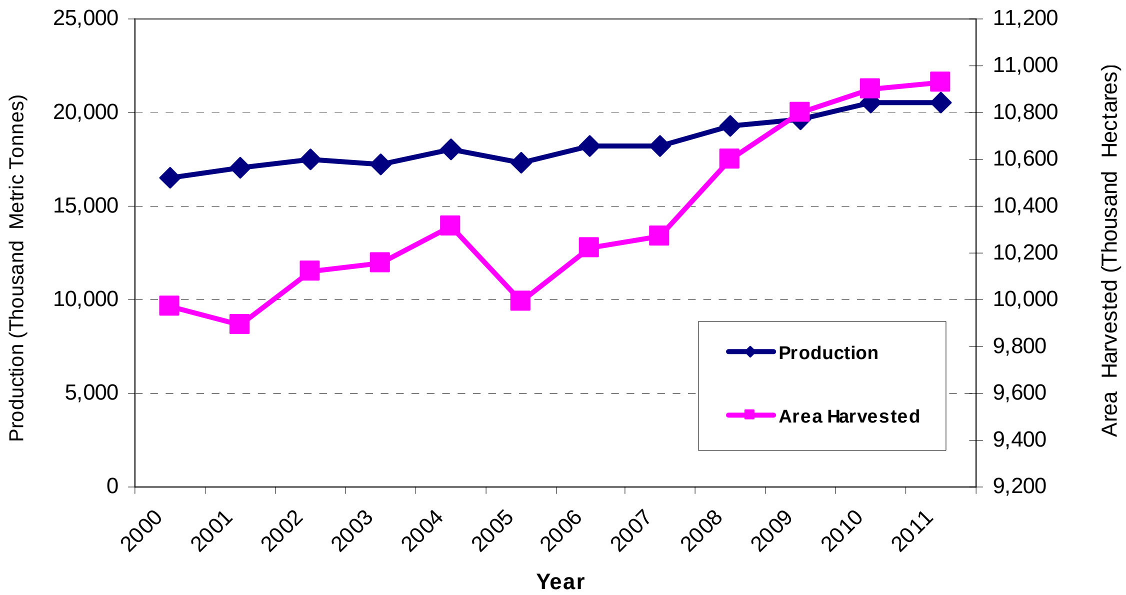


Figure 3-4: Paddy-Rice Production and Area Harvested, Thailand, 2000-2011(FAPRI 2010).

Figure 3-5 shows that Thai rice yield (metric tonnes per hectare) was stable from 2000 to 2011, but very low compared to rice yield in Vietnam, the Philippines, and China (FAPRI 2010). Although the overall Thai rice yield is stable, rice variety, seasonality, climate conditions, diseases, soil factors, physiological opportunities and insects can make rice yield unstable from year to year (Yoshida 1981; David 1992). For example, in 2001 the 105 jasmine rice yield was 321 kgs per *rai*, whilst the yield of Supanburi 1 could reach 604 kgs per *rai* (Department of Agriculture 2002). Farm type and size also makes a

difference in yield. Rice yield in irrigated areas was twice that of non-irrigated areas in Thailand (IRRI 1991). In addition, the rice yield on smaller rice farms (0.1-0.99 ha) is higher than on larger ones (Matsuda 1990). Moreover, uncertain weather and global warming has led to drought and flood in some cultivated areas in Thailand that can harm rice yields (Office of Agricultural Economics 2007).

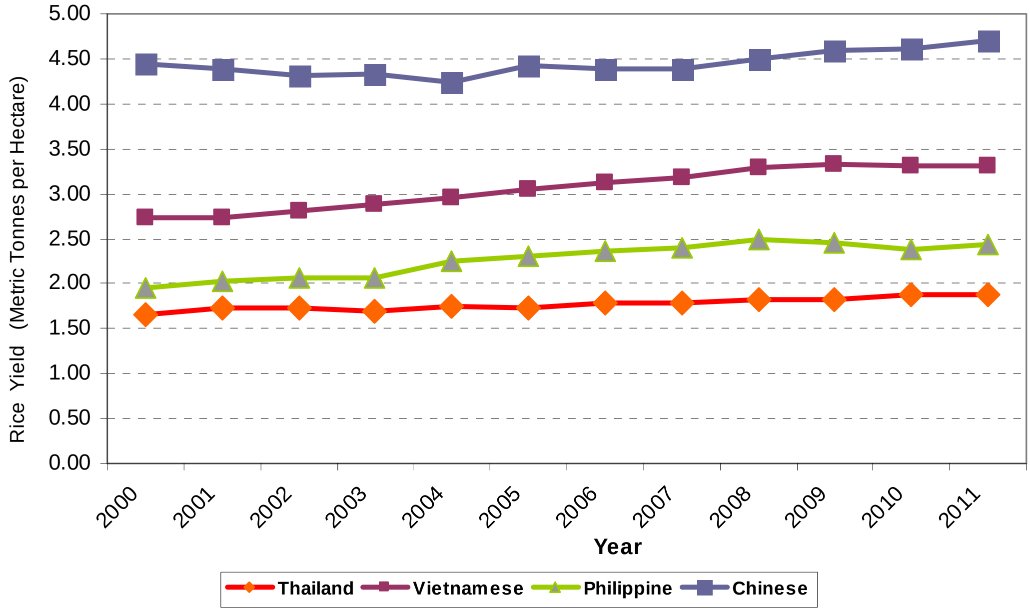


Figure 3-5: Paddy-Rice Yield, Thailand, Vietnam, Philippines and China, 2000-2011 (FAPRI 2010)

Rice yield and rice-land productivity in Japan, China and South Korea are very high compared with Thailand and other countries in East Asia. This is due to technological development in areas such as irrigation, transportation, development of modern rice varieties and the low cost of fertilisers since 1980. As the result of technological change, farmers tend to increasingly use fertilisers, weed killers and other chemicals and plant modern varieties of rice on their farms. Thus, at present insects and weeds are not the main factors that decrease rice yield. Rather, environmental conditions such as temperature and water have become the primary factors in decreased rice yield in South-East Asia (Herdt 1992).

3.6.2 Rice Demand

Demand for Thai rice can be divided into domestic and international demand. Domestic consumption accounts for 55 percent of the total production (Government Public Relations Department 2010). Domestic demand is relatively stable at nearly 10 million tonnes per year with a 0.55 percent average rate of increase every year (FAPRI 2010); this is due to slight increases in the Thai population, as illustrated in Figure 3-6. The Thai population growth rate was only about 0.91 percent in 2004 (National Statistical Office and Bank of Thailand 2004); this rate dropped to 0.566 percent in 2011 (CIA World Factbook 2011).

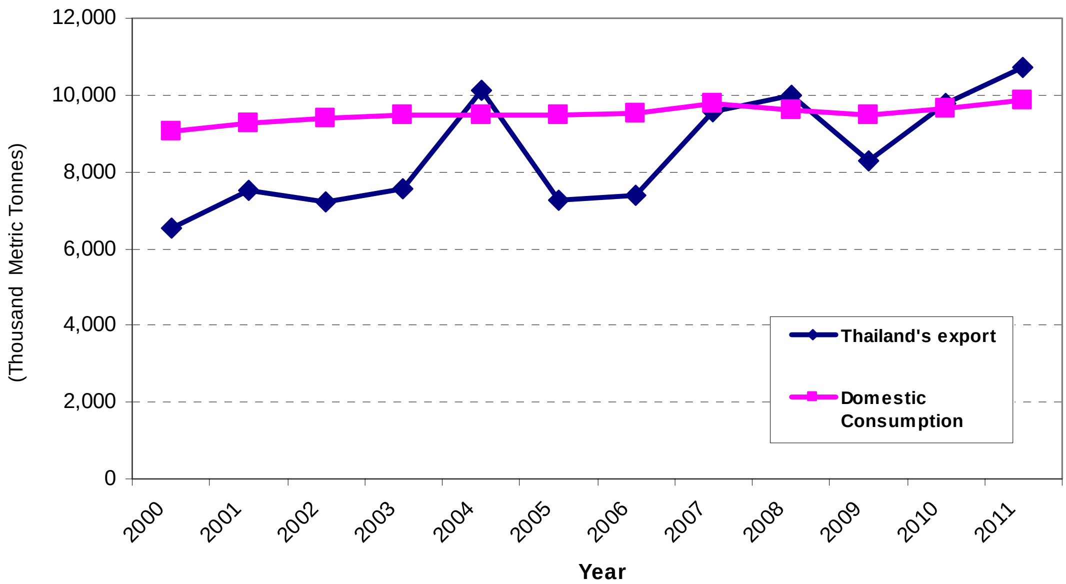


Figure 3-6: Thai Rice Domestic Consumption and Thai Rice Export , 2000-2011 (FAPRI 2010)

The international demand for Thai rice depends on many factors such as world population figures, eating behaviour and market competitiveness. Figure 3-6 shows the trend of the Thai rice trades in the world market. Although Thai rice exports are expected to grow continuously by approximately 3 percent from 2011 to 2020, the historical data from 2000 to 2010 shows fluctuations in the amount of Thai rice exported (FAPRI 2010). As mentioned in Section 2.7.1, this might be because the demand for rice on the world market has tended to grow as other rice-exporting countries such as Vietnam and the Philippines have faced difficulties in their rice production due to a number of natural disasters (IRRI 2007).

Figure 3-7 shows USA was the main international customer of Thai rice around 330 thousand tonnes with THB 9.5 million accounting for 23 percent of all Thai jasmine rice export in 2008. China and Hong Kong imported Thai jasmine rice around 147 and 126 thousand tonnes respectively. It accounted for approximately 8 percent of all Thai jasmine rice export in 2008.

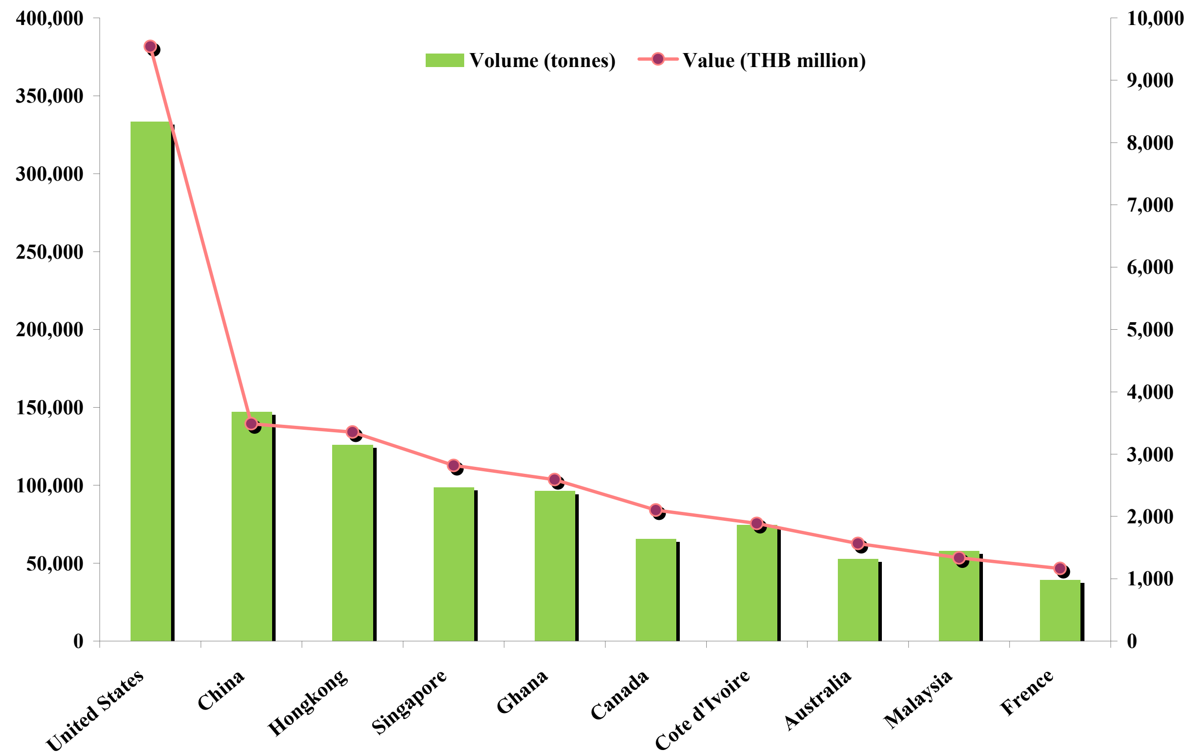


Figure 3-7: The volume of jasmine rice 100% exported by Thailand to the top ten countries in 2008 (Thailand Customs Department 2009).

Figure 3-8 illustrates top five countries (India, Pakistan, Thailand, United States and Vietnam) exporting rice to the international market from year 2000 to 2011. Thailand is the biggest exporter, while the second rank is Vietnam. The volume of rice exported by India has been fluctuated from 2000 to 2011. This is because the India government has a policy to reserve rice for domestic consumption.

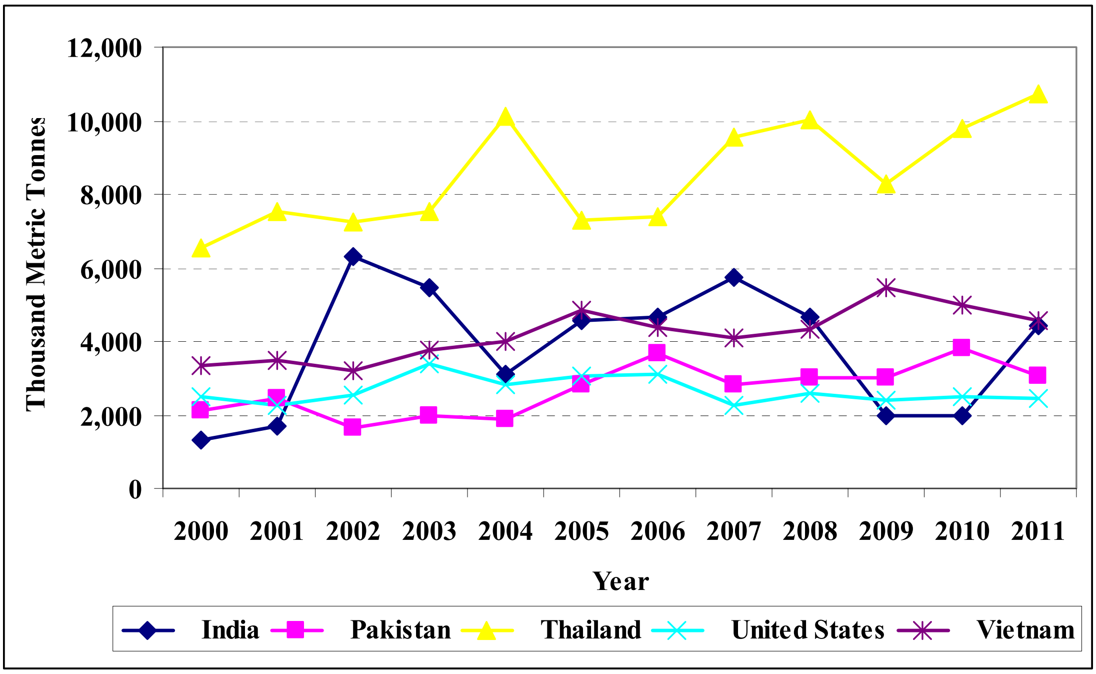


Figure 3-8: The Top Five Countries Export Rice, 2000-2011 (FAPRI 2010) (FAPRI 2010)

3.6.3 Distribution of Rice

This section describes the roles of transportation and inventory in the distribution of rice in Thailand

3.6.3.1 Transportation of Rice

The transportation of both inbound and outbound products is "a critical link in the supply chain because it connects and holds supply-chain members together" (Bentz 2003, p.156-157). The transportation of rice in Thailand can be divided into two stages. First, at the local level, paddy rice is transported from the farmers to the brokers at the rice mills; special conditions are required during transportation to preserve the moister content of paddy rice and milled rice (Gummert & Rickman 2006). The second stage is the delivery of rice from brokers in provincial areas to domestic and international end-customers as illustrated in Figure 3-7 (Punyasawat & Garearnvanan 1993).

The flow of rice from farmers to end-customers is explained in Section 3.5. The main method of transportation of paddy and milled rice to domestic customers is by road. Ships and trains are rarely used; merchant ships are the major method of transporting rice to

overseas markets (Punyasawat & Garearnvanan 1993). Rice supply chain members have three type of distribution channels (Goh & Pinaikul 1998): their own vehicles, vehicles they lease and third-party transport providers. (There is no data on how many third-party logistics providers are employed in this chain.)

3.6.3.2 Inventory Management of Rice

Because many firms cannot avoid uncertainty factors such as varying customer needs and external suppliers, inventory management aims to mitigate their negative impacts of these (Heath & Danks 2003). The major objectives of rice-inventory management are not only to handle the uncertainty factors, but also to maintain food security for the whole year. Given that there is a huge surplus of paddy rice at harvest time (December-April), the most important function of rice-inventory management is to maintain the quality of paddy rice and milled rice during storing (Rice Department 2007) Rice is a non-perishable food grain that can be stored over a number of years (Gill 1991) as long as it is held under proper conditions of temperature and humidity (Gummert & Rickman 2006). Thus, along the rice supply chain the inventory level of paddy rice and milled rice is very high and remains high for the whole year.

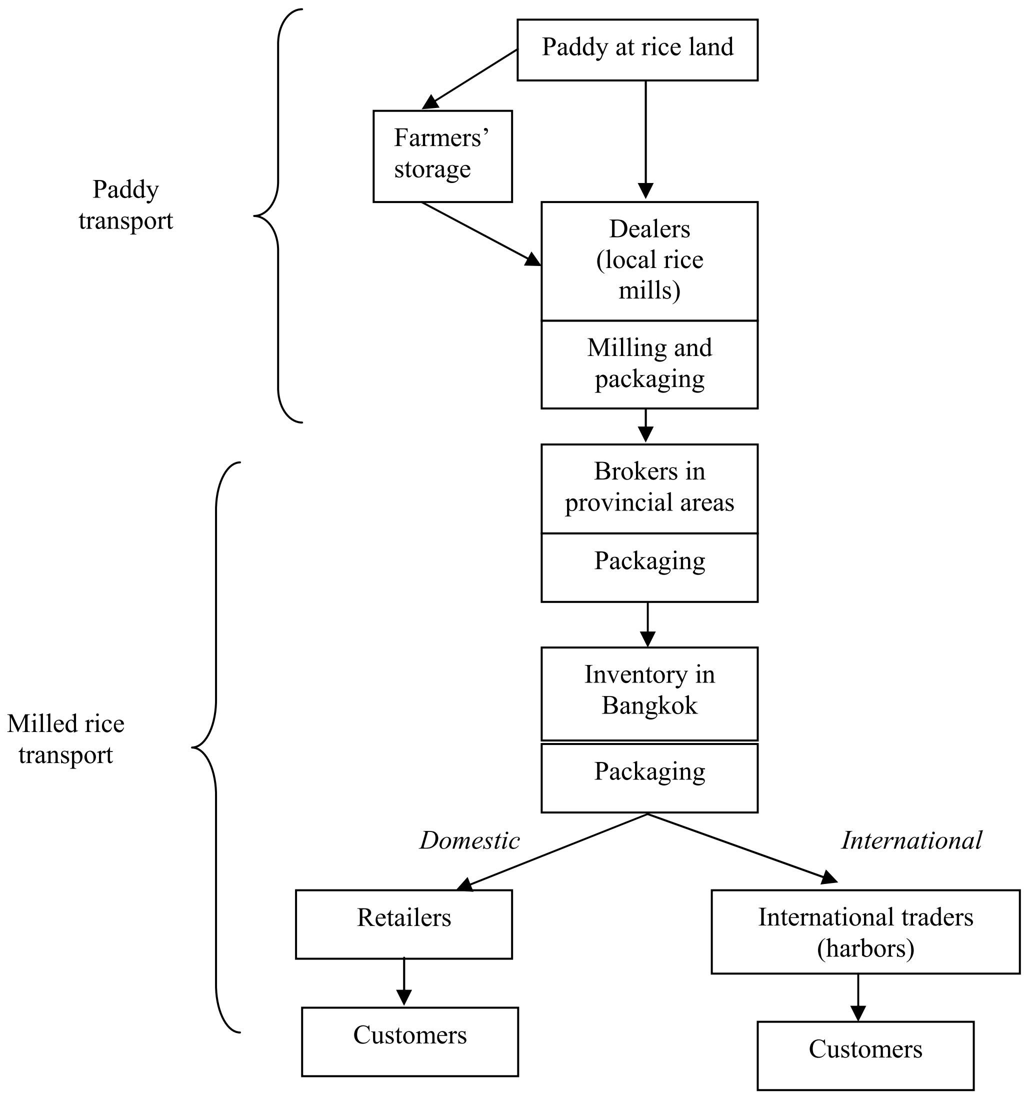


Figure 3-9: Transportation of Paddy and Milled Rice from Farmers to End Customers (Modified from Punyasawat & Garearnvanan 1993)

In Figure 3-9, rice farmers store some paddy rice in bulk storage (Gummert & Rickman 2006); however the majority is purchased by dealers immediately after harvesting (Punyasawat & Garearnvanan 1993). This means that the majority of stored paddy rice is under the management of millers or paddy merchants who need to keep paddy rice dry enough before milling. In particular, before 2010 the millers who joined the Rice Mortgage Scheme had to hold onto a large inventory of paddy rice before releasing it to the storage centre of the Marketing Organisation for Farmers, Ministry of Agricultural and Cooperatives, until the farmers paid their rice mortgage or government-to-government trade occurred. At the end of April 2008, this amounted to approximately 3 million tonnes of rice (Government Public Relations Department 2008). The overall final

inventory of rice in Thailand reached over 3.8 million tonnes in 2008, and is forecast to remain at about 3.4-3.5 million tonnes each year after 2009 (FAPRI 2008). After 2010, the inventory of rice under the Rice Mortgage Scheme policy will decline until no rice is left, as the government is replacing this policy with a price-guarantee policy that subsidise farmers but does not purchase rice from them.

3.7 Uncertainty Factors in the Rice Sector

There are several uncertainty factors that exist in the rice sector. Demand of Thai rice in the international market is unstable. The main reason is the high competitive market. Vietnam rice is more attractive to international customers as it is cheaper than Thai rice (Goletti & Minot 1997). Moreover, Thailand is expected to fail to be the biggest rice exporter in 2012 after India change its export rice policy. India proposes to export cheap rice again to the world market. In addition, Thai government policies promote high quality and price of rice (Thai Rice Exporters Association 2012). Therefore, the price is higher than other rice export countries. For example, Thai rice 5 percent is 550 USD/tonnes while Veitnam rice 5 percent is 426 USD/tonnes (FAO 2012). Thus, other rice export countries will take some market share from Thai rice which is expected to export decreased to only 6.5 million tonnes in 2012 (Thai Rice Exporters Association 2012). However, the high price of rice influence Thai people who live in rural area to crop rice more. Thus, rice output tends to increase unless natural disaster such as flooding in 2011 happen and destroy rice crop land.

The processes of rice production are uncertain as around 80 percent of rice harvested areas are non-irrigated (Office of Agricultural Economics 2008). They rely on the volume of rainfall in each year. Approximately 20 percent are irrigated rice crop land also can face uncertainty of planning and control in cultivation when famers can not access the data of water management from two main dams : in Thailand (Office of Agricultural Economics 2007). It is widely observed that in Thai rice milling is done by a large number of small rice mills using obsolete and inefficient machinery that lead to uncertain yield of milling process (Ninh 2003).

3.8 Chapter Summary

The rice industry plays an important role in developing countries where there are major rice producers and consumers. Food security, the economic value and the cultural importance are attributed to rice. In Thailand, rice is defined as life. Rice production involves almost 30 million Thai people, mainly those who live in rural areas. About 11-12 percent of Thai GDP is attributable to rice industry.

The TRSC includes rice producers, millers, dealers, wholesalers and exporters in the flow of paddy rice and milled rice. The demand for Thai rice in the international market fluctuates because the price of Thai rice is higher than that of its competitors and because of falls in competitors' rice output due to flooding. Likewise, the supply side of Thai rice primarily relies on the natural environment, leading to unstable rice output from year to year. Supply-chain transportation is mainly by road for domestic customers and by ship for international customers. The inventory level of rice is high and mostly owned by rice millers.

Since rice is an important grain for Thailand and the world and there is intense competition within both domestic and international markets, it is important to understand how TRSC members handle uncertainty factors through supply chain management practices.

Therefore, the next chapter will discuss the development of a conceptual framework related to the research questions and hypotheses.

CHAPTER 4

CONCEPTUAL FRAMEWORK AND HYPOTHESES

4.1 Introduction

Having addressed the gaps in the literature revealed by the in Chapter 2, this study now develops a conceptual framework to fill those gaps. The objectives of this chapter are to propose the framework based on the literature analysis of the causal relationships between uncertainty factors, supply chain management practices and performance in the context of the Thai rice supply chain (TRSC). A conceptual framework is helpful in examining relationships among several variables that are identified by a testable hypothesis and providing a better understanding of observed business behaviours.

This chapter is divided into four main sections. Section 4.2 proposes the conceptual framework for this research is proposed. In addition, this section establishes the three key constructs in the model (uncertainty factors, supply chain management practice, and supply chain performance) and reviews the literature relevant to those constructs. Section 4.3 discusses the links between the constructs.

4.2 Proposed Conceptual Framework

The conceptual framework is proposed as a way of analysing the causal relationships among three main constructs (Figure 4-1).

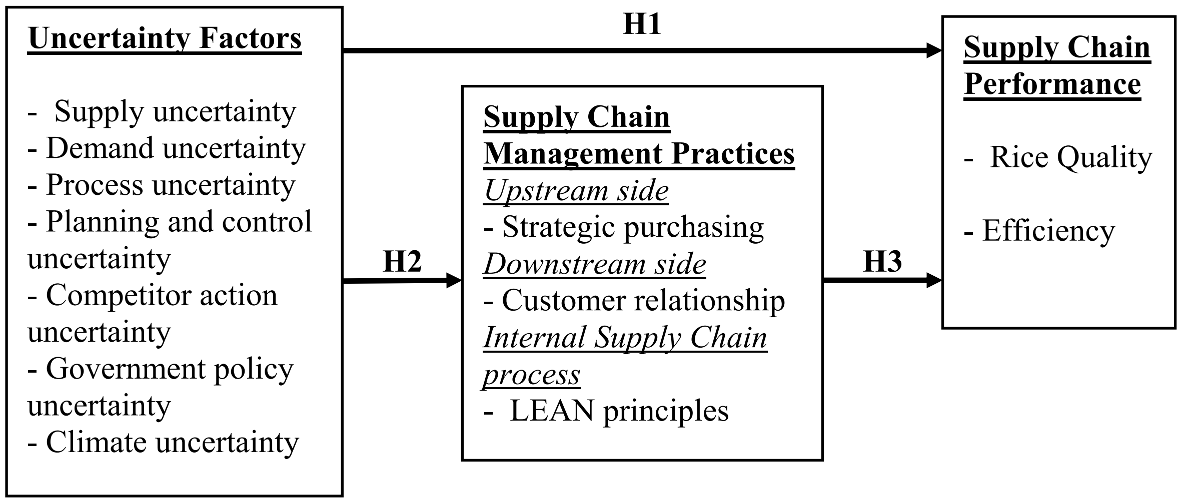


Figure 4-1: A Conceptual Framework of the Impact of Uncertainty Factors on TRSC Practices and Supply Chain Performance

Figure 4-1 presents the conceptual framework of this study, setting out the relationship between three constructs that are a major focus on this thesis: uncertainty factors, supply chain management practice and supply chain performance

4.2.1 Construct 1: Uncertainty Factors

Many researchers have considered environmental uncertainty as an important factor affecting supply chain implementation and performance (Bhatnagar & Sohal 2005). In addition, a wide range of uncertainty factors such as supply, demand, process (Ettlie & Reza 1992; Davis 1993), planning and control (Childerhouse & Towill 2004), competitor (Ettlie & Reza 1992) and transportation uncertainty (Wilson 2007) have been found to exist in a supply chain. At present, many conditions such as globalisation, the changing markets and technological advances (Fawcett 2007) coupled with supply chain network complexity in Asia (Easton, Thurwachter & Zhang 2003), have a great influence on the highly tentative environment within Asian supply chains operate.

Hence, it is crucial to have a clear understanding of the perceived uncertainty factors in a supply chain (Davis 1993). To discover all the uncertainty factors in the TRSC, this study will consider seven distinct sources of environmental uncertainty. Five sources (supply, demand, process, planning and control, and competitors) have been identified from previous studies of generic supply chains and food supply chains (Badri, Davis & Davis

2000; van der Vorst 2000; Li 2002; Paulraj & Chen 2007). The Thai rice industry literature in Chapter 2 identifies two additional uncertainty factors - government policy and climate uncertainty - which this study examines. These factors are defined below.

1) ***Supply uncertainty*** is related to the unpredictability of the delivery of raw or packed materials in time, in the right amount or according to the right specifications (van der Vorst 2000). In this study, the supply side is the paddy rice from rice producers or merchants to rice millers, and milled rice from rice millers or dealers to rice exporters.

2) ***Demand uncertainty*** relates to uncertainty about customers' requirements as a combination of unpredictability of demand and product variety (van der Vorst 2000). This study considers both the international (through rice exporters) and domestic (from rice millers) demand.

3) ***Process uncertainty*** relates to the production system. Specifically, process uncertainty can stem from uncertain process reliability and the quality of the product after processing; for example, the ability to adequately produce a particular product or the availability of sufficient raw materials (van der Vorst 2000). In this study, processes refer to any procedure carried out by supply chain members, such as milling, quality control and the packing process.

4) ***Planning and control uncertainty*** is related to incomplete information about production, inventory and customer demand. For instance, planning and control uncertainty reveals whether inventory levels are accurate or whether consumer needs are communicated correctly and on time (van der Vorst 2000). This study follows from the work of van der Vorst (2000) which considers planning and control uncertainty to be related to information availability, accuracy and throughput times.

Supply, demand, process, and planning and control uncertainty factors affect three aspects of the supply chain: quantity, quality and time. Table 4-1 summarises the specific ways in those uncertainty factors affect each of these aspects.

Table 4-1: Typology of Sources of Supply Chain Uncertainty and the Aspects They Concern (adapted from van der Vorst 2000, p76)

Uncertainty factors	Quantity	Quality	Time
Supply	Paddy rice quantities	Paddy rice qualities	Paddy rice timing to millers
Demand	Customer demand for quantities of milled rice	Customer demand for milled rice of particular specifications	Timing of customer orders
Process	Mill yield, packing yield	Milled rice quality before and after storage	Mill process throughput times
Planning and control	Information availability	Information accuracy	Information throughput times

5) ***Competitors' action uncertainty*** refers to unpredictable actions by competitors in intensely competitive markets. This includes reducing their product price or time to market, or increasing product quality and variety (Li 2002). Uncertainty about competitors' actions in the Thai rice industry can exist in both domestic and international markets.

6) ***Government policy uncertainty*** is the unpredictable set of laws, regulations, administrative procedures and policies formally sanctioned by the government, and which can affect an organisations' profitability (Badri, Davis & Davis 2000). This study specifically examines the government policies relating to the Thai rice industry in terms of rice production, rice trading, the paddy rice mortgage scheme and potential new policies (Javidan 1984; Badri, Davis & Davis 2000; Bran & Bos 2005).

7) ***Climate uncertainty*** is the unpredictable occurrence of serious weather events affecting agricultural areas. This study considers the occurrence of drought, flood and extreme temperatures in Thailand's agricultural areas. These phenomena can lead to rice supply shock, delay in the time of arrival of paddy rice to market or transportation disruptions (Cruz et al. 2007).

4.2.2 Construct 2: Rice Supply Chain Management Practices

Based on the literature study in Chapter 2, supply chain management practices are defined as "a set of activities undertaken in an organization to promote effective management of its supply chain" (Li et al. 2005, p.620). The nature of competition in the marketplace is forever changing; therefore, organisations have implemented various supply chain management practices with the intention of increasing competitive advantages in their business. This may include supply chain integration, LEAN principles, customer and supplier relationship management, information sharing and strategic purchasing (Fawcett 2007). Furthermore, supply chain management practices are collaborative practices that must link to business strategy and be driven by externally based objectives (Lummus & Vokurka 1999). Thus, organisations should simultaneously employ coordinated supply chain management practices upstream, downstream and internally.

This study focuses on the main supply chain management practices, which can be divided into three areas: strategic purchasing, which is supply-based; customer-relationship management, which is customer-based; and LEAN principles, which concern internal supply chain processes. Table 4-2 defines each of these areas.

4.2.2.1 Strategic Purchasing

Purchasing strategy is an important competition weapon (Spekman, Kamauff & Salmond 1994; Fawcett 2007), and a key ingredient of strategic supply management (Paulraj & Chen 2007). An effective purchasing process is the key supply management practice because it deals with communication in recognition and description of need, supplier selection, transaction management and relationship management (Fawcett 2007). Moreover, strategic purchasing can achieve better supply integration, which can increase supply chain performance for both buyers and sellers (Paulraj, Chen & Flynn 2006).

Table 4-2: Definitions of the Supply Chain Management Practices Examined in This Study

Sub-constructs	**Definitions**	**Reference**
Strategic purchasing	The purchasing focus on short- and long-term involved risk and uncertainty, and includes the firm's strategic planning process for collaborative buyer-supplier relationships and is aligned with the firm's goal	(Handfield 1993; Chen, Paulraj & Lado 2004; Paulraj & Chen 2007)
Customer-relationship management	The entire array of practices employed for the purpose of managing customer complaints, building long-term relationships with customers and improving customer satisfaction.	(Joel 2003; Li et al. 2005)
LEAN principles	The practice of developing a value stream to eliminate waste, and to ensure a level schedule. The seven common forms of waste are production of goods not yet ordered, waiting, rectifying mistake, excess processing, excess movement, excess transport and excess stock.	(Japan Management Association 1985; Shingo 1989; Bicheno 1994; Naylor, Naim & Berry 1999; Christopher & Towill 2001; Christopher 2003; Gattorna 2003)

As discussed in Section 2.3.1, in firms using strategic purchasing, the purchasing function is driven by the firm's strategic goal, purchasing performance, purchasing professionals' development and the integrative role of the purchasing department. This can increase buyer and supplier performance (Paulraj & Chen 2007). Thus, it aims to improve the performance of the whole supply chain through each connection between buyers and suppliers.

Similarly, in the TRSC, strategic purchasing also plays a major role for all supply chain members in terms of sourcing supply. For instance, millers' purchasing of paddy rice from farmers is the primary operating cost in this supply chain. The output from rice producers is seasonal and the price of rice tends to fluctuate. Thus, strategic purchasing should be implemented to handle this situation. Accordingly, this study considers strategic purchasing to represent the supply chain management practices on the upstream side of the TRSC.

4.2.2.2 LEAN principles

Based on the literature analysis in Section 2.3.2, LEAN production has been successful in improving efficiency and performance for both Toyota and its suppliers (Shingo 1989). It is responsible for reducing cost by eliminating the seven common forms of waste identified in Toyota's production systems and those of its suppliers (Japan Management Association 1985; Shingo 1989; Bicheno 1994). LEAN principles are based on LEAN production theory, which has been implemented by other industries worldwide.

A supply chain strategy that is developed by applying LEAN principles, specifically as they focus on customer values, has attracted several researchers in the area of general supply chains (Hines & Rich 1997; Jones, Hines & Rich 1997; Levy 1997; Naylor, Naim & Berry 1999; Cohen & Roussel 2005), and in the agri-food supply chains (Simons, Francis & Jones 2004; Taylor & Simons 2004; Cox & Chicksand 2005; Taylor 2005). These studies suggest that LEAN principles have been practiced widely in supply chains and have become a common strategy in organisations. Nonetheless, not all organisations can achieve the goals set out in LEAN theory (Cox & Chicksand 2005). Some organisations in a global supply chain, for example, face difficulty and increased expenses in order to successfully implement them (Levy 1997).

This study examines LEAN principles as an internal supply chain process in the TRSC. Certain characteristics of this supply chain make LEAN principles particularly suitable for improving performance and dealing with uncertainty factors.

4.2.2.3 Customer-Relationship Management

Customers are the key partner who place money into a supply chain (Fawcett 2007). Thus, this study cannot overlook a supply chain management practice dealing with this downstream side of the TRSC.

Customer-relationship management (CRM) is employed to manage customer complaints, build long-term relationships with customers and to improve customer satisfaction (Richards & Jones 2008). CRM is becoming more and more important in maintaining customers since they can easily access information about the quality and price of products from different sellers, and shift their demand to them (Chen & Popovich 2003). Thus,

there are many findings to support CRM's potential for providing a long-term profit (Winer 2001; Dull et al. 2003), customer equity (Richards & Jones 2008), higher flexibility and responsiveness by integrating between CRM and supplier-relationship management (Choy, Lee & Lo 2002).

As discussed in Section 2.3.3, CRM is defined as having two categories: strategic and operational. CRM at the strategy level is considered for this study to be on the downstream side of supply chain practice. This is because at the operational level CRM software alone cannot achieve the goals of CRM (Richards & Jones 2008). CRM software needs to collaborate with CRM strategy by using insights from customer information to develop a relationship based an understanding of customer needs and expectations in each customer segment (Winer 2001; Dull et al. 2003).

4.2.3 Construct 3: Rice Supply Chain Performance

It is essential to measure and evaluate supply chain performance to obtain guidelines for its improvement. Numerous studies of supply chain performance system have been discussed in Section 2.4. It is noted that in different industries such as a manufacturing (Persson 1995; Beamon 1999) and food (van der Vorst 2000; Aramyan et al. 2006), indicators of supply chain performance can be different because they focus on what is important to customers (Wisner & Fawcett 1991). To choose a proper supply chain performance measurement, Fawcett (2007) suggested that managers should select a measurement system that can provide insight into a critical value-added process, to communicate expectations and promote correct behavior, and to deliver high levels of the targeted performance.

As discussed in Chapter 3, the end customers within the TRSC are focused on quality and the low price of Thai rice products; government policy supports farmers in maintaining the premium quality of rice (Roumasset & Setboonsarng 1988). Meanwhile, international price competition is intense, and Thai rice suppliers must work hard to retain market share and competitive advantage over exporters in, for example, Vietnam and the Philippines (Thai Rice Exporters Association 2011). Thus, quality and efficiency are the two main performance indicators for the rice supply chain in Thailand. This study adapts

the agri-food supply-chain performance indicators - efficiency and rice quality - from the conceptual framework of Aramyan et al.(2006), as presented in Figure 4-2.

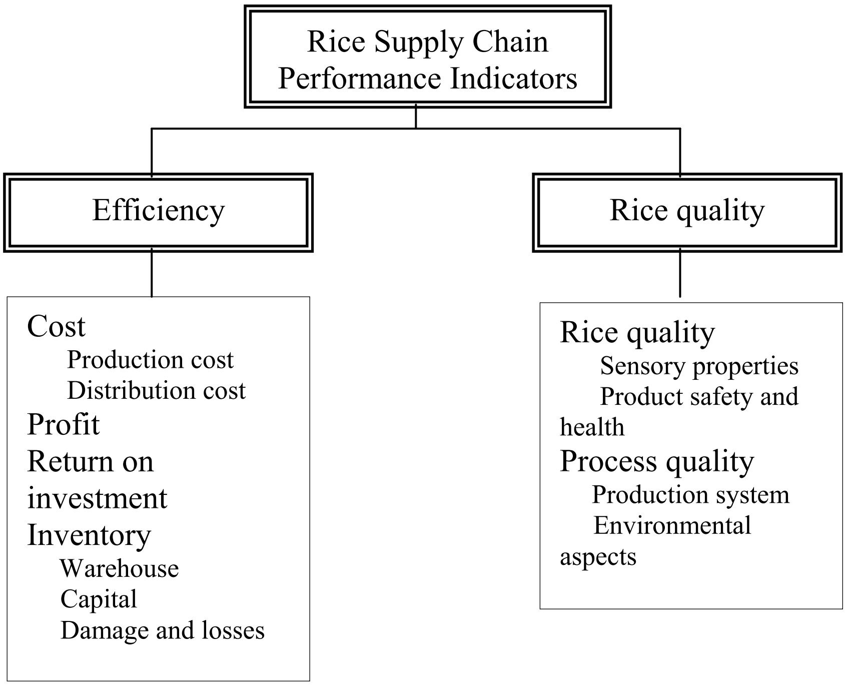


Figure 4-2: Agri-Food Supply-Chain Performance Indicators (adopted from Aramyan et al. 2006, p63)

4.3 Research Questions and Hypotheses

The relationships depicted in the conceptual framework are summarised in three sub-research questions derived from the main research question of this study ('*To what extent and in what way do uncertainty factors affect supply chain management practices and performance in the Thai rice supply chain*?')

The following three hypotheses are proposed in order to answer the three research questions set out in Section 1.4.

4.3.1 Research Hypothesis 1 (Uncertainty Factors and Supply Chain Performance)

Hypothesis 1 is developed to answer research question 1: "In the rice supply chain in Thailand, what are the key uncertainty factors that have the greatest impact on supply chain performance?"

Many scholars (Davis 1993; Fynes, Bu´rca & Marshall 2004; Jack 2004; Paulraj & Chen 2007; Boyle, Humphreys & McIvor 2008) have found the relationships between uncertainty factors and supply chain performance of great interest. They have investigated the extent to which uncertainty factors obstruct supply chain performance. Uncertainties on the supply side, on the demand side and within a supply chain lessen both supplier and buyer performance (Paulraj & Chen 2007). The entire supply chain performance in terms of customer fulfilment (Davis 1993), supply chain competitiveness (Bhatnagar & Sohal 2005), and total supply chain cost can be affected (Petrovic 2001).

Davis (1993) suggests that effective supply chain management comes from benchmarking current performance, controlling uncertainty and planning changes. Understanding the impact of variability in a supply chain can help maintain a satisfactory supply chain performance (Davis 1993; Childerhouse & Towill 2004). Supplier, manufacturing and customer uncertainty relate to the overall variability of supplier performance, irregular customer orders, the frequency of downtime (Davis 1993), and incomplete information (Childerhouse & Towill 2004). This leads suppliers to maintain to higher inventory levels to diminish late shipments to customers (Davis 1993; van der Vorst 2000; Childerhouse & Towill 2004). These uncertainties, ultimately, cause loss of sales, market share and profitability (Childerhouse & Towill 2004; Hua, Li & Liang 2006).

In the TRSC, the unpredictable quality of rice supply is expected to directly affect the quality of the rice product. Moreover, the unpredictable volume of rice supply in each production season may reduce the efficiency of the supply chain by forcing supply chain members to carry high levels of inventory, or to face inventory shortages.

Competitors, government policy and climate are the crucial external factors affecting the agri-food supply chain in developing countries. Any unpredictable practices by competitors can become a risk to organisations and to the supply chain, since those

practices can attract high customer satisfaction and loyalty to competitors (Mentzer, Min & Zacharia 2000). Consequently, such unpredictable actions by competitors can directly and indirectly affect the business performance of organisations all the way along the entire supply chain (Min & Mentzer 2000). As discussed in Section 3.4, Thai rice producers face fierce competition in the international market because of the development of new types of aromatic rice that, although of lower quality, still compete for market share.

Uncertainties stemming from government policies can provide both advantages and disadvantages for organisations seeking to improve supply chain performance (Marcus 1981). Many studies agree that changes in government policies can injure organisations' performance (Mendoza & Farris 1992; Yao 1999; Badri, Davis & Davis 2000), and lead managers in the Thai rice industry to apply inconsistent decision-making processes, resulting in unstable organisational performance (Roumasset & Setboonsarng 1988; Yao 1999).

In an environment characterised by agricultural production, climate variability can affect quality and efficiency along any parts of the agri-food supply chain including production, transportation, storage or farm management (Darwin et al. 1995; Ogallo, Boulahya & Keane 2000; Chinvanno 2003-2004; Sukin 2004). Thus, it can be expected climate uncertainty will harm the Thai rice industry.

Owing to the distinctive nature of the rice supply chain in Thailand as discussed in Chapter 3, this study considers the uncertainty factors that affect it to be supply, demand, process, planning and control, competition, government policy and climate turbulence. On the basis of the above discussion, it can be expected that perceived uncertainty factors have negative effects on the performance of the TRSC in the areas of quality and efficiency:

H1: The higher the level of uncertainty, the lower the level of rice supply chain performance in Thailand.

Corollary Hypotheses:

H1.1: The higher the level of supply uncertainty, the lower the level of rice quality.

H1.2: The higher the level of supply uncertainty, the lower the level of efficiency.

H1.3: The higher the level of demand uncertainty, the lower the level of rice quality.

H1.4: The higher the level of demand uncertainty, the lower the level of efficiency.

H1.5: The higher the level of process uncertainty, the lower the level of rice quality.

H1.6: The higher the level of process uncertainty, the lower the level of efficiency.

H1.7: The higher the level of planning and control uncertainty, the lower the level of rice quality.

H1.8: The higher the level of planning and control uncertainty, the lower the level of efficiency.

H1.9: The higher the level of competitor uncertainty, the lower the level of rice quality.

H1.10: The higher the level of competitor uncertainty, the lower the level of efficiency.

H1.11: The higher the level of government policy uncertainty, the lower the level of rice quality.

H1.12: The higher the level of government policy uncertainty, the lower the level of efficiency.

H1.13: The higher the level of climate uncertainty, the lower the level of rice quality.

H1.14: The higher the level of climate uncertainty, the lower the level of efficiency.

4.3.2 Research Hypothesis 2 (Uncertainty Factors and Supply Chain Management Practice)

A second hypothesis is developed to answer research question 2 ('How do uncertainty factors affect supply chain practices on the upstream side, on the downstream side and in internal supply chain processes in the Thai rice supply chain?').

Environmental uncertainty is impossible to remove from a supply chain, and is a crucial element to consider when establishing a supply chain strategy (Mason-Jones, Naylor & Towill 2000). Understanding the impact of variability in a supply chain encourages highly effective management (Davis 1993; Childerhouse & Towill 2004). In Dutch dairy

farms, farmers with high perceived environmental uncertainty are more likely to choose varied strategies than farmers with low perceived environmental uncertainty (Ondersteijn, Giesen & Huirne 2006). The literature review in Chapter 2 found many studies pointing out that supply, demand, process, planning and control and competitor ambiguity force organisations to protect supply chain performance by managing supply chain practices (Davis 1993; Levy 1995; van der Vorst 2000; Childerhouse & Towill 2004; van Donk & van der Vaart 2005; Paulraj & Chen 2007). However, this relationship between environmental uncertainty and supply chain management practices is not supported by Li (2002), working in the context of a sample of large firms in the United States.

Supply uncertainty forces organisations to work closely with their suppliers using strategic supply management practices such as strategic purchasing, whilst demand uncertainty does not play that role (Paulraj & Chen 2007). In addition, the uncertainties surrounded by customer demand, supplier and competitor actions do not drive organisations to form higher-level strategic customer relationships and LEAN systems (Li 2002). By contrast, unpredictable customer demand and competitor actions force organisations to focus on the formation of customer relationships to capture all the data related to customers. This data provides insights into the need for better services and analysis of customers demographics (Min & Mentzer 2000; Fawcett 2007).

The above inconsistent findings have highlighted the need for this study to investigate the relationship between environmental uncertainty and the supply chain practices for the three aspects of the TRSC. The differing nature of the supply chains could complicate the effects of diverse uncertainty factors. They may need to adopt different supply chain management practices to deal with these uncertainties.

Uncertain government policies and climate conditions could possibly influence the adoption of higher-level supply chain practices (Badri, Davis & Davis 2000; Cruz et al. 2007). In business practice, managers try to avoid unsuccessful implementation of any strategic management by considering the entire environment that may affect their goals. Government regulations are considered to influence organisations' implementation different operational strategies (Badri, Davis & Davis 2000). For example, organisations in Japan have different investment strategies when they deal with different levels of government policy uncertainty in the host country (Delios & Henisz 2003).

Since it is obvious that severe climate conditions harm agricultural production (Ogallo, Boulahya & Keane 2000), and although there is no study on the influence of climate factors on any strategy implementation in agricultural business, it is expected that these factors will impel organisations to employ higher level of supply chain management practices to handle the effects of these conditions.

Likewise, environmental uncertainty can seriously obstruct the effectiveness of any supply chain strategies (Mason-Jones, Naylor & Towill 2000). Uncertainty factors can lead to increased waste in inventory levels in a supply chain. However, it could force managers to implement a higher level of LEAN principles to eliminate waste. In addition, to reduce the effects of uncertainty, firms can employ strategies that aim to maintain a close relationship with customers through strategic customer relationships, and use strategic purchasing to diminish any issues involving risk and uncertainty.

According to the preceding discussion, uncertainty factors are assumed to force organisations to implement higher levels of supply chain practices to reduce their effects. Therefore, the following hypotheses are proposed in H2.

H2: The higher the level of uncertainty, the higher the level of supply chain practices.

Corollary Hypotheses:

H2.1: The higher the level of supply uncertainty, the higher the level of strategic purchasing.

H2.2: The higher the level of supply uncertainty, the higher the level of customer-relationship management.

H2.3: The higher the level of supply uncertainty, the higher the level of LEAN principles.

H2.4: The higher the level of demand uncertainty, the higher the level of strategic purchasing.

H2.5: The higher the level of demand uncertainty, the higher the level of customer-relationship management.

H2.6: The higher the level of demand uncertainty, the higher the level of LEAN principles.

H2.7: The higher the level of process uncertainty, the higher the level of strategic purchasing.

H2.8: The higher the level of process uncertainty, the higher the level of customer-relationship management.

H2.9: The higher the level of process uncertainty, the higher the level of LEAN principles.

H2.10: The higher the level of planning and control uncertainty, the higher the level of strategic purchasing.

H2.11: The higher the level of planning and control uncertainty, the higher the level of customer-relationship management.

H2.12: The higher the level of planning and control uncertainty, the higher the level of LEAN principles.

H2.13: The higher the level of competitor uncertainty, the higher the level of strategic purchasing.

H2.14: The higher the level of competitor uncertainty, the higher the level of customer-relationship management.

H2.15: The higher the level of competitor uncertainty, the higher the level of LEAN principles.

H2.16: The higher the level of government policy uncertainty, the higher the level of strategic purchasing.

H2.17: The higher the level of government policy uncertainty, the higher the level of customer-relationship management.

H2.18: The higher the level of government policy uncertainty, the higher the level of LEAN principles.

H2.19: The higher the level of climate uncertainty, the higher the level of strategic purchasing.

H2.20: The higher the level of climate uncertainty, the higher the level of customer-relationship management.

H2.21: The higher the level of climate uncertainty, the higher the level of LEAN principles.

4.3.3 Research Hypothesis 3 (Supply Chain Management Practice and Supply Chain Performance)

Research question 3 (‘How do different supply chain practices in the Thai rice supply chain affect its performance?’) is answered by testing Hypothesis 3.

As reviewed in Section 2.3, many supply chain management practices are implemented to deal with upstream, downstream and internal supply chain processes to improve the performance of the entire supply chain. The implementation of supply chain practices may vary from organisation to organisation and from industry to industry depending on the level of market competition, the nature of the business and the organisation’s business strategy.

Many scholars have stated the importance of strategic purchasing (Carr & Pearson 1999; Carr & Pearson 2002; Chen, Paulraj & Lado 2004; Paulraj, Chen & Flynn 2006), customer relationships (Choy, Lee & Lo 2002; Chen & Popovich 2003; Dull et al. 2003), and LEAN principles (Womack & Jones 1996; Hines & Rich 1997; Hines et al. 1998; Zokaei & David 2006) for the improvement of organisations’ overall and supply chain performance.

Strategic purchasing is an important strategy (Spekman, Kamauff & Salmond 1994) for driving the quality and efficiency of supply chain performance. Effective purchasing strategy through, for instance, a supplier-selection process (Fawcett 2007) can lead to the highest-quality products (Paulraj & Chen 2005; Fawcett 2007) at the lowest total cost (Fawcett 2007). This can achieve a significantly higher level of financial performance (Carr & Pearson 1999; Carr & Pearson 2002; Chen, Paulraj & Lado 2004; Paulraj, Chen & Flynn 2006; Fawcett 2007), a higher operational performance (Chen & Paulraj 2004; Paulraj, Chen & Flynn 2006), more value-added customer products (Russell & Thukral 2003) and increased competitive advantage (Porter 1985; Spekman, Kamauff & Salmond 1994). In summary, the higher the level of strategic purchasing, the higher the supply chain performance (Paulraj, Chen & Flynn 2006). Thus, strategic purchasing can be considered as one strategy that is crucial to an organisation’s performance as well as the performance along the supply chain. This study will assume that this applies as well to the TRSC specifically.

Effective CRM relies not only on information technology to gather insightful customer information that support an understanding of customer needs and expectations (Winer 2001; Dull et al. 2003), but also on a strategy of relationship maintenance and relationship initiation (Reinartz, Krafft & Hoyer 2004). This practice can lead to targeting a high number of profitable customers, the development customised products and service, sale-force efficiency, customer-service efficiency and competitive pricing (Richards & Jones 2008). The core advantage of Thai rice is quality. The quality of the product must be strongly considered and improved to satisfy customer expectations and permit relationship initiation. Quality can be improved by gaining knowledge of the characteristics and types of rice that customers require. Thus, CRM is expected to improve the TRSC performance with the use of quality and efficiency indicators.

Many researchers have demonstrated that LEAN production is associated with higher efficiency through eliminating waste (Japan Management Association 1985; Shingo 1989; Bicheno 1994). The adoption of LEAN principles throughout a food supply chain that focuses on the value of the supply chain customer can also lead to an improved level of customer satisfaction. The implementation of LEAN principles in a supply chain can achieve cost-efficient distribution, quality and consistency, value for money, delivery on time/in-full and strategic reserve. Moreover, it can improve supply chain efficiency (Zokaei & David 2006). However, even if LEAN principles can increase the quality of products, reduce lead-time and other wastes, they do not gain a total cost benefit for the whole supply chain since improvement in lead time and quality can increase the total cost of the supply chain (Taylor 2005). Accordingly, this study investigates whether LEAN principles can improve the TRSC performance in terms of rice quality and efficiency.

In conclusion, the three strategies can play a key role in the raising of the TRSC performance as proposed in H3.

H3: The higher the level of rice supply chain practices, the higher the level of rice supply chain performance.

Corollary Hypotheses:

H3.1: The higher the level of strategic purchasing, the higher the level of rice quality.

H3.2: The higher the level of strategic purchasing, the higher the level of efficiency.

H3.3: The higher the level of customer-relationship management, the higher the level of rice quality.

H3.4: The higher the level of customer-relationship management, the higher the level of efficiency.

H3.5: The higher the level of LEAN principles, the higher the level of rice quality.

H3.6: The higher the level of LEAN principles, the higher the level of efficiency.

4.4 Chapter Summary

As discussed in Chapter 2, a number of studies have shown how uncertainty factors affect supply chain management practices and performance, but no study has been done on the TRSC. Uncertainty factors are expected to influence organisations to employ higher level of supply chain management practices and to decrease supply chain performance. However, results from previous studies conflict: some show that uncertainty factors can affect supply chain management practices, but some, using different samples, do not. It can be assumed that uncertainty factors will affect different supply chains' management practices and performance differently. This study hypothesises that supply chain management practices improve TRSC performance.

This chapter discussed the conceptual framework derived from the literature review in Chapter 2. Three research questions and 42 hypotheses were drawn from the framework related to three main constructs in the context of the TRSC: uncertainty factors, supply chain management practices and supply chain performance.

Before testing the hypotheses, the next chapter will discuss the research methodology for generating items for survey instrument development and data collection.

CHAPTER 5

RESEARCH METHODOLOGY

5.1 Introduction

The previous chapter developed a conceptual framework and a set of hypotheses to meet the objectives of this research. This chapter discusses the research methodology (based on the approach outlined in Section 1.6) that will provide a basis for collecting the data to be used for statistical analysis in the next chapter. It describes research design, research context, sampling design, survey-instrument development and data-collection procedure applied for empirically assessing the hypotheses.

This chapter contains four major sections. Section 5.2 outlines the research design of this study including data-collection method, sampling design, unit of analysis and selection of key informants, and provides the rational for the quantitative research method chosen for this research. Section 5.3 describes the development of the survey instrument to measure the three main constructs (uncertainty factors, supply chain practices and supply chain performance) as adapted with slight modification from previous studies. This section also specifies the types of measurement models used, which has an impact on the statistical analyses conducted in Chapter 6 and Chapter 7. Finally, Section 5.4 explains the data- collection process.

5.2 Research Design

Research paradigms for creating management knowledge can be divided into three philosophies: positivism, anti-positivism and critical theory (Cohen 1979). Because this study's research question aims to test a theory, it uses positivism with a deductive approach. The positivist paradigm produces knowledge that is based on the experience of the senses; this experience comes from collecting verifiable empirical evidence in support of theories or hypotheses (Hussey & Hussey 1997; Denzin & Lincoln 2005). Theory testing is common in this research approach (Pathirage, Amaratunga & Haigh 2008). The positivist paradigm has been selected with the

suggested use of four criteria for maintaining efficient research: internal validity, external validity, reliability and objectivity (Denzin & Lincoln 2005).

Among the various research approaches, the qualitative research method is useful for comprehending the problem setting and focusing on culture, meaning or subjectivity. The objective method, by contrast, is useful for establishing reliability and validity by focusing on objectivity, measurement and statistics (Jean Lee 1992; Saunders 2003; Mangan, Lalwani & Gardner 2004; Veal 2005; Azhdar, Jennifer & Farhad 2006; Cooper 2006). As discussed above, the positivist paradigm defines a quantitative research approach that can be applied to investigation. Thus, a quantitative research approach is employed to collect data from a large representative sample of respondents. As discussed in Section 1.6, this study requires data collection from rice millers and exporters from all over Thailand. A survey method using mail-out questionnaires is employed to cover the wide geographical area and save cost (Sekaran 2003). Figure 5-1 shows the research design of this thesis, which is based on the research-design diagram proposed by Sekaran (2003, p.118).

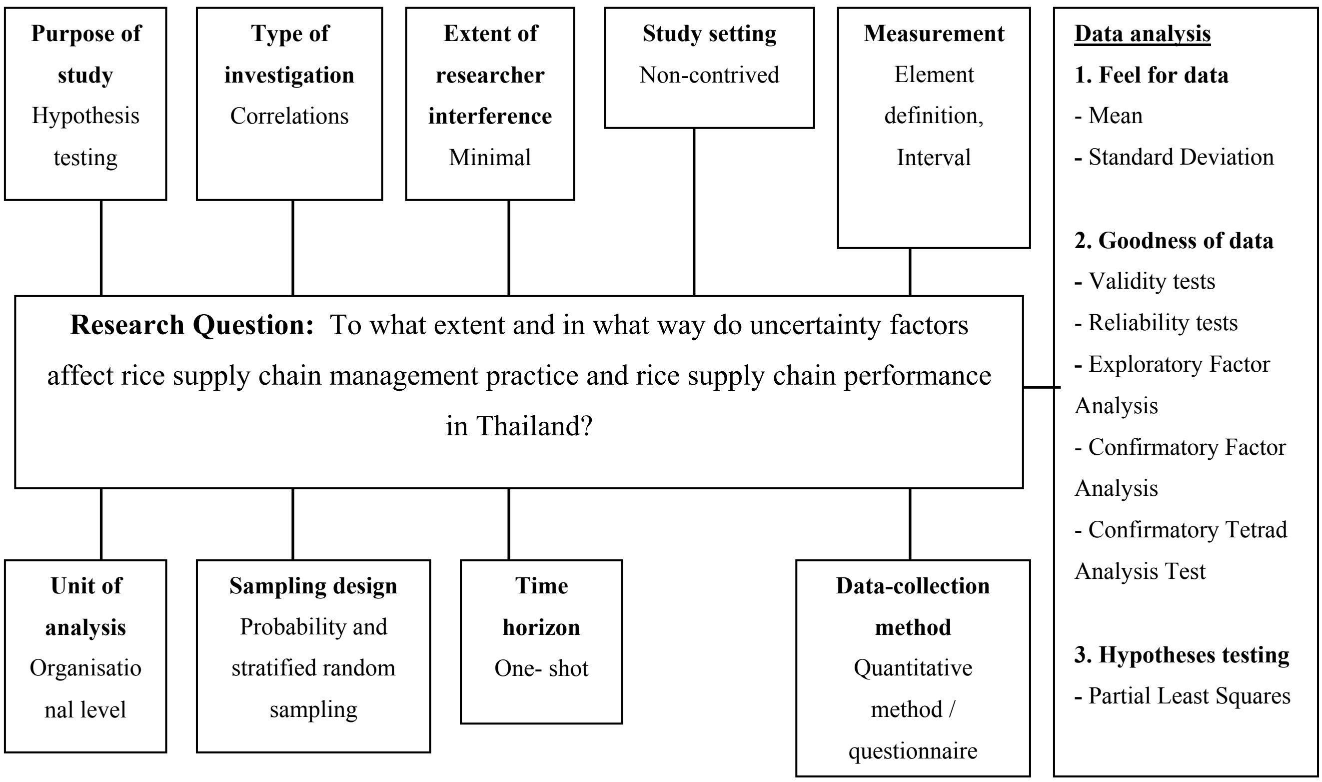


Figure 5-1: Thesis Research Design from Sekaran (2003, p118)

The type of investigation this research undertakes is a correlation study to determine and discuss the extent to which dependent variables are affected by independent variables. By using a posted questionnaire, the extent of researcher interference is minimal and the study setting is not contrived, as respondents answer the questions in the normal environment of their organisation. The time horizon of this study is cross-sectional, also called a 'one-shot study.' The survey was undertaken from May to December 2009; it continued for seven or eight months because the initial response rate was low, requiring follow-up letters and additional sendouts of questionnaires.

The empirical context for this study is the rice supply chain in Thailand. There are some important reasons that prompted this choice of context that is explained in Section 1.2 Background of the Research.

5.2.1 Data Collection Method

Emory (1985) recommends two alternative primary quantitative data-collection methods: observation and survey. Observation involves information being collected directly and personally by a researcher (Emory 1985; Chaudhary 1991; Easterby-Smith 1991). Since the current study focuses on data from the past, the observation method is not appropriate. Survey methods involve personal interviewing and questionnaires (Easterby-Smith 1991). The interview method involves a researcher posing questions to the respondents and recording the answers (Graziano 2003). The limitations of the interview method are that it is expensive, there is the possibility of bias on the part of the interviewers and it is time-consuming (Chaudhary 1991; Veal 2005); however, it may be more accurate, have a high response rate and provide more-complete answers (Veal 2005). The major advantages of using the questionnaire survey method are savings in cost and time (Emory 1985). The mail-out questionnaire can cover a wide geographical area (Sekaran 2003). However, its response rate can be low (Emory 1985; Easterby-Smith 1991; Saunders 2003; Sekaran 2003) due to non-response to a mail survey, or to some of the questions remaining unanswered even on surveys that are returned (Emory 1985). This can lead to non-response bias (Sekaran 2003). After weighting all these considerations, this research chose to obtain primary data from the questionnaire survey method.

To obtain an acceptably high response rate target of 30 percent and accurate data from returned questionnaires, researchers have suggested a number of effective techniques (Emory 1985; Chaudhary 1991; Bryman 2003; Sekaran 2003; Zikmund 2003), several of which have been used in this research:

1) The questionnaire was designed in a short, simple, logical sequence, avoiding technical terms and vague expressions, and avoiding requests for respondents' personal data. When the respondents are comfortable filling out the questionnaire, the response rate can increase.
2) Clear directions for filling out the questionnaire were provided.
3) A cover letter with the letterhead of the Sydney Business School, University of Wollongong was used, introducing the researcher, the objective of the research and the important contribution of the respondents to the Thai rice industry, as well as giving a brief summary of the ethical issues concerned with survey participation.
4) The cover letter was clearly addressed to key informants such as owners, senior managers or supply chain managers with experience in business operations or supply chain activities.
5) The respondents were able to request a copy of the summary of research if they filled in and returned the questionnaire.
6) A postage-paid return envelope was provided with the address of the researcher.
7) A follow-up reminder letter was sent to non-respondents when the questionnaire was not replied to within three weeks of the first mailing. If the list of respondents contained an e-mail address, both a follow-up letter and an electronic copy of the questionnaire were sent to this address.

5.2.2 Sampling Design

Sampling design is a key to this research because in the survey research method, the statistical data is collected in order to draw inferences based on samples. With an adequate sampling design, the sample is a true representation of the population (Chaudhary 1991; Graziano 2003). As discussed in Section 1.6, the target population of this study is rice millers and rice exporters in Thailand. The sampling frame of this study is the list of members of the Thai Rice Exporters Association and the Thai Rice

Mills Association in 2009. These lists provided the names and addresses of rice mill firms and rice export firms, and the e-mail addresses of some rice-exporting companies.

A stratified random sampling was done because the population can be categorised into the two subgroups (Sekaran 2003) of rice millers and exporters. The 181 members of the Thai Rice Exporters Association (Thai Rice Exporters Association 2008) and the 698 members of the Thai Rice Mills Association (Thai Rice Mills Association 2008) are representatives of rice millers and rice exporters in this research, as shown in Figure 5-2. The questionnaires were mailed to all members of each organisation. The returned questionnaires from rice millers and rice exporters are represented by n_1 and n_2 as the sample size of this study.

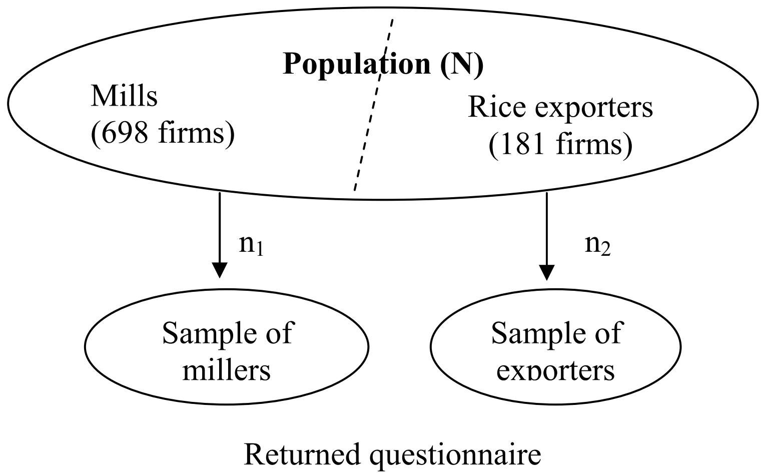


Figure 5-2: The Stratified Random-Sampling Design of this Research

5.2.3 Unit of Analysis

The unit of analysis is the major entity that is analysed in a study. A unit of analysis can be individuals, dyads, organisations, groups, artifacts, geographical units or social interactions (Sekaran 2003; Trochim & Donnelly 2006). As Sekaran (2003) notes, a research question is linked to a unit of analysis and then guides the data collection method and sample size. As mentioned in the previous section, this study has a unit of observation at the organisation level - that is, rice millers and rice exporters, in the context of the TRSC. This study draws conclusions about organisations' performance, their supply chain practices and their perceived uncertainty factors based on the

characteristics of the two groups. At the group level, data from the groups of rice millers and rice exporters are compared with each other. This analysis allows the researcher to understand more fully whether the proposed conceptual framework is different (Sekaran 2003) between rice supply chain members.

5.2.4 Key-Informant Technique

The key-informant technique is an effective tool for collecting data using a mail survey; in this technique, key informants are chosen from the responding organisations (John & Reve 1982).

Seidler (1974, pp816-17) defines the key-informant technique as that where "a small number of knowledgeable participants are asked to act in an informant role that involves giving reports about patterns of behavior and think in terms of the organisation". The key-informant technique is extensively used in social science research methodologies where the study of organisations and the use of informants are compatible (Campbell 1955; Seidler 1974).

However, the key-informant technique can introduce bias, or return solely numerical outcomes rather than qualitative information (Seidler 1974). In organizational buying research, for instance, the single key-informant technique is used with caution. To make up for the weaknesses identified in the key-informant technique, Hughes and Preski (1997) suggest that recognising and addressing potential sources of bias can improve the contextual variables when making use of organisational key informants. Informant-related bias involves, for example, informant position and attributes (Hughes & Preski 1997). Seidler (1974) and Campbell (1955) also suggest that the sampling of informants should take informants' perception and expertise into account rather than treating each respondent as just a simple universe member. The principles for optimal selection have to be developed. The careful selection of informants coupled with internally consistent scales can lead to reliable and valid data in organisation-level analysis (John & Reve 1982).

The use of the key-informant technique in this study involves the collection of data from selected managers or owners who have experience of their business operations

or supply chain activities within rice-milling and rice-exporting organisations. The choice of the right person to receive the questionnaires can increase response rate (Emory 1985), as well as providing- more- accurate data from returned questionnaires (Sekaran 2003). For this reason, the position and experience of the required key informant was clearly stated in the covering letter sent attached to the questionnaire. This- followed the recommendation of Campbell (1955) that key informants should be engaged in roles that make them knowledgeable about the issues related to the research, and make them tend to feel comfortable communicating with the researcher. As the result, the researcher considers that key informant bias should not be a major problem in this research.

5.3 Survey Instrument Development

The objective of this section is to develop the instrument for measurement in the research. Instrument measurement is slightly modified from previous valid and reliable studies of uncertainty factors (Javidan 1984; Badri, Davis & Davis 2000; van der Vorst 2000; Li 2002; Bran & Bos 2005; Cruz et al. 2007; Paulraj & Chen 2007), supply chain management practices (Li 2002; Chen, Paulraj & Lado 2004; Paulraj & Chen 2005; Paulraj, Chen & Flynn 2006) and agri-food supply chain performance (Luning, Marcelis & Jongen 2002; Aramyan et al. 2006; Aramyan et al. 2007). One uncertainty factor – climate uncertainty – had not been tested in previous pilot studies. Thus, an instrument to measure climate uncertainty was developed based on a critical review of relevant literature. A pilot study was employed to improve the clarity and comprehensive of the questionnaire, as discussed in Section 5.4.

There are a total of 12 groups of variables in the conceptual framework that are tested using the hypotheses: seven uncertainty factors (supply, demand, process, planning and control, competitor actions, government policy and climate), three supply chain practices (strategic purchasing, customer-relationship management and LEAN principles), and two supply chain performance indicators (quality and efficiency). Section 5.3.1 considers the general characteristics of the sample used to develop question 1 to 17 of the questionnaire. Sections 5.3.2 to 5.3.4 discuss the measurement of the three domains of the conceptual framework (uncertainty factors, supply chain

practices and supply chain performance) using a seven-point Likert scale (with 1 representing 'strongly disagree and 7 representing 'strongly agree').

Data from Likert scales is ordinal and of equal weight (Yount 2006). However, it can be appropriately analysed as interval data (Allen & Christopher 2007). Thus, this distinct feature of Likert scales allows the researcher to analyse data with statistical techniques at two levels of measurements: ordinal and interval data (Allen & Christopher 2007). The seven-point Likert scale is implemented in this study because it can reach the upper limits of the scale's reliability compared with the five-point Likert scale (Nunnally 1978). Although a wider Likert scale, such as a ten-point scale, has been recommended (Likert 1932), the data of this study does not need the high sensitivity of a 10-point or greater scale. However, a five-point scale does not provide adequate sensitivity (Cummins & Eleonora 2000). Thus, this study uses a seven-point Likert scale.

The draft questionnaires were designed in English first, and then translated into Thai. Appendix 3 contains the complete English-language survey questionnaires, and Appendix 4 contains the corresponding Thai versions.

5.3.1 Measurement of Characteristics of Sample

A structured questionnaire was applied in this study. The questionnaire was divided into 4 main parts. The first part (Question 1 to 17) focuses on characteristics of the sample.

The questions are descriptor variables use to derive descriptive statistics: the role of the participant, the establishment, size, location, type (miller, exporter or both), production capacity, quality assurance, the number of suppliers and extent of supply chain management (partially or fully integrated). All questions concerning general characteristics of the sample were adapted from the questionnaire of Jie (2008) as summarised in Table 5-1.

Table 5-1: Questions of the Questionnaire for General Characteristics of the Sample

General characteristic	Question
The role of participant	• What is your title/ role in the company?
Establishment	• When was your company established?
Size of organisation	• How many employees (approximately) in total does your company have? • What has the average annual turnover been over the last five years (in baht)?
Location	• In what region of Thailand is your main business located?
Type of organisation	• Have you recently exported rice? • To how many countries do you export your product? • What are the major countries to which you export?
Rice-milling capacity	• How much milling capacity do you have (tonnes per 24 hours)? • How many annual tons of paddy rice have you milled over the last five years (on average)? • How many annual tons of paddy rice have you stored (inventory level)? • Have you joined the government's paddy- rice mortgage policy over the last five years?
Rice-exporting capacity	• How many annual tons of milled rice (e.g. cleaning and packaging) have you exported over the last five years? • How many annual tons of milled rice have you stored (inventory level)?
Quality assurance	• Were you awarded certificated of quality assurance or food safety in the pass five years? (Please tick all that apply.)
The number of suppliers	• How many suppliers (approximately) do you have?
Supply chain management	• Is your supply chain function partially or fully integrated? (Please tick one only)

5.3.2 Measurement of Uncertainty Factors in the Thai Rice Supply Chain

To develop a measurement of uncertainty factors, the perspectives and attributes of these factors need to be considered carefully, as managers make decisions based on their perceptions of these uncertainty factors more than the objective reality of such factors (Duncan 1972; Bourgeois 1980). There are three perspectives on environment in organisations (Duncan 1972; Bourgeois 1980).

In addition, there are two attributes of uncertainty factors (Duncan 1972; Downey, Hellriegel & et al. 1975): the degree of change or unpredictability, and the complexity or diversity of environmental factors.

This study focuses on the unpredictability of factors because the degree of unpredictability affects the variability of perceived uncertainty more than does its complexity (Dill 1958; Duncan 1972). Moreover, unpredictable factors create more risk and difficulty for managers' decision-making process and effective strategy-making (Bourgeois 1978). Consequently, Table 5-2 summaries the characteristics of the uncertainty factors measured in this study.

Table 5-2: Characteristics of Measured Uncertainty Factors

Characteristics of uncertainty factors	**Measurement in this study**
Perspectives	Perception
Attitude	Degree of change or unpredictability

Three aspects of supply, demand, process and planning and control uncertainty are measured: quality, quantity and time; these are defined in Table 5-3. Competitor uncertainty is measured under three aspects: their actions, and competition in domestic and international markets (a slight modification of Li's 2002 study). The measurement of government policy uncertainty has four aspects: policies affecting rice production, trading, the paddy rice mortgage scheme and any new government regulations (Javidan 1984; Badri, Davis & Davis 2000; Bran & Bos 2005).

Table 5-3: Source and Aspects of Supply Chain Uncertainty (adopted from van der Vorst 2000, p76)

	Quantity aspects	**Quality aspects**	**Time aspects**
Supply	Inbound (paddy or milled) rice quantities	Inbound (paddy or milled) rice quality	Inbound (paddy or milled) rice timing to millers
Demand	Quantities of customer demand for -outbound rice	Specification of customer demand for outbound rice	Timing of customer order
Process	Mill yield, packing yield	Milled-rice quality, before and after storage	Process throughput times
Planning and control	Information availability	Information accuracy	Information throughput times

Finally, climate uncertainty is monitored under three aspects: drought and warmer temperatures (Cruz et al. 2007). Each drought and flood event is characterised by its duration, deficit volume (severity) and time of occurrence (Tallaksen & Hisdal 1997). However, as this measurement instrument relies on individual respondents' perception, question about the time of occurrence are avoided, as respondents may not have access to or recall that level of detail. To assure that the question delivers a common understanding to respondents, the simple terms 'drought' and 'flood' are selected. The indicators of uncertainty factors are measured by the questions as summarised in Table 5-4.

Table 5-4: Measurement Items of Uncertainty Factors in Thai Rice Supply Chain.

Uncertainty factor	Aspect of measurement	Question	References
Supply	Quantity	SU1: Rice quantity from rice producers is unpredictable	(van der Vorst 2000; Li 2002; Paulraj & Chen 2007)
	Quality	SU2: Rice quality from rice producers is unpredictable	
	Time	SU3: Rice producers' delivery time is unpredictable	
Demand	Quantity	DU1: The volume of customer demand is difficult to predict	(Li 2002; Paulraj & Chen 2007)
	Quality	DU2: Customers' rice preference changes over the year	
	Time	DU3: The lead time[1] of customer orders is unpredictable	
Process	Quantity	PU1: Yield of rice processing (e.g. milling, packing) can vary	(van der Vorst 2000)
	Quality	PU2: The quality of rice after processing (e.g. milled, stored) can change	
	Time	PU3: The throughput time of rice processing can vary	
Planning and control	Quantity	PCU1: Information about stock level of rice and rice production capacity is complete at this moment	(van der Vorst 2000)
	Quality	PCU2: Information about stock level of rice and rice production capacity is accurate	
	Time	PCU3: Information about stock level of rice and rice production capacity is timely	
Competitor	Actions	CU1: Competitors' actions are unpredictable	(Li 2002)
	Domestic market	CU2: Competition is intensified in domestic market.	
	International market	CU3: Competition is intensified from different countries	
Government policy	Rice production	GU1: Government rice- production policies directly affecting your firms are unpredictable	(Javidan 1984; Badri, Davis & Davis 2000; Bran & Bos 2005)
	Rice trading	GU2: Government rice-trading (e.g. FTA, tax) directly affecting your firm is unpredictable	
	Paddy- rice mortgage scheme	GU3: The guaranteed price from government regulation is unpredictable over the year	
	New government	GU4: New government regulation is introduced unexpectedly	
Climate	Drought	CMU1: Drought occurrences are unpredictable in each year CMU2: The duration of drought is unpredictable over the year	(Cruz et al. 2007)
	Flooding	CMU3: Flooding occurrences are unpredictable in each year CMU4: The duration of flooding is unpredictable over the year	
	Temperature	CMU5: The temperature varies unpredictably over the year	

[1] Lead time: duration of time from customers placing their order to the shipment of their requested product.

5.3.3 Measurement of Thai Rice Supply Chain Practices

According to the conceptual framework, three aspects of the three main supply chain practices – strategic purchasing, customer-relationship management and LEAN principles – are measured as shown in Table 5-5.

Table 5-5: Measured Aspects of Supply Chain Practices.

Supply chain practice	Aspects of measurement
Strategic purchasing	Strategic involvement, visibility and strategic focus
LEAN principles	Customer value analysis, visibility and strategic focus
Customer-relationship management	LEAN tools, visibility and strategic focus

Visibility and strategic focus are the two aspects that are measured in all three supply chain management practices. Visibility – top management's vision concerning the strategies – plays a critical role in determining an organisation's values and orientation (Mentzer, Min & Zacharia 2000), which in turn can allow top managers to lead organisations to achieve strategic goals (Pearson & Ellram 1996; Hines et al. 1998; Hitt, Ireland & Hosskisson 1999). The third aspect of measurement for each supply chain practice differs from the first two, in that it is based on evidence in the literature analysis, as discussed in the next subsections.

5.3.3.1 Measurement of Strategic Purchasing

In this study, a measurement of the strategic purchasing level is based on the research of Paulraj, Chen & Flynn (2006). These authors divided the levels of strategic purchasing into three levels: strategic involvement, visibility and strategic focus.

Strategic involvement of purchasing refers to the integration between the purchasing function and other strategic management decision-making processes (Pearson & Gritzmacher 1990) such as the firm's strategic planning process and the strategic goals (Freeman & Cavinato 1990). Strategic purchasing is different from the purchasing function at the clerical level, which is a routine function, and works when it is requested by other functions (Pearson & Ellram 1996).

The visibility of strategic purchasing should be apparent to top management for them to achieve a proactive and long-term focus (Pearson & Ellram 1996). Otherwise, strategic purchasing can be overlooked by top management. The strategic focus of purchasing is considered based on studies by Freeman and Cavinato (1990) and Juha and Pentti (2008) that claim that risk and uncertainty should be managed and considered in a strategic setting to effectively implement strategic purchasing.

Table 5-6 presents the measurement items for the three aspects of strategic purchasing.

5.3.3.2 Measurement of Customer-Relationship Management (CRM)

According to the literature review, CRM measurement can be divided into three aspects: customers value analysis, visibility and strategic focus.

Although CRM can be defined from three perspectives – "a particular technology solution, wide-ranging technology and customer- centric business process" (Payne & Frow 2005, p168)- this study focuses on customer centricity as it is defined broadly and strategically (Payne & Frow 2005). The application of customer-centric principles, should begin with understanding the nature of customer value to obtain and increase customer equity (Winer 2001; Payne & Frow 2005). This step is defined as an evaluation path that is the first step to successful CRM (Alt & Puschmann 2004). Consequently, satisfaction, future expectations and the customer relationship are monitored regularly as part of the customer value analysis process in order to understand customer needs and expectations (Winer 2001; Dull et al. 2003).

CRM requires top management support for its implementation within the organisation (Hitt, Ireland & Hosskisson 1999; Alt & Puschmann 2004). The visibility of this strategy can be measured in terms as of the degree that firms and customers share a sense of fair play as that can improve customers' attitudes (Richards & Jones 2008). The last aspect measured is a strategic focus, which is measured in terms of whether it is expressed in a business plan. This is because CRM necessitates a clear vision and implementation aligned with a business strategy (Radcliffe 2001; Gartner 2003). Table 5-6 presents the items used to measure CRM.

5.3.3.3 Measurement of LEAN principles

As with strategic purchasing and CRM above, the visibility and strategic focus of LEAN principles are evaluated in terms of the implementation of LEAN tools in participants' organisations. As discussed in Section 2.3, LEAN principles focus on eliminating all wastes along the supply chain (Japan Management Association 1985; Shingo 1989; Bicheno 1994). There are several tools to support LEAN principles, such as quality control, JIT or the pull production system, the Kan-Ban program, multi-skilling, low inventory, flexible manufacturing and a close relationship between supplier and customer (Levy 1997; Marosszeky & Karim 1997; Jamshed 2005). Specifically, the LEAN tools that are measured in this study are continuous quality improvement, nearby supplier locations, the pull production system and quality control, as these are the basic tools commonly implemented in the Thai rice industry.

The visibility of LEAN principles is measured in terms of how strongly top management feels that a close relationship with suppliers is important, as this is a main factor successfully implementing LEAN principles (John-Paul & Susan 1997). The measurement of strategic focus in LEAN principles is the articulation of LEAN practices as part of long-range plans. This is because implementing LEAN practices creates a value-chain stream that cannot achieve its goals in the short term (Hines et al. 1998). Table 5-6 presents the items that measure LEAN principles.

Table 5-6: Item Measurement items of Supply Chain Practices.

Supply Chain Practice	Aspect of measurement	Question	References
Strategic purchasing	Strategic involvement	SP1: Purchasing is included in the firm's strategic planning process SP2: The purchasing function has a good knowledge of the firm's strategic goals	(Carr & Pearson 2002; Chen & Paulraj 2004; Chen, Paulraj & Lado 2004; Paulraj & Chen 2005; Paulraj, Chen & Flynn 2006, p.108)
	Visibility	SP3: Top managers view purchasing strategy as important	
	Strategic focus	SP4: Purchasing strategy focuses on longer-term issues involving risk and uncertainty	
Customer-relationship management	Customer value analysis (satisfaction, future expectation and relationship)	CR1: Customer satisfaction is frequently evaluated and measured	(Li 2002; Chen & Paulraj 2004; Payne & Frow 2005)
		CR2: Future customer expectations are frequently determined	
		CR3: The importance of relationships with customers is frequently evaluated	
	Visibility	CR4: A sense of fair play is shared with customers CR5: Top managers view satisfying customer needs as an important strategy	
	Strategic focus	CR6: Customer focus is reflected in your business planning	
LEAN principles	LEAN tools	LP1: A continuous quality-improvement system is implemented	(John-Paul & Susan 1997; Jones, Hines & Rich 1997; Teo Chung 1998; Li 2002; Paulraj, Chen & Flynn 2006)
		LP2: Rice suppliers' warehouses/farms are located nearby	
		LP3: Production system is based on customer demand (pull production system)	
		LP4: Inspection of outbound rice has been reduced	
	Visibility	LP5: Top managers view a close relationship with suppliers as an important strategy	
	Strategic focus	LP6: Lean practices are focused on the organisation's long- term plan	

5.3.4 Measurement of Thai Rice Supply Chain Performance

Supply chain performance measures push supply chain members to improve their performance and create innovations that allow them to obtain competitive advantages in marketplaces (Nuthall 2003). To discern accurate supply chain performance, the outcomes of measuring have to be visible, linking with and fully understood by all partners throughout a supply chain to continually improve performance (Wisner 2005). In previous studies, supply chain performance was gauged with a traditional performance-measurement system focusing on cost-based information (Gattorna 2003; Walters 2003), a world-class performance-measurement system focusing on what is important to customers (Wisner & Fawcett 1991), the Supply Chain Operations Reference (SCOR) model (Meyr, Rohde & Stadtler 2002) or Balanced Scorecard Measures (Kaplan & Norton 1992).

To measure performance in this study, the perceived performance of respondents is measured as subjective ratings. The subjective ratings of performance, such as efficiency have been shown in other studies to be sufficiently valid indicators of actual performance (Vickery, Calantone & Droge 1999). In addition, the subjective rating of performance allows the researcher not to be involved in examining confidential sample data. Therefore, subjective ratings using a seven-point Likert scale questionnaire are considered to be an adequate validity measure for the purposes of this study. Table 5-7 defines the performance indicators used in this study.

Table 5-7: Definitions of Performance Indicators (Aramyan et al. 2007, p308-309)

Categories	**Indicators**	**Definition**
Rice quality	Physical properties of rice	Initial appearance of the rice. Combination of different attributes such as grain, color scale,
	Rice safety and health	Rice does not exceed an acceptable level of risk associated with any chemical hazards
	Environmental management system	An acceptable amount of energy and water used during the production process. A permitted amount of pesticide used, all component or material are recycled, reused or sold as used
	Marketing	The increase in number of sales influenced by activities that related to quality of product and intended to increase market share
Efficiency	Production cost	Combined costs of raw materials and labor in producing rice
	Distribution cost	Combined costs of transportation and handling
	Inventory cost	Combined costs of warehouse and management of operating inventory
	Return on investment	A measure of a firm's profitability and measures how effectively the firm uses its capital to generate profit, or ratio of net profit to total assets
	Profits	The positive gain from an investment or business operation after subtracting all expenses, or total revenue less expenses

5.3.4.1 Measurement of Rice Quality

Measurement of food quality can divided into two parts (Aramyan et al. 2006) product and process quality

Product quality refers to sensory property, shelf-life, product safety and health, and product reliability and convenience (Aramyan et al. 2007). Since rice from Thailand has a distinctive grain quality (distinguished by its size, shape, whiteness and aroma (Unnevehr, Duff & Juliano 1992), the physical properties of rice are consistently evaluated as part of the performance of the TRSC.

Process quality refers to production-system characteristics, environmental aspects and marketing (Aramyan et al. 2006). Production-system characteristics refer to "the way a food product is manufactured and includes such factors as pesticides used, animal welfare and the use of genetic engineering" (Luning, Marcelis & Jongen 2002, p306;

Aramyan et al. 2007). This study, however, does not monitor these system characteristics, as it focuses on the data collected from rice millers and rice exporters, not rice producers (farmers). Moreover, some production-system characteristics such as quality control are measured using LEAN principles. The use of packaging and food- waste management are environmental implications of the agri-food process for quality performance (Luning, Marcelis & Jongen 2002). Nevertheless, no study shows specific environmental-management systems such as energy use, water use and reuse in the Thai rice industry. Thus, this measurement item is limited in this study to whether environmental management systems are implemented in this industry.

Food safety is a vital part of product quality, and an important global issue (Kaferstein & Abdussalam 1999). Thai rice is consumed not only domestically but also worldwide. This has led the Thai rice industry to focus on rice health and safety as part of rice supply chain performance. This study measured rice health and safety as part of its examination of process-quality indicators. Table 5-8 present the items used to measure rice quality.

5.3.4.2 Measurement of Efficiency

The efficiency indicators used in this study (Table 5-8) were adopted from the study of Aramyan et al. (2006), in which operation cost, transportation cost, inventory cost, profit and return on investment are proposed as the efficiency measurement in agri-food supply chains.

Table 5-8: Measurement Items of Thai Rice Supply Chain Performance.

Performance indicator	Aspect of measurement	Question	References
Rice quality	Product quality	RQ1: Physical properties of rice are important performance indicators. RQ2: All inspections present good records. RQ3: Rice safety and health are important performance indicators.	(Luning, Marcelis & Jongen 2002; Aramyan et al. 2006; Aramyan et al. 2007)
	Process quality	RQ4: Environmental management system is implemented. RQ5: Sales increases because of marketing activities.	
Efficiency	Cost	EF1: Operation cost is low. EF2: Transportation cost is low. EF3: Inventory cost is low.	(Luning, Marcelis & Jongen 2002; Wisner 2005; Aramyan et al. 2006; Aramyan et al. 2007)
	Return in on vestment	EF4: Return on investment (approximate ratio of net profit to total assets) is high.	
	Profit	EF5: Profits (total revenue less expenses) are high	

In conclusion, there are 13 pools and 67 items, as summarised in Table 5-9.

Table 5-9: Summary of Questionnaire

Item	Number of Questions
Characteristics of sample	17
Uncertainty factors • Supply • Demand • Process • Planning and control • Competitor • Government policy • Climate	 3 3 3 3 3 4 5
Rice supply chain practices • Strategic purchasing • Customer relationship • LEAN principles	 4 6 6
Rice supply chain performance • Rice quality • Efficiency	 5 5
Total	67

5.3.5 Formative and Reflective Construct Specification

The two basic types of measurement models are reflective and formative indicators.

Reflective indicators aim to show the unobserved, underlying construct, with the construct giving rise to the observed measures; formative indicators define the construct, and are completely determined by a linear combination of indicators (Hulland 1995, pp6-7). A measurement model can include reflective and formative indicators; this is known as a Multiple Indicator/Multiple cause (MIMIC) construct (Joreskog & Goldberger 1975). A construct is multidimensional "when it consists of a number of interrelated dimensions and exists in multi-dimensional domains that can be conceptualized under an overall abstraction" (Law, Wong & Mobeley 1998, p741).

Measurement specification is the process of deciding whether an indicator construct is reflective or formative (Bollen & Lennox 1991). This is essential because misspecification of formative and reflective measurement models can lead to underestimation in conceptual framework testing (MacKenzie, Podsakoff & Jarvis

2005; Diamantopoulos & Siguaw 2006). In addition, these two measurement models are conceptually distinct (MacKenzie, Podsakoff & Jarvis 2005), and require different statistical analysis procedures, such as validity tests, reliability tests and structural model tests (Petter, Straub & Rai 2007). Moreover, measurement model misspecification will not be detected with many of the most commonly used goodness-of-fit indices (MacKenzie, Podsakoff & Jarvis 2005).

This section summarises the differences between formative and reflective measurement models (Table 5-10) and explain the decision rules for determining whether a measurement model is formative or reflective (Table 5-11) (Jarvis, MacKenzie & Podsakoff 2003). The measurement models of this study are then specified.

Although the measurement model in this study is modified from a previous study, the types of measurement model used in this study are clarified (Table 5-12), as misspecification of the measurement model has occurred even in some studies published in top journals. For example, there is a 29 to 30 percent misspecification rate in marketing and information system research (Jarvis, MacKenzie & Podsakoff 2003; Petter, Straub & Rai 2007).

Table 5-10: Summary of Differences Between Formative and Reflective Measurement Models (Jarvis, MacKenzie & Podsakoff 2003, p201)

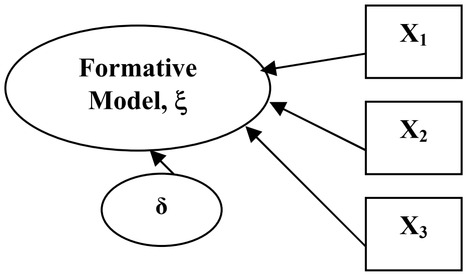
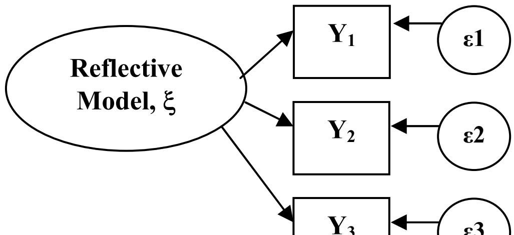
Composite Latent Variable (Formative) Model	**Principle Factor (Reflective) Model**
 $\xi = \omega_1 X_1 + \omega_2 X_2 + \omega_3 X_3 + \delta$ ξ : a latent variable X_i: the observed scores ω_i: item weight δ: disturbance term	 $Y_1 = \lambda_1 \xi + \varepsilon_1$ $Y_2 = \lambda_2 \xi + \varepsilon_2$ $Y_3 = \lambda_3 \xi + \varepsilon_3$ Y_j: the observed scores λ_i: factor loading ε_j: error term
Direction of causality is from measure to construct	Direction of causality is from construct to measure
No reason to expect the measures are correlated (internal consistency is not implied)	Measures expected to be correlated (Measures should possess internal consistency reliability)
Dropping an indicator from the measurement model may alter the meaning of the construct	Dropping an indicator from the measurement model does not alter the meaning of the construct
Takes measurement error into account at the construct level	Takes measurement error into account at the item level
Construct possesses ‘surplus’ meaning	Construct possesses ‘surplus’ meaning
Scale score does not adequately represent the construct	Scale score does not adequately represent the construct

Table 5-11: Decision Rules to Determine Whether a Construct is Formative or Reflective (Jarvis, MacKenzie & Podsakoff 2003, p203)

Decision rule	**Formative model**	**Reflective model**
1. Direction of causality from construct to measure implied by the conceptual definition	Direction of causality is from measure to construct	Direction of causality is from construct to measure
• Are the indicators (a) defining characteristics or (b) manifestations of the construct?	• Indicators are defining characteristics of the construct.	• Indicators are manifestation of the construct.
• Would changes in the indicators cause changes in the construct or not?	• Changes in the indicators should cause changes in the construct	• Changes in the indicators should not cause changes in the construct
• Would change in the constructs cause changes in the indicators?	• Changes in the construct do not cause changes in the indicators	• Changes in the construct do cause changes in the indicators
2. Interchangeability of the indicators	Indicators need not be interchangeable	Indicators should be interchangeable
• Should the indicators have the same or similar content? Do the indicators share a common theme?	• Indicators need not have the same or similar content/ indicators need not share a common theme	• Indicators should have the same or similar content/ indicators should share a common theme
• Would dropping one of the indicators alter the conceptual domain of the construct?	• Dropping an indicator may alter the conceptual domain of the construct	• Dropping an indicator should not alter the conceptual domain of the construct
3. Co-variation among the indicators	Not necessary for indicators to co-vary	Indicators are expected to co-vary
• Should a change in one of the indicators be associated with changes in the other indicators?	• Not necessarily	• Yes
4. Nomological net of the construct indicators	Nomological net for the indicators may differ	Nomological net for the indicators should not differ
• Are the indicators expected to have the same antecedents and consequences?	• Indicators are not required to have the same antecedents and consequences	• Indicators are required to have the same antecedents and consequences

Table 5-12: Types of Measurement Models in This Study.

Construct Name	Type of measurement models	Remarks
• Supply	Formative construct as shown in Figure 5.3	Each construct is composed of three dimensions – quantity, quality and time dimensions – that define characteristics of the construct.
• Demand	Formative construct as shown in Figure 5.4	
• Process	Formative construct as shown in Figure 5.5	
• Planning and control	Formative construct as shown in Figure 5.6	
• Competitor	Formative construct as shown in Figure 5.7	The construct is composite in action, domestics and international market dimensions, while the action dimension is measured in a reflective model with two indicators.
• Government policy	Formative construct as shown in Figure 5.8	It is clear that each government policy differs in nomological net.
• Climate	Multidimensional construct (formative first-order, formative second-order) as shown in Figure 5.9	The construct is composite in drought, floods and temperature dimensions that do not total share a common theme, while the drought and floods dimension is also measured in the formative model in terms of duration and frequency aspects.
• Strategic purchasing	Multidimensional construct (reflective first-order, reflective second-order) as shown in Figure 5.10	Although the measurements are developed to measure three aspects such as strategic involvement, visibility and strategic focus in the strategic purchasing construct, the type of these constructs is the reflective construct in both first-order and second-order. This is because the indicators are manifestations of the construct, and their different aspects are expected to correlate.
• Customer-relationship management (CRM)	Multidimensional construct (reflective first-order, reflective second-order) as shown in Figure 5.11	
• LEAN principles	Multidimensional construct (reflective first-order, reflective second-order) as shown in Figure 5.12	
• Rice quality	Multidimensional construct (reflective first-order, formative second-order) as shown in Figure 5.13	This construct is a composite of two characteristics of rice quality: product and process quality as a formative model, while product and process quality constructs are a reflective model. Thus, it is a multidimensional construct.
• Efficiency	Reflective construct as shown in Figure 5.14	The construct of efficiency is a reflective model because it is unidimensional, in that the measures are tightly centered around the concept of firm performing in cost, return on investment and profit.

The construct measurement models are presented in the figures below.

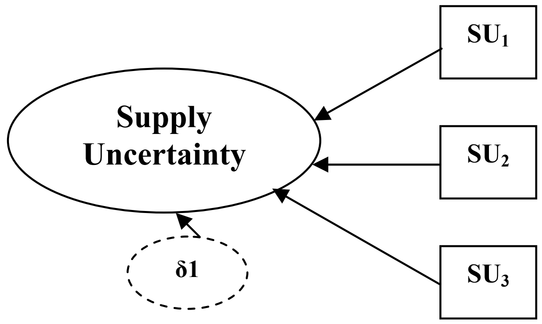


Figure 5-3: Formative Measurement Model of Supply Uncertainty

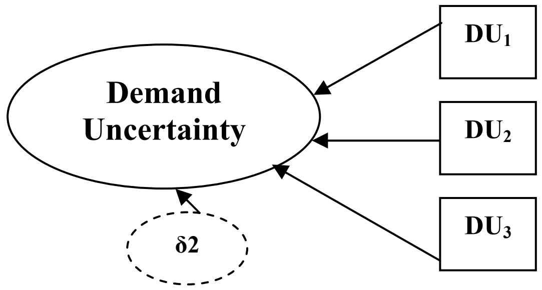


Figure 5-4: Formative Measurement Model of Demand Uncertainty

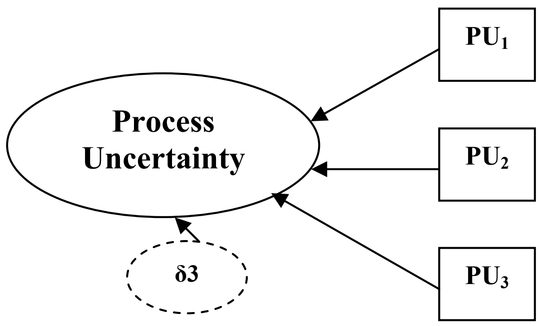


Figure 5-5: Formative Measurement Model of Process Uncertainty

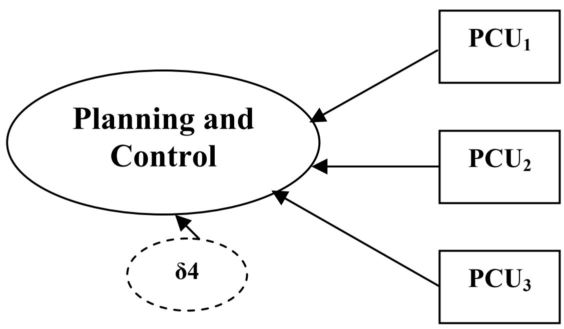


Figure 5-6: Formative Measurement Model of Planning and Control Uncertainty

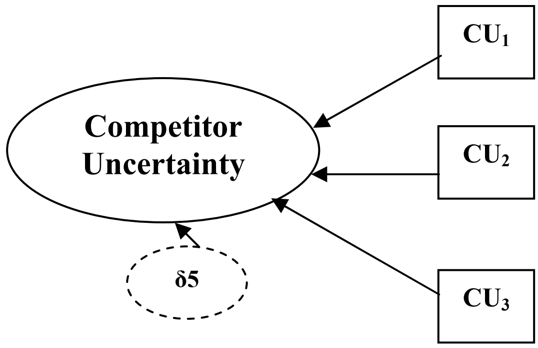


Figure 5-7: Formative Measurement Model of Competitor Uncertainty

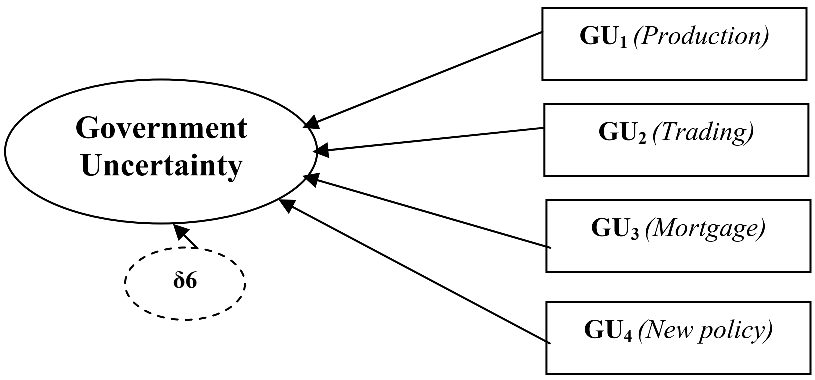


Figure 5-8: Formative Measurement Model of Government Uncertainty

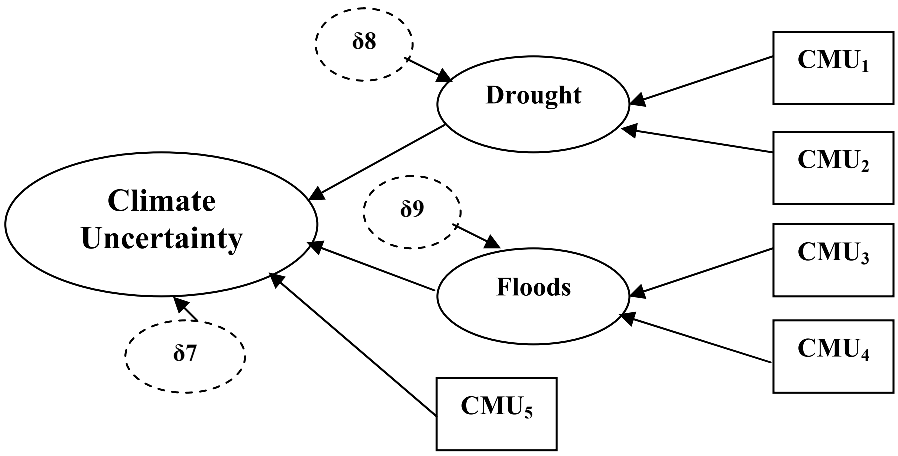


Figure 5-9: Formative Measurement Model of Climate Uncertainty

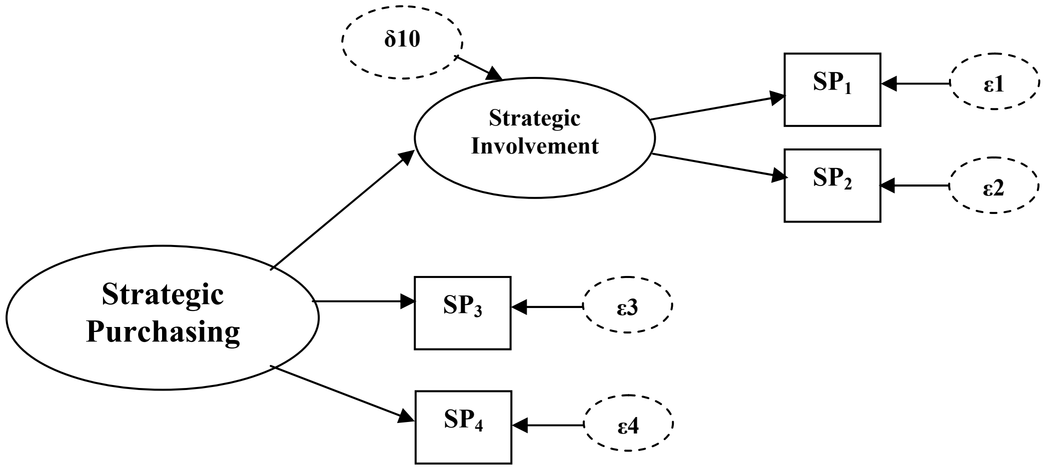


Figure 5-10: Multidimensional Measurement Model of Strategic Purchasing

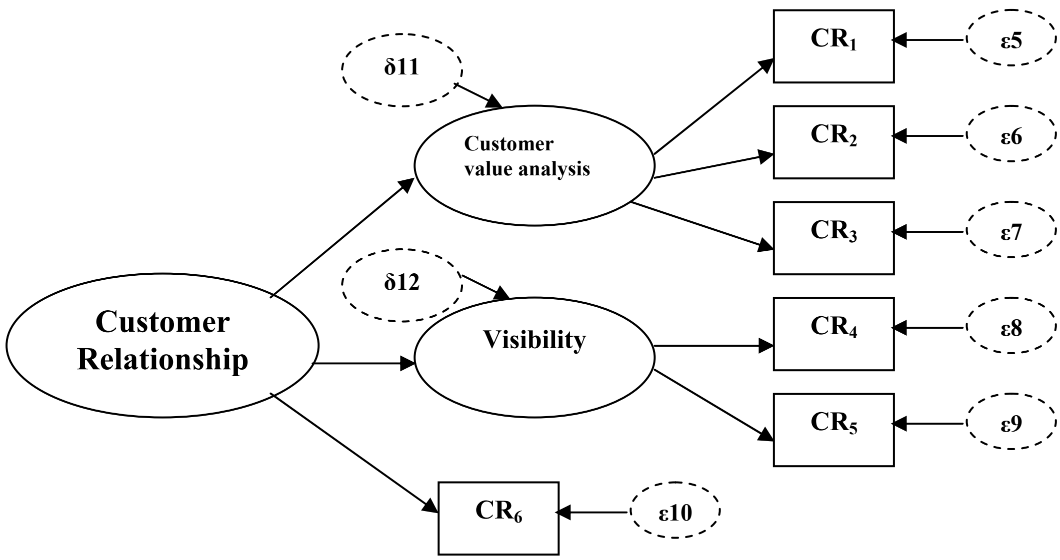


Figure 5-11: Multidimensional Measurement Model of CRM

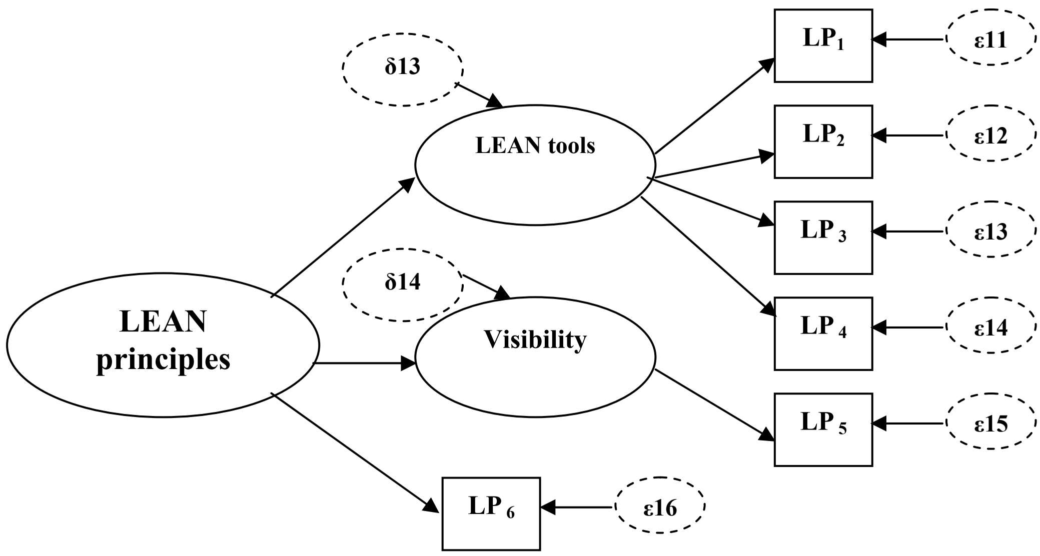


Figure 5-12: Multidimensional Measurement Model of the LEAN principles

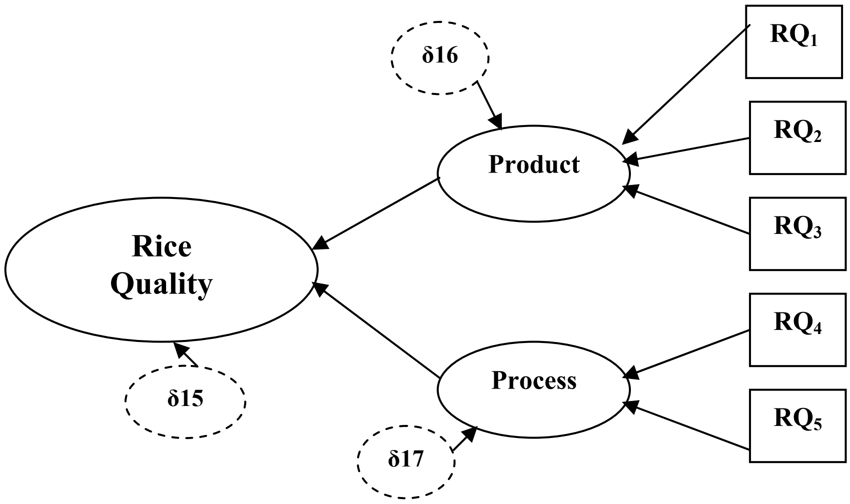


Figure 5-13: Multidimensional Measurement Model of Rice Quality

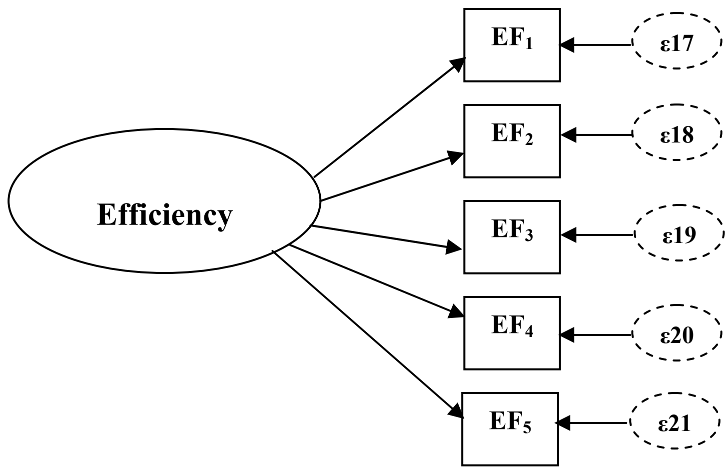


Figure 5-14: Reflective Measurement Model of Efficiency

5.4 Data-Collection Procedure

This section describes the development, pilot study and distribution of the questionnaire.

5.4.1 Pilot Study

Pilot testing can make a questionnaire easier to complete and more suitable for the respondents' range of knowledge and responsibility (Flynn et al. 1990). The feedback from the pilot study can "ensure the validity and reliability of measures" (Flynn et al.

1990, p262). The questionnaire for this study was translated from English to Thai by professional translators. Some of the rice millers are uneducated and the pilot study was conducted with a small sample group of 10: five managers from different rice-milling companies, three managers from different rice-exporting companies and two scholars in the business field from Kasetsart University, Thailand.

The objective of the pilot study was to improve the clarity of each question in the questionnaire. A face-to-face survey using the 67 questions in the first draft of the Thai version of the questionnaire was conducted. Participants were given no longer than 20 minutes, to provide time for participants to give the researcher feedback on how to improve the clarity, understanding and the length of the questions. Participants were asked such questions as:

1) Are there any questions that are too complicated?
2) Are there any questions that are equivocal?
3) Are there any questions that use too formal language?
4) Are there any questions that you do not understand and why?

The following are examples of feedback from the pilot study's participants:

1) The participants did not understand the meaning of the word 'partially integrated and fully integrated supply chain management' in the Thai version in question number 17.
2) The statement that 'these data will not be given to the Thai taxation department' needed to be included in the questionnaire to reassure participants.
3) The word 'rice producer' only means rice farmers, but they also purchase rice from other rice merchants.
4) Question numbers 37 to 41 asked about climate uncertainty. Participants felt that the questions should mention 'occurrences that affect companies' in the questions. For example, 'Drought occurrences are unpredictable in each year' should mention 'Drought occurrences that affected companies are unpredictable in each year'

Based on feedback received from these participants, the final draft of the Thai version of the questionnaire was constructed. The main content of the questions in Parts II, III and IV of the questionnaire remained unchanged from the version used in the pilot study.

5.4.2 Data-Collection Procedure

As discussed in Section 5.2, the final draft of the Thai version of the questionnaire was mailed to 698 rice-milling companies and 177 rice exporters (reduced from the original 181 rice-exporting companies because it was found that some were at the same address) across Thailand. The returned questionnaires are summarised in Table 5-13.

Table 5-13: Summary of Returned Questionnaires

Procedure	Rice millers	Rice exporters
The questionnaires distributed	698	177
Incomplete address or business failure	46	36
Incomplete data	14	7
Returned questionnaires with complete data	98	26 (1st round: mail-out questionnaires) 38 (2nd round: distributed in the meeting)
Total completed questionnaires returned	98	64
Response rate	15.03%	46.10%

Within one week 46 questionnaires were returned unanswered from rice millers and 36 from rice exporters due to, for instance, incomplete addresses, or business failure. In the first wave of answered questionnaires from rice millers, 89 questionnaires were returned, but 14 of them were rejected due to incomplete information, resulting in an effective response rate of 11.50 percent. After three weeks, a reminder letter was sent to rice millers. Twenty-three questionnaires were returned. The response rate

increased to 15.03 percent, with 98 completed questionnaires returned from 652 complete addresses for rice millers.

Meanwhile, in the first wave from rice exporters, 29 questionnaires were received, but seven of them were discarded due to incomplete information. This resulted in an effective response rate of 15.60 percent. After three weeks, a reminder letter was sent to rice exporters by e-mail. Four additional questionnaires were returned. The response rate increased to 18.43 percent with, 26 completed questionnaires returned from 141 complete addresses for rice exporters.

These response rates are generally considered to be normal for surveys in developing countries (Ahmed et al. 2002). The process of data collection took place during April-December 2009. This includes the process from when the questionnaires were posted to when they were returned. However, the sample size of 26 rice exporters was too small to process for statistical analysis. With a high level of cooperation by the Thai Rice Exporters Association, the questionnaires were distributed to 45 meeting members in the Association's annual meeting in December 2010. From that meeting 38 questionnaires were received back. Of these six were from members who had already answered the questionnaires in the first wave. Therefore, the response rate of rice exporters rose to 46.10 percent with, 64 completed questionnaires returned from 141 completed addresses for rice exporters.

This is considered to be the second wave of returned questionnaires. The requirement to test the validity of two waves of returned questionnaire is discussed in the next chapter.

5.5 Chapter Summary

This chapter discussed the research methodology, starting from an overview of research design, survey instrument development and data collection procedures. The research methodology in this study was adopted from previous studies. It is consistent with previous research practices in both qualitative and quantitative research fields.

The survey method chosen was a questionnaire method with a seven-point Likert scale. The survey instrument was developed that contained reflective, formative and multidimensional measurement models. It is very important to clarify the types of measurement models because they require different statistical analysis. This survey instrument was mailed out to rice millers and rice exporters in Thailand. These two groups were selected because they play a vital role in the Thai rice industry, and because their address lists could be obtained by the researcher.

A total of 98 returned questionnaires with completed data from rice millers and 64 from rice exporters led to response rate 15.03 percent and 46.10 percent respectively. The total sample size was 162; this is considered to be small, but adequate for certain robust statistical analyses.

As the sample size of this study is small, the statistical analysis for reliability, validity and hypothesis testing are carefully chosen in Chapter 6 and Chapter 7. This procedure can ensure that the data is valid and reliable, and the results from hypothesis testing are not in error. The statistical procedure analysed in Chapter 6 and Chapter 7 is shown in Figure 5-15. Chapter 8 shows the survey results.

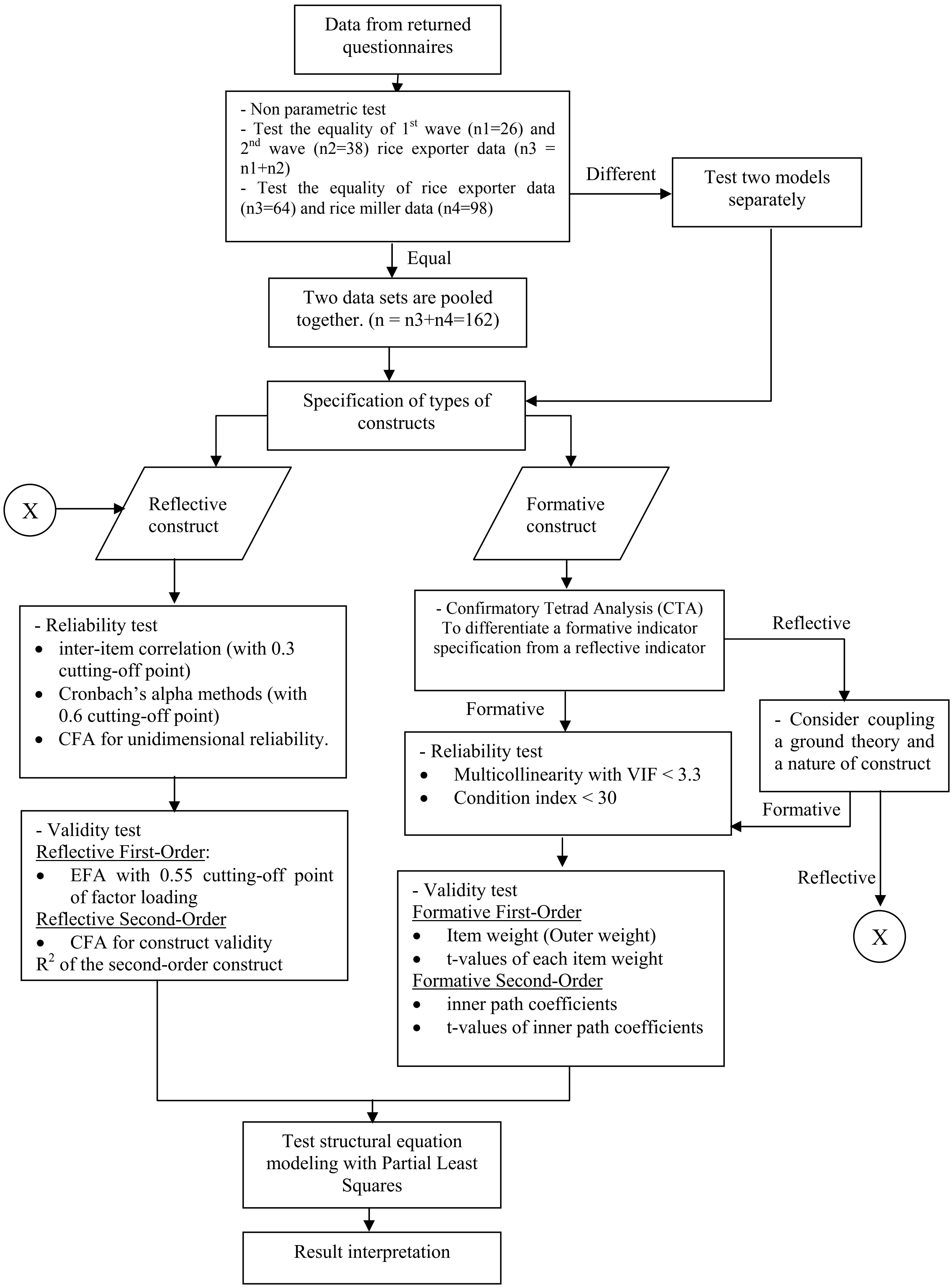


Figure 5-15: Statistical Analysis Procedures

CHAPTER 6

EXPLORATORY DATA ANALYSIS

6.1 Introduction

As described in the data-collection procedure in the previous chapter, the returned questionnaires provide data for the exploratory analysis in this chapter. The exploratory data analysis is crucial for testing and improving data reliability and validity. Thus, the objective of this chapter is to ensure that there is no response bias in the data and to confirm the measurement model specifications outlined in the previous chapter.

The next section summarises the characteristics of the rice-miller and rice-exporter samples. Section 6.3 presents the non-response bias tests for the rice-miller and rice exporter-samples. Section 6.4 applies non-parametric statistical analysis to determine whether the data sets of the two subgroups (rice millers and exporters) should be pooled. Section 6.5 presents the Confirmatory Tetrad Analysis Test for the formative constructs. Finally, in Section 6.6, the construct validity of the conceptual reflective constructs is assessed using exploratory factor analysis.

6.2 Descriptive Statistics of Samples

In this section, descriptive statistics are employed to clarify characteristics of the rice-miller and rice-exporter samples.

Sample characteristics of the respondents are indicated by their job title. Sample characteristics of surveyed organisations are expressed in terms of number of years a company has been established, employment size, average annual sales volume over the last five years, the number of suppliers and whether their supply chain functions are partially integrated or fully integrated.

Some characteristics differ between the two groups of surveyed organisations. For rice miller, these characteristics include the milling capacity, average annual paddy rice milled over the last five years, average annual inventory level of paddy rice, and joining rice mortgage policy are shown. For rice exporters, they include the average annual rice processed (e.g. cleaning and packaging) over the last five years and the average annual inventory level of rice product.

The detailed analyses of each variable are shown in Appendix 1 for characteristics of rice millers and Appendix 2 for characteristics of rice exporters. The next section explores these characteristics.

6.2.1 Characteristics of Miller Samples

The 98 usable questionnaires from rice miller provide general information about their characteristics.

- Eighty-two percent of the respondents are managing directors or supply chain managers. These high-level positions require experience of the firms' business operations. Thus, this should support accurate data being provided in the returned questionnaires.
- Sixty-three percent of the mills were established more than 20 years ago.
- Most mills (92 percent) employ fewer than 50 employees, placing them in the category of small business (Christodoulou 2009).
- Sixty-one percent earn an average annual sale volume of less than 50 million baht. This, too, categorises them as small businesses.
- Over half (55 percent) have a large capacity (more than 60 tonnes per 24 hours). However, only 33 percent mill paddy rice at an average above 24,999 tonnes per year.
- Sixty-two percent store less than 10,000 tonnes of paddy rice a year.
- Sixty-nine percent have joined the rice mortgage policy from government within the last five years.

6.2.2 Characteristics of Exporter Samples

The descriptive analysis of 64 exporter respondents provides a general overview of their characteristics.

- Eighty-four percent of the respondents are managing directors or general managers. As mentioned in the previous section, these positions have experience of their firms' business operations. Consequently, this should support accurate data being provided in the returned questionnaires.
- Fifty-five percent of the rice exporter samples were established more than nine years ago.
- More than three-fourths (79 percent) employ fewer than 50 employees placing them, like the millers, in the category of small businesses.
- About 53 percent reported that their average annual sale volume over the last five years was over 25 million baht.
- 45 percent send rice to fewer than five countries, while approximately 28 percent export to between five and ten countries.
- Above half (55 percent) process less than 10,000 tonnes of rice per year.
- Of the sampled rice exporters, more than half (53 percent) store less than 5,000 tonnes of milled rice per year.
- Around 66 percent have fewer than 25 suppliers.

6.3 Non-Response Bias Test

It is very crucial for a mail survey data collection method to test for non-response bias. Non-respondents tend to differ substantially from respondents, which can lead to an inability to generalise results of the sample to the population (Armstron & Overton 1977). Non-response bias can happen when the preferences between non-respondents and respondents are different (Pearl & Fairley 1985). There are three methods of non-response bias estimation (Armstron & Overton 1977): comparison with known values for the population, subjective estimation and extrapolation.

The first two methods are not appropriate for this study because the first requires values for the population as a whole, which are unknown, and the second requires

expert judgment (Goldstein 1977). Thus, following the study of Armstron and Overton (1977), the extrapolation method is used: this method compares the characteristics of respondents who returned the questionnaires in the first wave of the mailing to those who returned the questionnaires in the second wave who are assumed to represent a sample of non-respondents.

In this analysis, the non-response bias test uses Pearson's chi-square tests. A separate sample is undertaken for rice millers and rice exporters. Ninety-eight rice millers are separated into 49 cases for the first wave of respondents and 49 for the second wave. The rice exporter respondents are divided into the first wave, the 26 exporters who responded to the mailed questionnaires, and the second wave, the 38 respondents who responded to questionnaires distributed in the meeting. Pearson's chi-square is used to explore whether there is a relationship between two categorical variables (Fisher 1922). The null hypotheses of this analysis is that there is no difference in job title, the company's age, the average annual turnover, and the process capacity between the first and second waves of returned questionnaires.

Table 6-1: Non-Response Bias Test

Variables	**Rice millers**		**Rice exporters**	
	Chi-square test	**Significance (p-value)**	**Chi-square test**	**Significance (p-value)**
Job title	0.3960 (df = 5)	0.9954	5.1150 (df = 5)	0.4020
Company's age	0.0600 (df = 3)	0.9962	1.5370 (df = 3)	0.6737
Average annual turnover	0.1250 (df = 6)	0.9999	8.0920 (df = 6)	0.2315
Process capacity	3.3270 (df = 3)	0.3440	9.3680 (df = 3)	***0.0248***

The last column of Table 6.1 shows that only process capacity is significantly different at level 0.05, and even this displays an insignificant difference at level 0.01,

while the null hypotheses for the other variables are accepted. Therefore, non-response bias is not a cause for concern in this study.

6.4 Non-Parametric Test

As discussed in Section 5.4, the data from rice exporters was collected using two methods: mail-out questionnaires (n_1 = 26) and questionnaires distributed in the meeting (n_2 = 38). The two samples need to be tested for equality before the data can be pooled. In addition, the samples of rice exporters (n_3 = 64) and rice millers (n_4 = 98) are tested to determine the equality between them. If the two groups demonstrate equality, they can be combined to increase sample size for further statistical analysis.

The Mann-Whitney test and the Kolmogorov-Smirnov test are non-parametric tests that examine the differences between two independent samples. Their use requires that there are no assumptions about the distribution of data, or that data is not distributed normally (Hollander & Wolfe 1999); that the data is ranking or ordinal (such as Likert-scale data) which by definition, is not distributed normally (Kaplan 2009); and that all samples from both groups are independent of each other (Hollander & Wolfe 1999).

The Mann-Whitney test is the non-parametric equivalent of the independent t-test (Field 2009); the Kolmogorov-Smirnov test is also a non-parametric method for comparing two samples, as it is sensitive to the differences in both location and shape of the empirical cumulative distribution functions of the two samples (Sprent 1974). In effect, the Kolmogorov-Smirnov test is not different from the Mann-Whitney test, but tends to have better power when sample sizes are less than 25 per group (Field 2009).

In this study, the Mann-Whitney test and the Kolmogorov-Smirnov test are applied to compare questions 18 to 67 in the questionnaire for the two samples. This has two aims:

(1) To determine whether there is a difference in the raw data from the two waves of data collections of rice exporters (n_1 = 26, n_2 = 38).

The results show that in both the Mann-Whitney test and the Kolmogorov–Smirnov test, almost all the variables in the first wave did not differ significantly from the second wave at a significance level of 0.05. The exceptions were SP1 and EF4 (refer to the variable code in Table 5-8), where the first wave of data collection did not differ significantly from the second wave of collection data at a significance level of 0.01. Therefore, these two samples of data can be pooled together to represent the rice exporters.

(2) To determine whether the raw data from rice exporters (n_3 = 64) and rice millers (n_4 = 98) is different.

The results show that in the Mann-Whitney test and the Kolmogorov-Smirnov test, the variables from rice exporters did not differ considerably from rice millers at a significance level of 0.05. The exception were CU1, CU4, LP4, LP6 and EF1 (refer to the variable code in Table 5-8), which did differ at a significance level of 0.05. However, CU1, CU4, LP6 and EF1 did not differ significantly at a significance level of 0.01, while only LP4 did not differ drastically at a significant level of 0.001. Therefore, these two samples can be pooled for validity and reliability testing, increasing the sample size to 162.

6.5 Confirmatory Tetrad Analysis Test

Although the types of measurement models in this study were specified by a ground theory and a nature of construct in Section 5.3.5, confirmatory tetrad analysis can be applied to confirm the formative measurement model specification. Thus, this section differentiates the formative indicator specification from a reflective indicator specification by employing confirmatory tetrad analysis (CTA) (also known as the vanishing tetrad test). It provides an empirical assessment of whether a formative or reflective scale specification of the first order construct is appropriate (Bollen & Ting 2000). A tetrad is the difference between the product of two pairs of covariance formed among four variables (Bollen, Lennox & Dahly 2009, p1526), as expressed in Equation 6-2.

There are several reasons to perform CTA rather than other approaches, such as maximum likelihood (ML), weighted least squares (WLS), or confirmatory factor analysis (CFA) (Bollen & Long 1993, p149).

(1) CTA provides a goodness-of-fit test for a model that can lead to result differences from the usual likelihood test associated with ML, WLS or CFA.
(2) CTA applies to some under-identified models.
(3) CTA allows the overall fit of some non-nested model to be compared directly.
(4) CTA is an asymptotically distribution-free test; when applied to covariances and correlations, and uses a non-iterative estimator that does not contain non-convergence problems.

Referring back to Table 5-10 in Chapter 5, the treatment of measurement errors is a key difference between formative and reflective measurement. The measurement error (ε) of each reflective indicator can be identified and eliminated by using CFA, whereas there is no simple way to empirically assess the measurement error (δ) in a formative model (Coltman et al. 2008). Nevertheless, a CTA test can assess measurement errors that are implied when comparing causal and effect indicator models (Bollen & Ting 2000). The null hypothesis in this test is that the inter-correlation of each pair of error term (τ_{ghij}) in a reflective model is zero (Equation. 6-4). If the null hypothesis is rejected, the formative measurement model should be considered as an appropriate scale specification (Bollen & Ting 1993). Four variables can contain six covariances, and can create three tetrads (Equation 6-3).

$$\sigma_{ij} = \lambda_i \lambda_j \phi \qquad \text{Equation 6-1}$$

where σ_{ij} is the population covariance between x_i and x_j, λ_i is a function of path coefficient and ϕ is the variance of the latent variable.

$$\tau_{ghij} = \sigma_{gh}\sigma_{ij} - \sigma_{gi}\sigma_{hj} \qquad \text{Equation 6-2}$$

where τ_{ghij} is the population tetrad difference.

$$\tau_{1234} = \sigma_{12}\sigma_{34} - \sigma_{13}\sigma_{24}$$

$$\tau_{1342} = \sigma_{13}\sigma_{42} - \sigma_{14}\sigma_{32} \qquad \text{Equation 6-3}$$

$$\tau_{1423} = \sigma_{14}\sigma_{23} - \sigma_{12}\sigma_{43}$$

The hypothesis test of CTA is:

$$H_o : \tau_{ghij} = 0$$
$$H_1 : \tau_{ghij} \neq 0 \qquad \text{Equation 6-4}$$

The CTA test procedure consists of the following steps (Hipp, Bauer & Bollen 2005, p79):

(i) Identify all model-implied vanishing tetrads,
(ii) Select an independence set of vanishing tetrads and
(iii) Form the simultaneous statistics test for the independent vanishing tetrads.

Software is available to derive a CTA model for categorical data (such as Likert-scale data); this study used SAS software for modeling, and the CTANEST1.mac program to perform the nested test. The output gives the chi-square values, degrees of freedom, and associated p-value.

In this study, each of the formative constructs (supply, demand, process, planning and control, and competitor behavior uncertainty) has three indicators. They can be assessed using CTA by including a fourth – unrelated – indicator (Bollen & Ting 2000). The formative government policy uncertainty has four indicators; the climate uncertainty and rice quality constructs each have five indicators.

Referring to the null hypothesis in Equation 6-4, a result that "fails to reject the null hypothesis lends to support the model that implied vanishing tetrads" (Ting 1995, p165). If the null hypothesis is rejected by the CTA test, the construct is better measured formatively; common method error – a possible source of contamination – should also be ruled out (Coltman et al. 2008).

However, Coltman, Devinney et al. (2008, p1254) suggest that CTA is a confirmatory procedure that is not to be used as a stand-alone criterion for distinguishing between formative and reflective measurement models. Moreover, the results of CTA do not definitively provide a proof of measurement model specification. Thus, a ground theory and a nature of measurement model should be coupled to differentiate between the types of measurement models used.

In this study, the rejected hypothesis is considered to indicate that the formative scale specification is appropriate as a significant result. Applying the CTA test to each formative construct in this study, Table 6-2 shows that chi-square rejects the null hypothesis of supply uncertainty, demand uncertainty, process uncertainty, planning and control uncertainty, competitor uncertainty, and rice quality constructs lending additional support to the formative view.

Table 6-2: CTA Results for Formative Constructs.

Construct	**Number of indicators**	**Chi-square (df)**	**Significance**	**Implication**
Supply uncertainty	3	10.54(2)	0.01	Formative
Demand uncertainty	3	6.49(2)	0.05	Formative
Process uncertainty	3	12.92(2)	0.01	Formative
Planning and control uncertainty	3	7.64(2)	0.05	Formative
Competitor uncertainty	3	5.31(2)	0.10	Formative
Government policy uncertainty	4	3.25(2)	0.20	*Reflective*
Climate uncertainty	5	4.88(5)	0.59	*Reflective*
Rice quality	5	12.52(5)	0.05	Formative

Although government policy and climate uncertainty are not supported as formative views in the CTA test, theory suggests that they are better conceptualised formatively as theory indicates because their indicators are totally not share a common theme that is an important characteristics of formative measurement model. The next section

illustrates the Exploratory Factor Analysis (EFA) of the reflective constructs in this study.

6.6 Exploratory Factor Analysis

Exploratory factor analysis (EFA) is used "to analyse the structure of the interrelationships (correlation) among a large number of variables by defining a set of common underlying dimensions, known as factors (a latent variable)" (Hair et al. 1995, p36-67). It can be applied in both objective and subjective data such as Likert-scale in this study. All measurement items within a particular factor are highly correlated among themselves, but have relatively small correlation with measurement items in a different factor (Johnson & Wichern 2002). Its main purpose is to reduce the number of original variables with a minimum loss of information (Hair et al. 1995). In another view, EFA can be used when there is no basis of previous research or strong theory to separate factors (Kim & Mueller 1978).

Likewise, Thompson (2004, p4-5) concludes that there are three main application of factor analysis: to inform evaluations of score validity; to develop theory regarding the nature of constructs; and to summarise relationships in the form of a more parsimonious set of factor scores, which can then be used in subsequent analyses (e.g., analysis of variance, regression, or descriptive discriminant analysis).

In this study, the measurement items were developed with strong theoretical support, as discussed in Chapter 5. Thus, EFA is used to assess construct validity (Hair et al. 1995) and dimensionality (Hair et al. 1995) of reflective constructs (Coltman et al. 2008) because this technique can explain latent variables' relationship to the observed data (Lattin 2003). Factor loading and communality of each reflective indicator can assess composite reliability (Coltman et al. 2008) or item validity (Segars & Grover 1993). The low factor loading of the reflective measurement indicator can be considered to be eliminated (Flynn et al. 1990; Bryman 2003).

According to Hair et al. (1995), sample size should preferably be greater than 100. As a general rule, the minimum is to have at least five times as many observations as there are variables to be analysed. In this study, the reflective constructs to be

assessed by EFA are strategic purchasing, LEAN principles and CRM, with 16 observed items (referring to Questions 42 to 57 in the questionnaire). Thus, the sample size of 162 is adequate because it is greater than 80 (the minimum sample size of this analysis, derived by multiplying the number of variables, or 16, by 5).

The study now examines the assumptions of factor analysis and assesses the overall fit of EFA.

- A correlation matrix is used to check that the data has sufficient correlation to form factors (Table 6.3). If there is no correlation coefficient greater than 0.3, the EFA is properly inappropriate (Hair et al. 1995, p374); also, a correlation coefficient greater than 0.9 can create a problem of multicollinearity (Field 2009, p.648). Visual inspection of the matrix reveals no concerns about correlation and multicollinearity of the data.

Table 6-3: Correlation Matrix of 16 Measurement Items of Supply Chain Practices (SP: Strategic Purchasing, CR: Customer-Relationship Management, and LP: LEAN Principles)

Correlation Matrix																
	SP1	**SP2**	**SP3**	**SP4**	**CR1**	**CR2**	**CR3**	**CR4**	**CR5**	**CR6**	**LP1**	**LP2**	**LP3**	**LP4**	**LP5**	**LP6**
SP1	1.00	0.56	0.46	0.33	0.22	0.11	0.29	0.49	0.51	0.39	0.41	0.16	0.20	0.12	0.21	0.33
SP2	0.56	1.00	0.49	0.31	0.22	0.04	0.65	0.51	0.46	0.40	0.24	0.11	0.27	-0.03	0.27	0.34
SP3	0.46	0.49	1.00	0.50	0.28	0.10	0.44	0.58	0.47	0.31	0.27	0.28	0.42	-0.09	0.36	0.43
SP4	0.33	0.31	0.50	1.00	0.32	0.36	0.31	0.45	0.36	0.20	0.45	0.25	0.16	0.05	0.17	0.41
CR1	0.22	0.22	0.28	0.32	1.00	0.52	0.15	0.31	0.21	0.06	0.34	-0.02	0.22	0.19	0.06	0.12
CR2	0.11	0.04	0.10	0.36	0.52	1.00	0.02	-0.01	0.10	0.04	0.25	0.10	0.10	-0.04	0.07	0.06
CR3	0.29	0.65	0.44	0.31	0.15	0.02	1.00	0.63	0.63	0.52	0.26	0.17	0.42	-0.02	0.51	0.39
CR4	0.49	0.51	0.58	0.45	0.31	-0.01	0.63	1.00	0.85	0.66	0.47	0.23	0.46	0.01	0.46	0.59
CR5	0.51	0.46	0.47	0.36	0.21	0.10	0.63	0.85	1.00	0.77	0.51	0.26	0.41	-0.08	0.59	0.66
CR6	0.39	0.40	0.31	0.20	0.06	0.04	0.52	0.66	0.77	1.00	0.30	0.17	0.32	-0.07	0.48	0.45
LP1	0.41	0.24	0.27	0.45	0.34	0.25	0.26	0.47	0.51	0.30	1.00	0.38	0.13	0.04	0.27	0.67
LP2	0.16	0.11	0.28	0.25	-0.02	0.10	0.17	0.23	0.26	0.17	0.38	1.00	0.17	-0.22	0.44	0.49
LP3	0.20	0.27	0.42	0.16	0.22	0.10	0.42	0.46	0.41	0.32	0.13	0.17	1.00	-0.23	0.35	0.29
LP4	0.12	-0.03	-0.09	0.05	0.19	-0.04	-0.02	0.01	-0.08	-0.07	0.04	-0.22	-0.23	1.00	-0.34	-0.16
LP5	0.21	0.27	0.36	0.17	0.06	0.07	0.51	0.46	0.59	0.48	0.27	0.44	0.35	-0.34	1.00	0.47
LP6	0.33	0.34	0.43	0.41	0.12	0.06	0.39	0.59	0.66	0.45	0.67	0.49	0.29	-0.16	0.47	1.00

Note: Table 5-8 contains the variable codes.

- Bartlett's test of sphericity is a statistical test for the presence of correlation among the measurement items (Hair et al. 1995, p.374). The probability level

should be significant at the 0.05 level (p<0.05). Table 6.4 shows the results of this test.

- The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) is a representation of the ratio of the squared correlation between measurement variables to the squared partial correlation between variables (Field 2009, p647). It is used to quantify the degree of intercorrelations among the measurement variables and the appropriate factor analysis (Hair et al. 2010). The KMO statistic ranges between 0 and 1. Values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great, and values above 0.9 are excellent (Hutcheson & Sofroniou 1999). The value of 0.7809 (in Table 6-4) is considered good for adequate sample sizes.

Table 6-4: KMO and Bartlett's Test, and Correlation Matrix of 16 Measurement Items of Supply Chain Management Practices

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.7809
Bartlett's Test of Sphericity	Approx. Chi-Square	1417.4753
	df	120.0000
	Sig.	0.0000

- Factor extraction is used to find the number of factors that can adequately explain the observed correlation among the observed variables (Kim & Mueller 1978, p48). The techniques for extracting factors are numerous such as principal components analysis, principal axes factor analysis and maximum likelihood. In this study, principal components analysis is performed because it assumes that the scores on measured variables have perfect reliability (Thompson 2004), and it is concerned only with establishing which linear components exist within the data and are less complex in terms of theory (Field 2009). The criterion for extracting factors is the Kaiser's criterion, which considers factors with an eigenvalue greater than one as common factors (Nunnally 1978).

- Factor rotation involves moving the factor axes that measure the locations of the variables in the factor space. Therefore, the nature of the underlying constructs becomes more obvious to the researcher (Thompson 2004, p.38). There are two types of rotation: orthogonal and oblique (Field 2009). Oblique rotation (direct oblimin and promax in SPSS) allows factors to correlate (Field 2009), or is used when factors are difficult to interpret (Thompson 2004). On the other hand, orthogonal rotation (varimax, quartimax, and equamax in SPSS) is used when factors are expected to remain uncorrelated and independent (Johnson & Wichern 2002; Thompson 2004), Therefore, orthogonal varimax rotation was chosen in this study.

- Communality is the variance of an observed variable that is accounted for by the common factor (Kim & Mueller 1978, p75). Its value ranges between 0 (a variable shares none of its variance with other variables) and 1 (a variable has no specific variance). Communalities after extraction should be greater than 0.7 when fewer than 30 variables are analysed (Field 2009). However, there is no cutting-off of communality values for dropping any variable.

- Factor loading is a general term referring to a coefficient in a factor pattern (Kim & Mueller 1978) that represents the correlation between an original variable and its common factor (Hair et al. 1995). In this study, 0.45 is the cutting-off point for factor loading due to the 162-item sample size (Hair et al. 1995, p385). Additionally, a given variable is dropped if it has a meaningful factor loading on more than one factor in order to preserve an appropriate internal consistency reliability (Hatcher 1994, p90).

Table 6-5: Summary of EFA Performed in This Study

EFA	**EFA in this study**
Factor extraction	Principal components analysis
Criteria for extracting factors	Kaiser’s criterion (eigenvalue > 1.0)
Factor rotation	Orthogonal rotation (varimax)
Communality	Preferable > 0.7
Factor lding	0.45 cutting-off point and greater than 0.4 on more than one factor

Table 6-6: Initial Factor Analysis for Supply Chain Management Practice Construct

Communalities		
	Initial	Extraction
SP1	1.0000	0.5320
SP2	1.0000	0.5897
SP3	1.0000	0.5238
SP4	1.0000	0.5524
CR1	1.0000	0.7187
CR2	1.0000	0.7146
CR3	1.0000	0.6696
CR4	1.0000	0.8049
CR5	1.0000	0.8136
CR6	1.0000	0.6050
LP1	1.0000	0.7568
LP2	1.0000	0.6451
LP3	1.0000	0.6027
LP4	1.0000	0.6831
LP5	1.0000	0.6572
LP6	1.0000	0.7683
Average		0.6648

Rotated Component Matrix*				
	Component (factor)			
	1	2	3	4
SP1	0.5953			
SP2	0.7536			
SP3	0.5989		0.3258	
SP4	***0.5324***	***0.4124***		
CR1			0.8128	
CR2			0.8221	
CR3	0.7975			
CR4	0.8326	0.3177		
CR5	0.7909	0.4212		
CR6	0.7179			
LP1		0.7605		
LP2		0.7204		0.3538
LP3	***0.5143***			***0.5187***
LP4		-0.8151		
LP5	***0.4562***	***0.5537***		0.3749
LP6	0.4232	0.7560		
Eigenvalue	6.0865	1.8430	1.5072	1.2007
% of variance	38.0408	11.5190	9.4203	7.5043
Cumulative % of variance	38.0408	49.5598	58.9801	66.4844

Note: Factor loading less than 0.3 has not been displayed.

The results of EFA (Table 6-5) show that communalities of SP1, SP2, SP3 and SP4 are low between 0.524 and 0.590, whilst the rest are above 0.60. The average of communalities is 0.6648 (calculated by adding them and dividing by the number of

communalities); this is considered to be acceptable. Four factors are extracted (as presented in Table 6.6), although the questionnaire was developed from three main factors (strategic purchasing, CRM and LEAN principles).

Table 6.6 shows an analysis of the factor loadings above 0.3 in the rotated component matrix. Obviously, strategic purchasing items (SP1, SP2 and SP3) and CRM items (CR3, CR4, CR5 and CR6) load on Component 1. This indicates that the apparent characteristics between strategic purchasing and CRM become less distinct between Thai rice millers and rice exporters. Nonetheless, CR1 ('customer satisfaction is frequently evaluated and measured') and CR2 ('future customer expectation is frequently determined') are high-loading factors that load on Component 3. An examination of these items finds that both are related to customer value analysis in terms of customer satisfaction and future expectations, which are highly correlated, but they are not correlated with CR3 ('the importance of relationship with customers is frequently evaluated'), because this is related to customer value analysis.

Finally, LEAN principles items are separated into two components (Component 2 and 4). It is possible that LP1 ('a continuous quality improvement system is implemented'), LP2 ('rice suppliers' warehouses/farms are located nearby') and LP6 ('LEAN practices are focused on the long-term plan of your organisation') are highly correlated, but they are less correlated with LP3 ('production system is based on customer demand'), LP4 ('inspection of outbound rice has been reduced') and LP5 ('top managers view a close relationship with suppliers as an important strategy) because they are developed to be measured in different aspects (see in Section 5.3.3).

A 'cross-loading' item is an item that loads at 0.32 or higher on two or more factors. This cross-loading should be dropped if there are several adequate strong loaders (0.50 or higher) on each factor (Costello & Osborne 2005, p4). In this case, LP3 has a cross loading of 0.514 and 0.519. These cross-loadings are possible since it appears that this item is too broad and already included in CR items, and thus deleted. Although SP4 and LP5 also have cross-loading of 0.5324 and 0.4124, and 0.4562 and 0.5537, they are not deleted because 0.4124 and 0.4562 are not too high, and do not exceed 0.5 (Costello & Osborne 2005). Field (2009) suggests that factor analysis is an exploratory tool that should be used as the guideline to make decisions. After

removing the LP3 item, a factor analysis is performed and the results are shown in Table 6-7.

Table 6-7: Final Factor Analysis for Supply Chain Management Practice Construct

Communalities

	Initial	Extraction
SP1	1.0000	0.5186
SP2	1.0000	0.6455
SP3	1.0000	0.5167
SP4	1.0000	0.5503
CR1	1.0000	0.6935
CR2	1.0000	0.7538
CR3	1.0000	0.6920
CR4	1.0000	0.8031
CR5	1.0000	0.8169
CR6	1.0000	0.6100
LP1	1.0000	0.7737
LP2	1.0000	0.6418
LP4	1.0000	0.7337
LP5	1.0000	0.6930
LP6	1.0000	0.7841

Rotated Component Matrix

	Component (factor)			
	1	2	3	4
SP1	0.5858			
SP2	0.7811			
SP3	0.6005		0.3247	
SP4	0.3029	0.3881	0.5501	
CR1			0.7875	
CR2			0.8485	
CR3	0.8140			
CR4	0.8128	0.3649		
CR5	0.7893	0.4328		
CR6	0.7250			
LP1		0.7825		
LP2		0.6982		0.3897
LP4				-0.8553
LP5	0.4045	0.3244		0.5858
LP6	0.4115	0.7741		
Eigenvalue	5.8460	1.8274	1.5072	1.0461
% of variance	38.9733	12.1827	10.0483	6.9740
Cumulative % of variance	38.9733	51.1560	61.2043	68.1782

Note: LP3 is dropped.

In this study, the number of factors theoretically underlies three factors in supply chain practices: strategic purchasing, customer-relationship management and LEAN principles. Thus, in the next analysis, the three supply chain management practice constructs – strategic purchasing, customer-relationship management and LEAN principles – remain, as they are supported by the ground theories discussed in Chapter 4.

6.7 Chapter Summary

In this chapter, a non-response bias test of the data has shown that the non-response bias is not an issue in this study. There were two rounds of data collection from rice exporters. Therefore, a non-parametric test was used to differentiate those groups of data before allowing them to pool. This test was performed again to compare between data from rice millers and rice exporters. The result showed that their data is equal, and they can combine. This leads to a sample size of 162 for this study.

The CTA test is applied to confirm formative measurement model specification in this study. The result indicates that the formative scale specification is appropriate at a significant result except for the government policy and climate uncertainty measurement models. However, both models are supported to be formative measurement models as the theory indicates. Then, the EFA was applied to supply chain management practices since they are reflective measurement models. As a result, LP3 ('production system is based on customer demand') as an indicator of LEAN principles was dropped to improve the reliability and validity of the LEAN principles measurement model.

The next chapter examines the tests of reliability and validity for all 12 measurement models.

CHAPTER 7

TEST OF MEASURES

7.1 Introduction

As discussed in Chapter 5, this study uses three types of measurement models: formative, reflective and multidimensional constructs. Each reliability and validity test requires a different measurement constructs. The main objective of this chapter is to describe the procedure used to test the reliability and validity of the measurement models in this study.

The chapter is divided into two major sections. Sections 7.2 and 7.3 establish the reliability and validity respectively of the measurement models used in this study. Both sections present the tests applied to the different measurement models to prepare for the equation structural modeling in Chapter 8.

Table 7-1 summaries the reliability and validity tests of the measurement constructs used in this study. The EFA and CTA tests were presented in the previous chapter.

Table 7-1: Reliability and Validity Tests of the Measurement Constructs.

Construct Name	Types of Construct	Reliability Test	Validity Test
• Supply uncertainty • Demand uncertainty • Process uncertainty • Planning and control uncertainty • Competitor uncertainty • Government uncertainty	Formative construct	• Multicollinearity with VIF • Condition index	• Confirmatory tetrad analysis Test • Item weight (outer weight) t-values of each item weight
• Climate uncertainty • Rice quality	Multidimensional construct (formative first-order, formative second-order)	**Formative First/Second-Order** • Multicollinearity with VIF • Condition index	**Formative First-Order** • Confirmatory tetrad analysis Test • Item weight (outer weight) • t-values of each item weight **Formative Second-Order** • Inner path coefficients • t-values of inner path coefficients
• Strategic purchasing • Customer-relationship management • LEAN principles	Multidimensional construct (reflective first-order, reflective second-order)	**Reflective First/Second-Order** • Inter-item correlation • Cronbach's alpha methods • CFA for unidimensional reliability: R^2 and factor loading • Construct reliability and AVE	**Reflective First-Order** • EFA : factor loading • Discriminant validity **Reflective Second-Order** • CFA for construct validity: goodness-of-fit index • Convergent validity: R^2 of the second-order construct
• Efficiency	Reflective construct	• Inter-item correlation • Cronbach's alpha methods • CFA for unidimensional reliability: R^2 and factor loading • Construct reliability and AVE	• CFA for construct validity: goodness-of-fit index • Discriminant validity

7.2 Reliability Test

Reliability is "the consistency of the a measure of a concept" (Bryman 2003, p71). Reliability is concerned with the extent to which any measuring procedure yields the same results on repeated trials (Carmines & Zeller 1979). There are several methods for computing reliability, but they focus on the same fundamental definition (DeVellis 2003).

There are six general methods of assessing reliability (Trochim 2001; Straub, Boudreau & Gefen 2004): inter-rater or inter-observer, test-retest, parallel-forms, internal consistency, unidimensional and split halves. Straub, Boudreau et al (2004) suggest that a combination of reliability methods would strengthen the component as an instrument of validation. The following subsection discusses the selection of reliability tests and which tests are used in this study.

Inter-rater reliability testing is used to assess the degree to which different raters or observers give consistent estimates of the same phenomenon. This test is often performed as a pilot study. Human judgement from the pilot study is used to refine a survey (Trochim 2001). The researcher can establish this test by giving the survey to two respondents in the same organisation. And the joint-probability of agreement or inter-rater correlation can be used to determine inter-rater reliability (Shrout & Fleiss 1979; Saal, Downey & Lahey 1980).

Test-retest reliability testing compares the results of the same test give to the same sample on different occasions (Emory 1985) as an estimation of its reliability (Valentin, Theo & Burkhardt 2002).

Parallel-forms reliability testing (also known as the alternative forms of reliability) assesses the consistency of the results by two equivalent measures administered to the same person at roughly the same time and in the same content domain (Emory 1985; Trochim 2001). The correlation between the scores from the parallel forms is an assessment of reliability (Flynn et al. 1990). However, these reliability tests are not used in this study because the survey was not administered repeatedly or in splits.

Internal consistency, split halves and unidimensional reliability require a single measurement instrument to be administered to a single group sample on one occasion (Trochim & Donnelly 2006).

Internal consistency testing measures the agreement between the results of different questions measuring the same construct (Straub, Boudreau & Gefen 2004). Many internal consistency measures can be applied: average inter-item correlation, average item-total correlation, split-half reliability and Cronbach's alpha (α) (Trochim 2001). The average inter-item correlation is calculated by averaging the correlation between each pair of items for all possible pairs. The average item-total correlation is measured by averaging the total correlations of each item for all items (Trochim & Donnelly 2006). Split-half reliability is tested by separating all items in the same construct into two sets, then calculating the average correlation between the scores on the halves (Nunnally 1978; Carmines & Zeller 1979). This is recognised as the traditional test in the view of Straub, Boudreau & Gefen (2004). However, the different ways that the items can be grouped (into halves) can lead to certain indeterminacy problems, resulting in slightly different correlations between the two halves (Carmines & Zeller 1979).

Cronbach's alpha (α) is a common technique used to measure the internal reliability of a set of two or more construct indicators, or multiple-item measures (Hair et al. 1995; Bryman 2003). The degree of intercorrelation among items should be high (Flynn et al. 1990). The value ranges between 0 and 1.0; higher values indicate higher reliability (Hair et al. 1995). Generally, a figure of 0.7-0.8 denotes an acceptable level of reliability (Flynn et al. 1990; Bryman 2003); however, Nunnally (1967) suggested a Cronbach's alpha as low as 0.6 for exploratory research and 0.7 for confirmatory research. Alternatively, if Cronbach's alpha is low, the items that do not share equally in the common theme should be eliminated (Churchill 1979), especially when their corrected item-total correlation as a measurement of their relationship to the overall score of their reflective construct is lower than 0.3 (Field 2009). Formative indicators that are not expected to share the same common theme can have unlikely formative constructs, as indicated by high or low intercorrelations among indicators (Coltman et al. 2008). Therefore, internal consistency reliability is irrelevant for formative

measurement models (Diamantopoulos & Winklhofer 2001; Diamantopoulos, Riefler & Roth 2008).

The distinction between unidimensionality and reliability lies in the mathematical definition of each concept. The dimensionality of a scale can be evaluated by examining the pattern of indicator correlations. In contrast reliability is a function of the number of items that define the scale and the respective reliability of those items (Segars 1997).

Unidimensional reliability testing is used to measure each measurement item reflecting one and only one latent construct (Anderson, Gerbing & Hunter 1987) without having patterns of parallel correlation (Segars 1997). This test can be assessed using covariance-based SEM techniques such as those used in the AMOS software (Gefen, Straub & Boudreau 2000) for reflective observed variables (Gerbing & Anderson 1988). This reliability test cannot be estimated by exploratory factor analysis (EFA) or Cronbach's alpha (α) (Anderson, Gerbing & Hunter 1987; Gerbing & Anderson 1988) because, for example, in EFA, each factor is defined as a weighted sum of all observed variables (Gerbing & Anderson 1988), and the variables can be reflected in more than a single factor (Gefen, Straub & Boudreau 2000). Therefore, unidimensional measurement is extremely arduous in terms of a statistical perspective (Straub, Boudreau & Gefen 2004). Gerbing and Anderson (1988) suggest that the confirmatory factor analysis (CFA) of a multiple-indicator measurement model affords a more accurate assessment of unidimensionality. Only CFA directly tests unidimensionality as formally defined. Moreover, CFA provides direct and quantifiable evidence regarding the external and internal consistency among a set of construct indicators (Segars 1997).

Based on the overview of reliability tests above, the next section evaluates reliability tests for reflective, formative and multi-dimensional constructs.

7.2.1 Reliability Test for Reflective Constructs

This research considers the application of reliability tests that do not require splitting or repeating of measurement as an instrument of administration: inter-item correlation, Cronbach's alpha (α) methods for internal consistency reliability and CFA for unidimensional reliability.

The inter-item correlation and Cronbach's alpha (α) methods concerning internal consistency reliability are widey recommended as they provide a good reliability estimation on a homogeneous scale (Nunnally 1978) or a reflective construct. The unidimensionality of the reflective construct is an important instrument of assessment (Li et al. 2005). Gerbing and Anderson (1988) suggest that CFA can assess both internal and external consistency criteria for unidimensionality. Working from the results of CFA, the proportion of variance (R^2 or the squared multiple correlation coefficients) and factor loading of each measurement item (observed item) assess unidimensionality. Factor loadings are interpreted as the standardised regression weights that estimate the direct effects of the factors on the indicators (Kline 2005). R^2 is accounted for by the first-order reflective latent constructs. This can be applied to estimate the reliability of the measurement items (Doll et al. 1995). If the R^2 of any measurement items is less than 0.5, they can be deleted from the first run (Easterby-Smith 1991). CFA is performed again on the remaining items until the R^2 of all remaining items is more than 0.5. At this point, the construct reliability (CR) value and average variance extracted (AVE) value are computed (Easterby-Smith 1991; Hair et al. 1995).

As construct reliability (or composite reliability) and AVE measure are not provided directly from the CFA performed by the AMOS software, they must be calculated separately for each construct (Hair et al. 1995, p642).

$$Construct\ reliability = \frac{(\sum std.loading)^2}{(\sum std.loading)^2 + \sum \varepsilon_j}$$ Equation 7-1

where the standardised loadings ($std.loading$) and the measurement error (ε_j) for each indicator are obtained directly from AMOS output.

$$AVE = \frac{\sum(std.loading^2)}{\sum(std.loading^2) + \sum \varepsilon_j}$$ Equation 7-2

The general guidelines for theses tests are:

- A Cronbach's alpha (α) of more than 0.6 denotes an acceptable level of reliability (Nunnally 1967) for each reflective construct in an exploratory study (Churchill 1979).
- The inter-item correlation of each indicator can be measured with corrected item-total correlation in SPSS with 0.3 as the cutting-off point to enhance Cronbach's alpha (Field 2009).
- In CFA, factor loading should have loadings of 0.6 or higher on the latent variable (Kline 2005).
- R^2 values above 0.5 are considered as evidence of acceptable reliability. R^2 values of less than 0.5 are considered to be deleted (Easterby-Smith 1991).
- The regression weight should be significant. Thus, the p-value for the regression weight of each indicator should be less than 0.05 to ensure that its regression weight is not equal to 0.0 (Field 2009).
- The value for construct reliability should be greater than 0.7 (Easterby-Smith 1991).
- The value for average variance extracted should be greater than 0.5 (Hair et al. 1995).

The necessary requirements for CFA are that the number of free parameters is less than or equal to the number of observations such that the degrees of freedom ≥ 0, and every latent variable (construct) must have an indicator (Kline 2005). Moreover, if a standard CFA model with a single factor has at least three indicators, the model is identified. If a standard model with two or more factors has at least two indicators per factor, the model is identified (Kline 2005). The recommended sample size ranges between 100 and 200 (Hair et al. 1995, p637). This study meets all these requirements, and its reflective construct is only an efficiency construct.

The overall fit of a hypothesised model can be tested by using the maximum likelihood chi-square (χ^2) statistic provided in the AMOS output. However, the χ^2 statistic is sensitive with respect to large sample sizes and models with large numbers of indicators (Bearden, Sharma & Teel 1982) and categorical data (Byrne 2001), such as the seven-point Likert scale used in this study. Furthermore, the χ^2 value cannot be significant even if there is a good model fit (Bollen 2002). Thus, in this study the χ^2 value will be reported but will not be mainly considered.

Table 7-2 shows mean, standard derivation (S.D), Cronbach's alpha (α), inter-item correlation and CFA results. Cronbach's alpha is 0.873 and the inter-item correlation of each indicator is greater than 0.6. These values support the reliability of this construct. The χ^2 value of 126.548, with five degrees of freedom and a probability of less than 0.0001 ($p < 0.0001$), indicates that the fit of data to the hypothesised model is not entirely adequate. The p-value for the regression weight of each indicator is less than 0.001. This means that the hypothesis (that is an estimate equal to 0.0) can be rejected.

The construct reliability is equal to 0.9506 and the AVE is equal to 0.8004, which demonstrates that the reliability of the construct is high. EF1, EF2 and EF3 relate to the efficiency of the load on the common factor; their R^2 and factor loading range between 0.613-0.903 and 0.783-0.950 respectively. EF4 is the poorest among the efficiency indicators with an R^2 value of 0.310 and a factor loading of 0.557.

Table 7-2: Reliability Test of Efficiency Construct.

Coding (α = 0.873)	**Mean**	**S.D**	**Inter-Item Correlation**	**CFA** Construct reliability = 0.9506 AVE = 0.8004	
				R^2	**Factor Loading**
EF1	3.5802	1.8507	0.6466	0.6130	0.7830
EF2	3.6543	1.6878	0.8297	0.9030	0.9500
EF3	3.6049	1.7949	0.7760	0.7350	0.8570
EF4	3.5988	1.4972	0.6042	0.3100	0.5570
EF5	3.5309	1.4324	0.6589	0.3450	0.5870

Note: Table 7-20 contains the variable codes.

Although the cut-off criteria for R^2 and factor loadings are 0.5 and 0.6 respectively, EF4 and EF5 are retained. It is likely that a two-factor model is more appropriate to describe efficiency in terms of cost sub-construct (EF1, EF2 and EF3), as well as return on investment (ROI) and profit sub-construct (EF4 and EF5). To test this possibility, CFA was performed on the model in Figure 7-1.

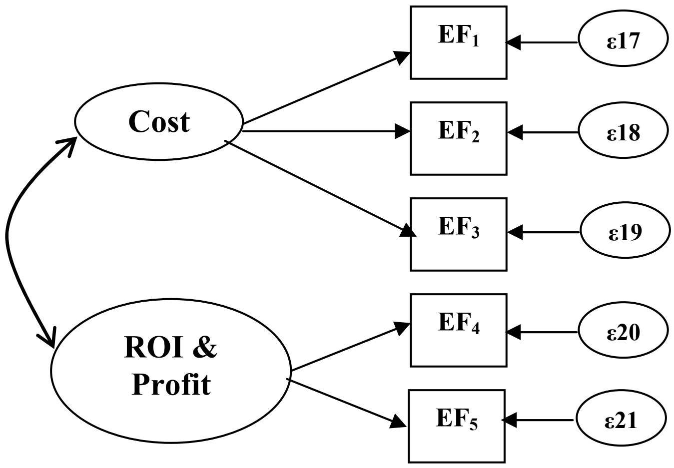


Figure 7-1: Measurement Model of Efficiency Separated into Cost, and ROI and Profit.

The results from CFA of the model in Figure 7-1 show that the χ^2 value of 16.686, with four degrees of freedom and a probability of 0.002 (p = 0.002), indicates that the null hypothesis of a good fit to the data can be rejected. The p-value for the regression weight of each indicator is less than 0.001. This means that the hypothesis (that is, an estimate equal to 0.0) can be rejected. The construct reliability and AVE of cost sub-construct, and the ROI and profit sub-construct were recalculated as presented in Table 7-3. Their values show that the reliability of both sub-constructs is high. Moreover, the R^2 and factor loading of each item is also higher than 0.5 and 0.6 respectively. This indicates that this measurement model appears to fit the data substantially better than the single-factor model.

Table 7-3: Reliability Test for Cost and for ROI and Profit Construct.

Coding (α =0.896)	**Inter-Item Correlation**	**CFA** Construct reliability = 0.9429 AVE = 0.8474	
		R^2	**Factor Loading**
EF1	0.7379	0.6150	0.7840
EF2	0.8739	0.9490	0.9740
EF3	0.7705	0.7030	0.8390
Coding (α =0.8839)	**Inter-Item Correlation**	**CFA** Construct reliability = 0.8859 AVE = 0.8422	
		R^2	**Factor Loading**
EF4	0.7921	0.7490	0.8650
EF5	0.8429	0.8380	0.9150

7.2.2 Reliability Test for Formative Constructs

Because a formative construct is a composite of different aspects of a construct, it is not necessary that its indicators correlate with each other (Diamantopoulos & Winklhofer 2001). However, “there are no simple, easy and universally accepted criteria for assessing the reliability of formative indicators” (Coltman et al. 2008, p1253). Diamantopoulos and Siguaw (2006) and Rossiter (2002) agree that no dimensionality and reliability test are performed on formative indicators because factorial unity in factor analysis and internal consistency are not relevant. Although low item-to-total correlation should be dropped from measurement scales to increase internal consistency reliability for a reflective measurement model, because the scales are from the same content construct, the removal of measurement scales in formative measurement model can lead to changes in the empirical and conceptual meaning (MacKenzie, Podsakoff & Jarvis 2005). Therefore, Andreev, Heart et al. (2009) conclude that a test of the construct reliability of a formative construct should be performed using multicollinearity, test of indicator validity (path coefficients significance) and optionally, if appropriate, test-retest.

A high degree of reliability of formative constructs in terms of multicollinearity should not be present because it means that indicators are tapping into the same aspect

of the construct (Petter, Straub & Rai 2007). Likewise, the formative measurement model is based on a multi-regression that should not demonstrate multicollinearity (Diamantopoulos & Winklhofer 2001). Thus, reliability evaluation for formative constructs aims to assess the assumption of no multicollinearity (Diamantopoulos & Siguaw 2006). The variance inflation factor (VIF) is evaluated. Collinearity can also have harmful effects on formative constructs. A condition index – the standard diagnostic that measures the relative amount of variance associated with an eigenvalue – should be applied.

- A VIF less than 3.3 is an excellent value (Diamantopoulos & Siguaw 2006).
- If a VIF is less than 10, there is no collinearity (Hair et al. 1995).
- The condition index's threshold value should be less than 30 to find no support for the existence of collinearity (Hair et al. 1995).

If multicollinearity exists, Petter, Straub et al. (2007) recommend that, as the model construct may have both formative and reflective measures, the correlated measurement items can be removed if this does not affect content validity. The correlated measurement items can be collapsed into a composite index or converted into a multidimensional construct.

The VIF and condition index can be calculated using SPSS software. The manifest variable scores are considered to be independent variables and the latent variable score is a dependent variable. The manifest variable scores and the latent variable score are in the output of SmartPLS software (PLS algorithm) (Ringle, Wende & Will 2005).

As discussed in Section 5.3.5, there are six formative measurement models: supply, demand, process, planning and control, competitor, and government policy uncertainty. Their reliability is evaluated by VIF and condition index. Table 7-4 shows the mean, standard derivation (SD), condition index and VIF for each formative indicator. The VIF values of all indicators are less than 3.3, and the condition indices range between 8 and 17, indicating that multicollinearity is not a concern.

Table 7-4: Reliability Test for Uncertainty

Construct Name	Code	Mean	S.D.	VIF
Supply *(Condition Index =8.7132)*	SU1	4.5864	1.5550	1.1568
	SU2	4.6049	1.7529	1.3390
	SU3	3.8333	1.7059	1.2019
Demand *(Condition Index =8.9511)*	DU1	4.7716	1.5293	1.1828
	DU2	4.5062	1.7240	1.5834
	DU3	3.5185	1.6006	1.4824
Process *(Condition Index =8.0839)*	PU1	4.2099	1.7318	1.2930
	PU2	4.5494	1.6192	1.2660
	PU3	2.8827	1.4886	1.1227
Planning and control *(Condition Index =12.6825)*	PCU1	4.9938	1.4382	1.2070
	PCU2	4.7531	1.5566	1.2619
	PCU3	5.1914	1.1718	1.2918
Competitor *(Condition Index =12.2023)*	CU1	4.9506	1.5476	1.0557
	CU2	5.7160	1.3581	1.2708
	CU3	5.3395	1.6500	1.2145
Government policy *(Condition Index =17.1029)*	GU1	4.8075	1.7339	1.7641
	GU2	4.7284	1.7375	1.7254
	GU3	5.6358	1.6522	2.8672
	GU4	5.3889	1.5494	2.6419

Note: Table 7-20 contains the variable codes.

7.2.3 Reliability Test for Multidimensional Constructs

As noted in Section 7-2, there are several methods of reliability testing. They are limited to only first-order reflective constructs (Petter, Straub & Rai 2007), and are irrelevant for testing multi-dimensional measures (Hanisch, Hulin & Roznowski 1998; Martin & Heinz-Martin 2005). Thus, Edwards and Bagozzi (2000, p160) state that "reliability is not an issue of debate when a multidimensional construct and its dimensions are treated as latent variables that contain no measurement error." However, composite (or construct) reliability should be assessed for multidimensional measures (Martin & Heinz-Martin 2005).

As multidimensional constructs are used to represent several distinct dimensions, which can be either reflective or formative indicators, the reliability tests for this study's multidimensional constructs follow the types of construct (formative or reflective construct) discussed in Sections 7.2.1 and 7.2.2.

7.2.3.1 Reliability Test for Reflective First-Order and Reflective Second-Order Constructs

The reliability tests for reflective first-order constructs are inter-item correlation, Cronbach's alpha (α), R^2, factor loading, construct reliability and AVE. Their criteria are the same as noted in Section 7.2.1. However, it is not clear that reliability is a concept that applies well to reflective second-order constructs (Bacon 1995). Although R^2 can be applied to estimate reliability (Doll et al. 1995) it evaluates convergent validity, as shown in Section 7.3.3.1.

The testing of the CFA model is performed for the strategic purchasing, CRM and LEAN principles constructs. Table 7-5 shows the construct reliability test for strategic purchasing. Cronbach's alpha (α) is 0.7583, and the inter-item correlation of each indicator is greater than 0.4. This supports the reliability of this construct. The χ^2 value of 12.503, with two degrees of freedom and a probability of less than 0.002 ($p = 0.002$), indicates that the fit of data to the hypothesised model is adequate at a level above 0.001, but not at a significance level of 0.01. The p-value for the regression weight of each indicator is less than 0.001. This means that the null hypothesis (that is, an estimate equal 0.0) can be rejected.

Table 7-5: Reliability Test for Strategic Purchasing

Coding (α =0.7583)	**Mean**	**SD**	**Inter-Item Correlation**	**CFA** Construct reliability = 0.9347 AVE = 0.7838	
				R^2	**Factor Loading**
SP1	5.4691	1.2470	0.5630	0.4880	0.6980
SP2	5.4938	1.1703	0.5655	0.5020	0.7090
SP3	5.8704	1.0640	0.6253	0.5150	0.7180
SP4	5.4012	1.3671	0.4539	0.2860	0.5350

Note: Table 7-20 contains the variable codes.

Table 7-5 shows that the construct reliability is equal to 0.9347, and the AVE is equal to 0.7838, indicating that the reliability of the construct is high. As these values support the reliability of this construct, SP4 is retained in this construct even though its R^2 and factor loading are less than 0.5 and 0.7 respectively. In addition, SP4

measures the strategic-focus aspect of the strategic purchasing construct that can lead to less correlation with the other indicators. Additionally, if SP4 is dropped, Cronbach's alpha for this construct decreases to 0.751.

In customer-relationship management (CR) construct, Cronbach's alpha is 0.7740 and the inter-item correlation of each indicator is greater than 0.3, except for CR2 (0.2258), 'Future customer expectation is frequently determined' (see Table 7-6). Consequently, CR2 is removed. Without CR2, the Cronbach's alpha increases to 0.8209, and inter-item correlation of each remaining indicators is greater than 0.3. This supports the reliability of this construct. Thus, CFA proceeds on the CR construct without the CR2 indicator.

The χ^2 value of 21.008, with five degrees of freedom and a probability of 0.001 ($p = 0.001$), indicates that the null hypothesis of a good model fit is rejected. As seen in Table 7-6, the construct reliability is equal to 0.9611, and the AVE is equal to 0.8489 after CR2 is deleted. These values demonstrate that the reliability of the construct is high. The p-value for the regression weight of each indicator is less than 0.001 except for CR1 ($p= 0.005$). This means that the null hypothesis of CR1 (that is, an estimate equal to 0.0) can be accepted at a level of 0.005. In addition, CR1's R^2 and factor loading are low at 0.051 and 0.227 respectively. Thus, CR1 'Customer satisfaction is frequently evaluated and measured' is dropped. Subsequently, the final CFA test is undertaken (Table 7-7).

Table 7-6: Initial Reliability Test for Customer-Relationship Management

Coding (α = 0.8209 *after CR2 deleted)*	**Mean**	**SD**	**Inter-Item Correlation**	**CFA** Construct reliability = 0.9611 AVE = 0.8489 *(after CR2 deleted)*	
				R^2	**Factor Loading**
CR1	4.9506	1.6373	0.3512	0.0510	0.2270
CR2	5.0864	1.2921	*0.2258*	deleted item	
CR3	6.0988	1.1045	0.5260	0.4370	0.6610
CR4	6.3333	1.0031	0.7009	0.7740	0.8800
CR5	6.2840	1.1337	0.7232	0.9360	0.9680
CR6	6.2222	1.1900	0.5360	0.6200	0.7880

Note: Table 7-20 contains the variable codes.

In Table 7-7, Cronbach's alpha is 0.8932 and the inter-item correlation of each indicator is greater than 0.3 after CR1 and CR2 are dropped. Construct reliability and AVE are improved to 0.9801 and 0.9263 respectively.

The χ^2 value of 6.469, with two degrees of freedom and a probability of 0.001 (p = 0.001), indicates that the null hypothesis of a good model fit is rejected. The p-value for the regression weight of each indicator is less than 0.001. This means that the null hypothesis of each indicator (that estimate equal 0.0) can be rejected at a significance level of 0.001. In addition, the R^2 and factor loading range from 0.622-0.942 and 0.789-0.971 respectively for CR4, CR5 and CR6, whilst CR3's R^2 and factor loading are below the cut-off values at 0.434 and 0.658 respectively (Table 7-7). However, CR3, 'The importance of relationship with customers is frequently evaluated' is retained in this construct because it measures the importance of the relationship with customers. This is of significant importance to the concept of CRM (Payne & Frow 2005).

Table 7-7: Final Reliability Test for Customer-Relationship Management

Coding (α =0.8932) *(after CR1 and CR2 deleted)*	**Inter-Item Correlation**	**CFA for unidimensional reliability** Construct reliability = 0.9801 AVE = 0.9263 *(after CR1 and CR2 deleted)*	
		R^2	**Factor Loading**
CR3	0.6426	0.4340	0.6580
CR4	0.8189	0.7670	0.8760
CR5	0.8726	0.9420	0.9710
CR6	0.7273	0.6220	0.7890

Note: Table 7-20 contains the variable codes.

Next, the CFA of the LEAN principles construct is assessed. Table 7-8 shows that Cronbach's alpha is 0.561 and the inter-item correlation of each indicator is greater than 0.3, except for LP4 (0.224), 'Inspection of outbound rice has been reduced'. Thus, this indicator is dropped, which increases Cronbach's alpha to 0.768, and inter-item correlation of the remained indicator is rise to be greater than 0.3. This supports to persuade the reliability of this construct. Construct reliability and AVE are 0.9200 and 0.9263 respectively.

The χ^2 value of 12.060, with two degrees of freedom and a probability of less than 0.002 ($p = 0.002$), indicates that the fit of data to the hypothesised model is adequate at a significance level of 0.001, but not at a significance level of 0.01. The p-value for the regression weight of each indicator is less than 0.001. This means that the null hypothesis (that is, an estimate equal to 0.00) of each indicator can be rejected.

The R^2 values of LP1, LP2 and LP5 are below 0.5 cut-off value, and the factor loadings for LP2 and LP5 are below 0.7 (Table 7-8). However, they are retained because Cronbach's alpha and the inter-item correlation support the remaining indicators. If LP1, LP2 or LP5 is dropped, Cronbach's alpha for this construct decreases, as their inter-item correlation is higher than 0.3. Moreover, LP3 (dropped in EFA in Chapter 6) and LP4 measures the LEAN tools practiced in terms of a pull production system and outbound martial inspection. Their removal could erroneously imply that pull production systems and outbound martial inspection might not exist in the Thai rice industry.

Table 7-8: Reliability Test for LEAN Principles

Coding (α =0.7680 *after LP4 deleted*)	**Mean**	**SD**	**Inter-Item Correlation** (*after LP4 deleted*)	**CFA** Construct reliability = 0.9200 AVE = 0.7536	
				R^2	**Factor Loading**
LP1	5.5000	1.3662	0.5323	0.4960	0.7050
LP2	5.3272	1.5795	0.5412	0.2960	0.5440
LP4	3.1111	1.9240	***0.224***	*deleted item*	
LP5	5.9136	1.3300	0.4816	0.2550	0.5050
LP6	5.7716	1.2121	0.7108	0.8700	0.9330

Note: Table 7-20 contains the variable codes; LP3 was dropped in EFA (Chapter 6).

7.2.3.2 Reliability Test for Formative First-Order and Second-Order Constructs

As explained in Section 5.3.5, the first-order and second-order formative constructs in this study are the climate-uncertainty construct and the rice-quality constructs. The reliability test for these constructs is the non-existence of multicollinearity in the construct as indicated by VIF value and condition index, as discussed in Section 7.2.2. There is no specific reliability test for formative second-order constructs (Straub, Boudreau & Gefen 2004); validity testing for this construct will mainly focus on the tests in Section 7.3.3.2.

Table 7-9 shows the mean, standard derivation (SD) and VIF of each formative indicator. The VIF values for all indicators are less than 10. The condition index of the rice quality is 22.9024 suggesting that there is no excessive multicollinearity in the data. However, the condition index of climate uncertainty is high at 30.0414, indicating that analysis should carefully consider the multicollinearity of this construct.

Table 7-9: Reliability Test of Climate Uncertainty and Rice Quality

Construct Name	Code	Mean	SD	VIF
Climate uncertainty	CMU1	5.2099	1.6014	5.2147
(Condition Index =30.0141)	CMU2	5.1296	1.7018	5.8479
	CMU3	5.1420	1.6185	7.3547
	CMU4	5.0494	1.6449	6.3717
	CMU5	4.5679	1.7724	2.3008
Rice quality	RQ1	6.0432	1.3110	1.4790
(Condition Index =22.9024)	RQ2	5.8580	0.9898	1.2543
	RQ3	5.2840	1.3897	1.7071
	RQ4	5.3519	1.1977	1.2787
	RQ5	4.9136	1.4887	1.0291

Note: Table 7-20 contains the variable codes.

Mean of climate uncertainty variables is high (4.5679 – 5.2099) meaning that TRSC members perceived high uncertainty of climate. Climate uncertainty can be verified by stardard deviation (SD) of the amount of rainfall as shown in Table 7-10. The SD of rainfall in Uttaradit is highest as 480.14 mm. When considering in regions, The SD of rainfall in central is 389.82mm that is higer than the others.

Table 7-10: Annual Rainfall: Selected Location by Region, 2006 - 2010 (Unit: mm.)
(Thai Meteorological Department 2011)

Region / Province	2006	2007	2008	2009	2010	SD
North						
Kamphaeng Phet	1,257.60	1,426.50	1,704.40	1,169.30	1,594.40	223.62
Chiang Mai	1,500.00	1,125.30	1,141.00	1,070.20	1,156.00	171.63
Chiang Rai	1,935.20	2,041.70	1,729.10	1,625.00	1,824.80	164.40
Tak	1,334.50	1,203.10	1,212.20	1,006.40	1,151.50	118.72
Nakhon Sawan	1,221.20	1,185.60	1,486.20	1,415.40	1,575.50	168.60
Nan	1,194.20	1,096.30	1,173.00	1,095.30	1,456.80	148.64
Phetchabun	1,682.40	1,179.60	1,375.20	1,026.20	1,186.70	251.84
Phrae	1,398.70	1,046.10	1,245.40	1,168.50	1,009.80	157.27
Phayao	1,263.10	1,138.40	1,172.90	847.00	1,158.20	157.73
Phitsanulok	1,513.40	1,642.40	1,338.50	1,348.60	1,368.60	132.36
Mae Hong Son	1,531.80	1,207.20	1,550.00	841.50	1,363.10	291.14
Lampang	1,467.80	1,101.20	994.50	977.00	986.40	208.74
Lamphun	1,142.30	890.20	1,226.70	737.20	1,355.10	252.07
Uttaradit	2,241.00	1,083.80	1,305.70	1,183.30	1,156.70	**480.14**
Standard Deviation within North =		280.68				
North-east						
Khon Kaen	1,201.50	1,378.90	1,780.60	1,039.90	1,230.10	281.07
Chaiyaphum	951.40	1,342.90	1,695.20	1,502.10	1,506.30	279.90
Nakhon Phanom	2,684.70	2,308.40	2,786.20	2,244.50	1,939.60	344.41
Nakhon Ratchasima	991.80	1,177.80	1,375.70	1,212.50	1,386.20	162.32
Mukdahan	1,378.60	1,300.30	1,400.10	1,212.00	1,738.00	199.89
Roi Et	1,483.20	1,515.20	1,342.80	1,305.20	1,147.70	148.01
Loei	1,150.40	1,270.70	1,274.60	1,347.80	1,541.20	143.97
Sakon Nakhon	1,602.20	1,823.40	2,142.00	1,440.50	1,449.80	295.70
Surin	1,545.50	1,522.40	1,541.70	1,534.80	1,315.00	99.27
Nong Khai	1,375.10	1,404.80	2,331.00	1,843.60	1,591.80	394.58
Udon Thani	1,324.00	1,159.90	1,662.60	1,513.90	1,507.70	194.49
Ubon Ratchathani	1,526.70	2,035.50	1,396.10	1,976.20	1,551.50	288.64
Standard Deviation within North-East =			378.11			
Central						
Bangkok	1,598.70	1,684.20	1,902.40	2,272.00	2,023.70	269.71
Kanchanaburi	1,045.80	1,091.70	1,324.80	1,329.20	1,120.40	134.68
Prachuap Khiri Khan	1,233.80	1,408.30	932.10	793.10	722.60	293.31
Phetchaburi	944.70	1,113.40	881.60	871.30	1,169.10	136.94
Lob Buri	1,226.90	900.90	1,473.20	1,206.30	1,227.30	203.33
Suphan Buri	940.30	782.00	945.00	654.20	962.60	134.71
Standard Deviation within Central =			389.82			

7.3 Validity Test

Validity is the ability of a construct's indicators to measure accurately the concept under study (Hair et al. 1995). Table 7-11 summarises several validity tests used in positivist research (Straub, Boudreau & Gefen 2004).

Table 7-11: Validity Tests and Their Terms of Use (Straub, Boudreau & Gefen 2004, p383)

Validity Component	**Terms of Use**
Instrument validity	Validation of data-gathering
Internal validity	Ruling out rival hypothesises
Statistical validity	Statistical inference
External validity	Generalisability

Validity can be considered in three broad aspects (Flynn et al. 1990; Hair et al. 1995; Sekaran 2003): content, criterion-related and construct validity.

Content validity examines the measurement items from the comprehensive literature review and the number of redundant questions (Flynn et al. 1990). Pre-testing the instrument with different groups of scholars is highly recommended by Straub, Boudreau & Gefen (2004) to test content validity. Thus, in this study content validity is assessed by a comprehensive review of the literature concerning the scale items that represent the study's constructs.

Criterion-related validity, also known as practical validity, predictive validity or concurrent validity (Sekaran 2003; Straub, Boudreau & Gefen 2004), investigates the relationship between measurement scores as predictors and constructs as the criteria (Straub, Boudreau & Gefen 2004) that they are expected to predict (Sekaran 2003; Straub, Boudreau & Gefen 2004). The multiple correlation coefficients between the measurement score and the criterion are most commonly used to measure criterion-related validity (Flynn et al. 1990). However, criterion-related validity is only necessary when there is at least one reflective indicator as the criterion especially in formative constructs (MacKenzie, Podsakoff & Jarvis 2005) or when using Multiple Indicators and Multi Causes (MIMIC) which is measured through both formative and

reflective indicators in the same order construct (Diamantopoulos & Winklhofer 2001). In this study, criterion-related validity testing is not performed because it is not relevant to the measurement models.

Construct validity "measures whether a scale is an appropriate operational definition of a construct" (Flynn et al. 1990, p266). It tests "how well the results obtained from the use of measure, fit the theories in which the test is designed" (Sekaran 2003, p207). There are two forms of construct validity (Sekaran 2003; Trochim & Donnelly 2006): convergent and discriminant. Both give evidence for construct validity. However, neither one alone is sufficient for establishing it conclusively (Trochim & Donnelly 2006).

Convergent validity is indicated when there is a high correlation between measurement scores attained using two distinct instruments measuring the same concept (Sekaran 2003; Straub, Boudreau & Gefen 2004; Trochim & Donnelly 2006). Discriminant validity is assessed when two constructs measured by different sets of indicators are uncorrelated (Sekaran 2003). This validity can be tested for both formative and reflective measures (MacKenzie, Podsakoff & Jarvis 2005). The measurement items of one construct should differ with the items on the other constructs (Li et al. 2005).

The validity tests in this study are presented separately below, depending on the types of construct.

7.3.1 Validity Test for Reflective Constructs

Construct validity can be measured by factor analysis. First, EFA identifies tentative dimensions by evaluating whether all measurement items within a single summated scale load on the same construct or on more than one construct. Second, CFA is used to assess construct validity in an already-developed measurement scale to determine whether the number of dimensions and the specified indicators load on those dimensions (Flynn et al. 1990). Factor loading and communality of each reflective indicator can assess composite reliability (Coltman et al. 2008) or item validity (Segars & Grover 1993). (The EFA for this study is discussed in Chapter 6).

Convergent validity is also assessed by CFA (Straub, Boudreau & Gefen 2004), where the factor loading of each indicator should be relatively high to demonstrate the evidence for convergent validity (Campell & Fiske 1959). (This test is discussed in Section 7.2.1).

The discriminant validity of a reflective construct is assessed by the correlation coefficient between constructs, which should be no higher than 0.85 (Campell & Fiske 1959; Reis & Judd 2000). In this study, the discriminant validity of the efficiency construct is tested because it is composed of the cost and the ROI and profit sub-constructs, which should be unrelated to each other. Therefore, the correlation coefficient between cost, and ROI and profit factors should be less than 0.85 to ensure the distinctiveness of both factors. The Fornell-Larcker criterion, the root squared of AVE and latent variable correlation (Nunnally & Bernstein 1994; Henseler, Ringle & Sinkovics 2009) are applied to these sub-constructs using SmartPLS software. The root squared of AVE should be greater than the correlation to indicate discriminant validity (Nunnally & Bernstein 1994) as shown in Table 7-12.

Table 7-12: Latent Variable Correlation and Discriminant Validity on the Construct Level

Construct	**Cost**	**ROI and Profit**
Cost	**0.9082**	
ROI and Profit	0.5528	**0.9465**

Note: The root squared of AVE is in the diagonal.

The correlation coefficient between cost, and ROI and profit is 0.5528. As this is less than 0.85, and the root squared of AVE is greater than the latent variable correlation (Table 7-12), the discriminant validity of this construct is validated.

The construct validity of the efficiency construct, which is composed of the cost sub-construct, and the ROI and profit sub-construct (Figure 7-1) is tested by CFA, focusing on model-fit statistics. Kline (2005) recommends at least four indices for assessing model fit from CFA, such as the model chi-square (CMIN), root mean square error (RMSEA), comparative-fit index (CFI), normal-fit index (NFI) and standardised root mean square residual (SRMR), while Joreskog and Sorbom (1981)

recommend first reposting the goodness-of-fit index (GFI). The maximum-likelihood estimates and goodness-of-fit statistics from AMOS outputs are reported and explained below:

- CMIN (minimum discrepancy) is the discrepancy between the unrestricted sample covariance matrix and the restricted covariance matrix; it is most commonly expressed as χ^2. P-value should be greater than 0.05.
- CMIN/DF refers to χ^2 divided by degrees of freedom (Byrne 2001). The ratio of chi-square to the degrees of freedom shows the relative efficiency of competing models. Value between 2 and 5 indicate a reasonable fit (Marsh & Hocevar 1985).
- GFI (goodness-of-fit) is a measure of the relative amount of variance and covariance in the sample data that is jointly explained by $\sum$. It ranges from 0 to 1.00, with value close to 1.00 being indicative of good fit (Byrne 2010, p.77). A GFI score between 0.8 and 0.89 indicates a reasonable fit, and a value higher than 0.9 indicates a good fit (Dull et al. 2003).
- RMR (root mean square residual) measures the mean absolute value of the covariance residual. Perfect model fit is indicated by an RMR value of 0; higher values indicate worse fit (Kline 2005). An RMR value of less than 0.05 is considered as evidence of good fit (Byrne 2001).
- NFI (normal-fit index) compares the χ^2 of some baseline model that usually specifies complete independence among the observed variables, and the χ^2 of the target model of interest. Values close to 1.00 suggest that the target model is an improvement over the baseline model (Kaplan 2009).
- CFI (comparative-fit index) is also a measure based on comparative fit to a baseline model: in this case a null model that assumes the indicator variables in the model are uncorrelated (the "independence model") (Bollen 2002). CFI is similar in meaning to NFI but is less affected by sample size (Fan, Thompson & Wang 1999).

Table 7-13 shows the construct validity of the efficiency construct assessed by CFA.

Table 7-13: Goodness-of-Fit Indices for the Efficiency Constructs

CMIN (DF)	CMIN/DF	GFI	RMR	NFI	CFI
16.6860 (4)	4.1720	0.9610	0.1040	0.9700	0.9770

The χ^2 value of 16.6860, with four degrees of freedom and a p-value of 0.002, indicates that the fit of data to the hypothesised model is not entirely adequate. However, as discussed in Section 7.2.1, χ^2 is not the main value used in validity testing. The ratio of chi-square to the degrees of freedom (CMIN/DF) is 4.1720 indicating a reasonable fit. GFI, NFI and CFI are all well above 0.90, and RMR is about 0.10, which also indicates a reasonable fit.

7.3.2 Validity Test for Formative Constructs

Validity assessment is one of the most controversial issues in formative measurement (Diamantopoulos, Riefler & Roth 2008), since it has limited applicability (Hardin et al. 2008). A number of authors recommend various external validity tests such as estimated error term (Diamantopoulos 2006) and individual indicator validity (Diamantopoulos, Riefler & Roth 2008). External validity examines "how well the index relates to measures of other variables" (Bagozzi 1994, p333). However, the author is unclear on exactly how this should be applied in this study.

Convergent validity can be assessed for formative measurement models only when the indicators theoretically should be related to each other (Trochim & Donnelly 2006). However, in this study convergent validity is not appropriate, because formative indicators are not expected to correlate with each other in the same construct (Diamantopoulos & Winklhofer 2001; Straub, Boudreau & Gefen 2004; Freeze & Raschke 2007).

Criterion-related validity can be applied to formative constructs as composite latent constructs if the constructs have at least one reflective indicator that measures the overall formative construct (Diamantopoulos & Winklhofer 2001; Diamantopoulos, Riefler & Roth 2008). This validity can be estimated by using the standardised indirect effects from the SEM program. This estimation of the impact of the formative

indicators on the composite latent construct is multiplied by the estimation of the impact of the composite latent construct on the reflective indicator. It represents the relationship between the formative indicators and overall measures of the construct as an index of item validity (MacKenzie, Podsakoff & Jarvis 2005). Nevertheless, in this study there is no formative construct that has at least one reflective indicator to measure the overall formative construct. Consequently, criterion-related validity is not applied in this study.

In formative measurement models, indicator validity refers to the importance of each individual indicator of the related formative construct (MacKenzie, Podsakoff & Jarvis 2005; Andreev et al. 2009). It should critically examine whether a particular indicator should enter into the formative index (Henseler, Ringle & Sinkovics 2009) The estimation of this validity is performed by the partial least square (PLS) approach with a bootstrapping method to calculate item weights (either PLS scores or outer weights) and t-values for each first-order formative indicator to determine whether they are significant (Chin 1998; Diamantopoulos & Winklhofer 2001; Bruhn, Georgi & Hadwich 2008). However, Petter, Straub et al. (2007) and Diamantopoulos and Winklhofer (2001) suggest that the item weights of insignificant indicators may be eliminated, or remain to preserve content validity (Bollen & Lennox 1991). Elimination of formative indicators carries the risk of changing the theoretical perspective of the constructs (Nunnally & Bernstein 1994). Therefore, any cut-off values for formative constructs are approached with caution (Diamantopoulos & Winklhofer 2001).

In this section, item weight (outer weight) and t-statistics of each item should be adequate for testing the indicator validity of the formative constructs – supply, demand, process, planning and control, competitor and government policy uncertainty – with SmartPLS software. A PLS algorithm is performed to evaluate item weights, and bootstrapping is undertaken (cases: 162 and sample: 1,000) to evaluate the t-statistics of the item weights (Ringle, Wende & Will 2005). A two-tailed t test is considered with 1.645, 1.96 and 2.576 critical values of t at with a significance level (p-value) 0.1, 0.05 and 0.01 respectively (Wagner 1992). Table 7-14 shows the results of the indicator validity test. T-values of all formative indicators are significant, even

though different p-values. Therefore, indicator validity for the formative constructs is accepted.

Table 7-14: Indicator Validity Test of the Uncertainty Formative Constructs.

Construct Name	Code	Item Weight	t-values	Significance at p-value
Supply	SU1	-0.2014	1.9692	$p<0.05$
	SU2	0.9552	2.4352	$p<0.05$
	SU3	0.2064	1.8489	$p<0.1$
Demand	DU1	0.0830	2.2297	$p<0.05$
	DU2	1.0201	4.3135	$p<0.01$
	DU3	-0.1022	1.7716	$p<0.1$
Process	PU1	-0.3888	1.6788	$p<0.1$
	PU2	1.0559	4.9259	$p<0.01$
	PU3	0.1837	1.9843	$p<0.05$
Planning and control	PCU1	0.8840	3.1909	$p<0.01$
	PCU2	0.0266	1.6745	$p<0.1$
	PCU3	0.2275	2.0363	$p<0.05$
Competitor	CU1	0.6139	3.8855	$p<0.01$
	CU2	0.4766	2.4067	$p<0.05$
	CU3	0.3149	1.8806	$p<0.1$
Government policy	GU1	0.2973	2.1389	$p<0.05$
	GU2	0.2315	1.7427	$p<0.1$
	GU3	0.4714	2.4916	$p<0.05$
	GU4	0.1986	2.7649	$p<0.01$

Note: Table 7-20 contains the variable codes.

7.3.3 Validity Test for Multidimensional Constructs

As discussed in Section 7.3.1 and 7.3.2, validity tests are different for reflective and formative constructs. A multidimensional construct consists of interrelated dimensions that can be incorporated into reflective and/or formative measurement

models. Therefore, validity tests of multidimensional constructs also vary depending on the types of constructs (reflective or formative constructs).

7.3.3.1 Validity Test for Reflective First-Order, Reflective Second-Order

The validity assessments for this study's reflective first-order constructs (strategic purchasing, CRM and LEAN principles) follow the procedure described in Section 7.3.1. The construct validity of CRM, strategic purchasing and LEAN principles constructs assessed by CFA is presented in Table 7-15.

Table 7-15: Goodness-of-Fit Indices of CRM, Strategic Purchasing and LEAN Principle Constructs

Construct Name	CMIN (DF)	CMIN/DF	GFI	RMR	NFI	CFI
CRM	6.4640 (1)	6.4640	0.9810	0.0230	0.9850	0.9880
Strategic purchasing	0.2880 (1)	0.2880	0.9990	0.0110	0.9980	0.9989
LEAN principles	11.9920 (1)	11.9920	0.9650	0.1160	0.9380	0.9410

The model-fit criteria and acceptable-fit levels from CFA are explained in Section 7.3.1. Table 7-17 shows that only the χ^2 value of strategic purchasing (0.288 with one degree of freedom) is not significant at a p-value of 0.5920; this indicate that the theoretically specified model fits the sample data. The χ^2 values for CRM and LEAN principles are not significant, indicating that the fit of data to the hypothesised model is not entirely adequate. However, as discussed in Section 7.2.1, χ^2 value is not the main value used in validity testing. The GFI, NFI and CFI for the three constructs are all well above 0.90, and the RMR is about or below 0.10, which indicates a reasonable model data fit.

The discriminant validity test follows the procedure described in Section 7.3.1. The reflective construct is assessed by the latent variable correlation coefficient between constructs, which should not be above 0.85 (Campell & Fiske 1959; Reis & Judd 2000). The root squared of AVE should be greater than the correlation (Nunnally & Bernstein 1994), as shown in Table 7-16. There is evidence of discriminant validity.

Table 7-16: Latent Variable Correlation and Discriminant Validity on the Construct Level

Construct	**Strategic purchasing**	**LEAN principles**	**CRM**
Strategic purchasing	**0.7623**		
LEAN principles	0.5114	**0.7696**	
CRM	0.6509	0.6297	**0.8717**

Note: The root squared of AVE is in the diagonal

Table 7-16 shows that the correlation coefficients among strategic purchasing, CRM and LEAN principles constructs are less than 0.85, and the root squared of AVE is greater than the latent variable correlation. This demonstrates strong discriminant validity among the three constructs.

The next step is to assess convergent validity. This validity is assessed by the average variance in the first-order constructs that is accounted for by the second-order latent construct (MacKenzie, Podsakoff & Jarvis 2005). This can be calculated by averaging the squared multi correlation (R^2) for the first-order construct. The R^2 for each first-order construct should be greater than 0.5 (Kim 2010). Referring to Chapter 5, CRM, strategic purchasing and LEAN principles constructs have three first-order constructs. Their R^2 is calculated by running SmartPLS software (Table 7-17).

The R^2 of the visibility first-order construct within the LEAN principles second-order construct is lower than 0.5 (R^2 = 0.4932). It is; however, close enough to 0.5 to be considered acceptable for convergent validity. The other R^2 values range from 0.5427 to 0.9200. This result supports convergent validity.

Table 7-17: Convergent Validity for the First-Order Constructs of CRM, Strategic Purchasing and LEAN Principles

Second-Order Construct	First-Order Construct	R^2
CRM	Customer value analysis	0.6243
	Visibility	0.9200
	Strategic focus	0.7159
Strategic purchasing	Strategic Involvement	0.6610
	Visibility	0.7180
	Strategic focus	0.5427
LEAN principles	LEAN tools	0.8117
	Visibility	***0.4932***
	Strategic focus	0.7623

7.3.3.2 Validity Test for Formative First-Order, Formative-Second Order

The validity test for the formative first-order constructs is discussed in Section 7.3.2. The item weight (outer weight) and t-statistics for each item should be significant for testing the indicator reliability of the formative constructs – climate uncertainty and rice quality – with SmartPLS software (PLS algorithm and bootstrapping method) (Diamantopoulos & Winklhofer 2001), as shown in Table 7-18.

As Table 7-17 shows, the results of the t-values of item weights for CMU1, CMU2 CMU3 and CMU4 supports the first-order formative model: the t-values are significant at $p<0.05$ and $p<0.01$ respectively, except for CMU5 ('The warmer temperatures affecting companies vary unpredictably over the years') However, CMU5 is retained for validity testing of the formative second-order construct, as it is the indicator of the temperature sub-construct. The indicator validity test of rice quality supports the first-order formative model because the t-values are in the range of $p<0.01$ to $p<0.1$.

Table 7-18: Indicator Validity Test for Climate Uncertainty and Rice Quality Formative Constructs

Second-Order Construct Name	First-Order Construct Name	Code	Item Weight	T-values	Significance at p-value
Climate uncertainty	Drought	CMU1	-0.0181	2.0841	p<0.05
		CMU2	1.0159	5.4107	p<0.01
	Flooding	CMU3	0.8625	3.5450	p<0.01
		CMU4	0.1494	2.6426	p<0.01
	Temperature	CMU5	0.4076	***1.5221***	***insignificant***
Rice quality	Product quality	RQ1	0.4420	1.8234	p<0.1
		RQ2	0.3843	2.3424	p<0.05
		RQ3	0.4432	2.6351	p<0.01
	Process quality	RQ4	0.9492	6.4736	p<0.01
		RQ5	0.2308	1.8214	p<0.1

The validity test of the formative second-order construct determine whether the inner path coefficients have the right signs and adequate t-statistics (Coltman et al. 2008), as presented in Table 7-19.

As shown in Table 7-19, the t-values for the inner path coefficients of the drought and flooding sub-construct support the second-order formative construct (climate uncertainty) since the t-values are significant at p< 0.01. However, the t-value for the inner path coefficients of temperature sub-construct is insignificant. After consideration together with the previous test on CMU5 (‘temperatures vary unpredictably over the year’), this sub-construct is removed from the climate uncertainty construct. This does not affect content validity of this construct because the crucial climate factor that mainly affects the rice industry is drought and flooding.

For the second-order formative construct of rice quality, the t-values for the inner path coefficients of the product quality and process quality sub-constructs support the second-order formative model at a significance level of p<0.05 and p<0.01 respectively.

Table 7-19: Inner Path Coefficient Validity Test of Climate Uncertainty and Rice Quality Formative Constructs

Construct Name	Code	Inner Path Coefficients	T-values	Significance at p-value
Climate uncertainty	Drought	0.3858	5.3709	p<0.01
	Flooding	0.4116	5.3626	p<0.01
	Temperature	0.0369	0.9106	***insignificant***
Rice quality	Product quality	0.3165	2.0194	p<0.05
	Process quality	0.2247	2.5922	p<0.01

7.4 Chapter Summary

This chapter has presented reliability and validity tests of the measurement model developed in Chapter 5. The reliability and validity tests were applied depending on the types of measurement models in this study: reflective constructs, formative constructs, formative first-order/second-order constructs and reflective first-order/second-order constructs. Table 7-1 summarises the reliability and validity tests of the measurement constructs in this study.

After testing, some indicators were removed to improve the constructs' reliability and validity. Two indicators of CRM were drooped: CR1 ('customer satisfaction is frequently evaluated and measured') and CR2 ('future customer expectations are frequently determined'). LP4 ('inspection of outbound rice has been reduced') as an indicator of LEAN principles was dropped, while LP3 ('production system is based on customer demand (pull production system)'), another indicator of LEAN principles, was dropped in the course of EFA, as described in Chapter 6. Finally, CMU5 ('temperatures vary unpredictably over the year') as an indicator of climate uncertainty was eliminated.

After the indicators were removed, the final measurement instrument for all 12 constructs was found to be valid and reliable as shown in Table 7-20. Therefore, they will be employed in SEM for hypothesis testing in the next chapter.

Table 7-20: Final List of Measurement Items in the Thai Rice Supply Chain

Construct	Aspect of Measurement	Coding	Item
Supply	Quantity	SU1	Rice quantity from rice producers is unpredictable
	Quality	SU2	Rice quality from rice producers is unpredictable
	Time	SU2	Rice producers' delivery time is unpredictable
Demand	Quantity	DU1	The volume of customer demand is difficult to predict
	Quality	DU2	Customers' rice preference changes over the year
	Time	DU3	The lead time[1] of customer order is unpredictable
Process	Quantity	PU1	Yield of rice processing (e.g. milling, packing) can vary
	Quality	PU2	The quality of rice after processing (e.g. milling, storing) can be changed
	Time	PU3	The throughput time of rice processing can vary
Planning and control	Quantity	PCU1	Information about the stock level of rice and rice production capacity is complete at this moment
	Quality	PCU2	Information about the stock level of rice and rice production capacity is accurate
	Time	PCU3	Information about the stock level of rice and rice production capacity is timely
Competitor	Actions	CU1	Competitor's actions are unpredictable
	Domestic market	CU2	Competition is intensified in the domestic market
	International market	CU3	Competition is intensified from different countries
Government policy	Rice production	GU1	Government policies in rice production directly affecting your firms are unpredictable
	Rice trading	GU2	Government policies in rice trading (e.g. FTA, tax) directly affecting your firms are unpredictable
	Paddy rice mortgage scheme	GU3	The guarantee price from government regulation is unpredictable over the year
	New government	GU4	New government regulation is introduced unexpectedly

Table 7-19: (Cont)

Construct	**Aspect of Measurement**	**Coding**	**Item**
Climate	Drought	CMU1 CMU2	Drought occurrences are unpredictable in each year The duration of drought is unpredictable over the year
	Flooding	CMU3 CMU4	Flooding occurrences are unpredictable in each year The duration of flooding is unpredictable over the year
	Temperature	CMU5 (deleted)	Temperatures vary unpredictably over the year
Strategic Purchasing	Strategic involvement (SI)	SP1 SP2	Purchasing is included in the firm's strategic planning process The purchasing function has a good knowledge of the firm's strategic goals
	Visibility (VS)	SP3	Top managers view purchasing strategy as an important strategy
	Strategic focus (SF)	SP4	Purchasing strategy focuses on longer-term issues involving risk and uncertainty
Customer-relationship management	Customer value analysis (CV)	CR1 (deleted)	Customer satisfaction is frequently evaluated and measured
		CR2 (deleted)	Future customer expectations are frequently determined
		CR3	The importance of relationships with customers is frequently evaluated
	Visibility (VS)	CR4 CR5	A sense of fair play is shared with customers Top managers view satisfying customer needs as an important strategy
	Strategic focus (SF)	CR6	Customer focus is reflected in your business planning
LEAN principles	LEAN tools (LT)	LP1	A continuous quality improvement system is implemented
		LP2	Rice suppliers' warehouses/farms are located nearby
		LP3 (deleted)	Production system is based on customer demand (pull production system)
		LP4 (deleted)	Inspection of outbound rice has been reduced
	Visibility (VS)	LP5	Top managers view close relationship with suppliers as an important strategy
	Strategic focus (SF)	LP6	Lean practices are focused on your organisation's long-term plan

Table 7-19: (Cont)

Construct	Aspects of Measurement	Coding	Item
Rice Quality	Product quality	RQ1	Physical properties of rice are the important performance indicators
		RQ2	All inspections present good records.
		RQ3	Rice safety and health are important performance indicators
	Process quality	RQ4	Environmental management system is implemented
		RQ5	The number of sales increases because of marketing activities
Efficiency	Cost	EF1	Rice operation cost is low
		EF2	Transportation cost is low
		EF3	Inventory cost is low
	Return on investment (ROI)	EF4	Return on investment (approximate ratio of net profit to total asset) is high
	Profit	EF5	Profits (total revenue less expenses) are high

CHAPTER 8

CAUSAL MODEL AND EMPIRICAL RESULTS

8.1 Introduction

The previous chapter examined and improved the reliability and validity of the measurement models. The chapter will analyse the structural equation modeling (SEM). Chapter 4 developed a number of hypotheses relating to the uncertainty factors, supply chain management practices and supply chain performance of the Thai rice supply chain (TRSC). To test these hypotheses, the two types of SEM (covariance- and component-based SEM) will be evaluated, and the SEM that provides the most robust statistical results will be selected.

Section 8.2 of this chapter introduces the basic concept of SEM in both covariance-based and component-based SEM (PLS). This section provides the main reasons for selecting PLS in this study. Section 8.3 presents more details on the concept of PLS in terms of model structure, path coefficients and model fit, and validation. Section 8.4-presents the results of the PLS analysis (using SmartPLS software), and discusses the implications of these results for the research hypotheses.

8.2 Structural Equation Modeling (SEM)

The main objective of this section is to introduce the foundation concept of SEM. The first part outlines the basic concept of SEM, and the second describes two types of SEM: covariance-based SEM and component-based SEM (or PLS).

8.2.1 Overview of Structural Equation Modeling

Structural equation modeling (SEM) is defined as a class of multivariate analysis. It seeks to "represent hypotheses about summary statistics derived from an empirical measurement in terms of a smaller number of structural parameters defined by a hypothesised underlying model" (Kaplan 2009, p1). The hypothesised model is tested

statistically in a simultaneous analysis of the entire SEM (Byrne 2010). The general SEM consists of two parts (Joreskog & Sorbom 1981): a measurement model, which links observed variables to a latent variable (construct); and a structural model, which links latent variables to each other.

SEM tools are increasingly being applied to complex causal modeling (Hair et al. 2010), as SEM provides researchers with a comprehensive means for assessing and modifying conceptual frameworks (Anderson & Gerbing 1988). It permits complicated variable relationships to be expressed through recursive and non-recursive structural equations. This presents a more complete picture of the entire model (Hanushek & Jackson 1977; Gefen, Straub & Boudreau 2000).

To understand the differences between covariance- and component- based SEM and, to determine which specific form of SEM should be used in this study, the next section presents some comparisons and contrasts between them.

8.2.2 Types of Structural Equation Modeling

In the growing literature that discusses SEM, there is no complete guide to choosing the most appropriate form. Covariance-based SEM procedures, such as maximum likelihood, are theory-oriented, and emphasise the transition from exploratory to confirmatory analysis. PLS is primarily intended for causal-predictive analysis in situations of high complexity but low theoretical information (Joreskog & Wold 1982). Table 8-1 summarises the strengths of both techniques; it shows that the techniques are dissimilar in their analysis, statistical assumptions and fit statistics.

Figure 8-1 shows that covariance-based SEM and PLS are partially different in terms of theory testing and prediction. Covariance-based SEM is the most appropriate statistical technique when “prior theory is strong, and further testing and development is the goal in the causal modeling situation” (Henseler, Ringle & Sinkovics 2009, p296). PLS is appropriate for prediction and/or theory building (Henseler, Ringle & Sinkovics 2009). Although the component-based SEM (PLS) can be applied for theory testing, PLS parameter estimates are less than optimal regarding bias and

consistency of global goodness-of-fit. This definitely limits the use of component-based SEM (PLS) for theory testing (Chin 1997).

Table 8-1: Comparative Analysis and Capability between Covariance-Based SEM and Component-Based SEM (PLS) (Gefen, Straub & Boudreau 2000, pp9-10).

Issues	Covariance-Based SEM	Component-Based SEM
Objective of overall analysis	The null hypothesis of the entire proposed model is plausible, while rejecting path-specific null hypotheses of no effect.	Reject a set of path-specific null hypotheses of no effect.
Objective of variance analysis	Overall model fit	Variance explanation (R^2)
Required theory base	Requires sound theory base. Supports confirmatory research.	Does not necessarily require a sound theory base. Supports both exploratory and confirmatory research.
Assumed distribution	Multivariate normal if estimation is through maximum likelihood. Deviations from multivariate normal are supported with other estimation techniques.	Relatively robust to deviation from a multivariate distribution.
Required minimal sample size	At least 100-150 cases	At least 10 times the number of items in the most complex construct.
Maps paths to many dependent (latent or observed) variables in the same research model and analyses all paths simultaneously rather than one at a time	Supported	Supported
Maps specific and error variance of the observed variables into the research model	Supported	Not Supported
Maps reflective observed variables	Supported	Supported
Maps formative observed variables	Not Supported	Supported
Analyses all paths (measurement and structural) in one analysis	Supported	Supported
Can perform a CFA	Supported	Supported
Permits rigorous analysis of all the variance components of each observed variables (common, specific, and error) as an integral part of assessing the structural model	Supported	Not Supported
Allows non-common variance of an observed variable to be set a given value in the research model	Supported	Not Supported
Provides statistics to compare alternative CFA models	Supported	Not Supported
Can cope with a relatively small sample size	Problematic	Supported
Readily examines interaction effects with numerous variable level	Problematic	Supported

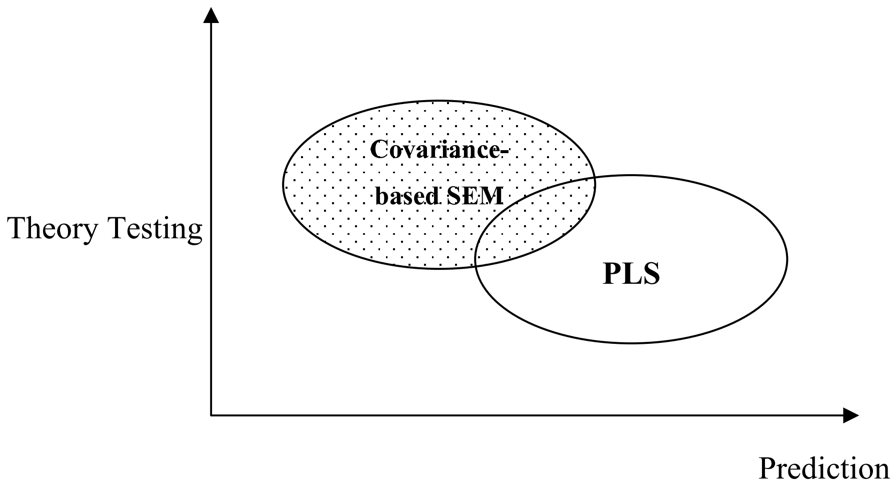


Figure 8-1: Purpose of Covariance-Based SEM (AMOS) and Component-Based SEM (PLS) (Henseler, Ringle & Sinkovics 2009, p297)

In this study, PLS is employed for the following reasons:

1) PLS can avoid the problem of small sample size (Henseler, Ringle & Sinkovics 2009). In addition, PLS is useful when theory and/or data are weak, and sample size is low (Chin 1998; Gefen, Straub & Boudreau 2000). Meanwhile, covariance-based SEM commonly uses maximum likelihood and the chi-square test for estimation approach; these are sensitive to a sample size less than 100 (Hair et al. 1998) or 150 (Bollen 2002). Since in this study the sample size is 162, covariance-based SEM can lead to a poor fit because the critical sample size of covariance-based SEM with maximum likelihood estimation is 200 (Hair et al. 1995). In contrast, PLS is more robust with a small sample size. PLS requires a sample size at least 10 times the number of items in the most complex construct. The most complex construct in this study is the rice-quality second-order construct, which is comprised of seven measurement items. To perform PLS, the critical sample size is at least 70 samples. Therefore, adequate sample size is not a concern in this study.

2) PLS can handle both reflective and formative measurement models (Henseler, Ringle & Sinkovics 2009). As discussed in Chapter 5, this study uses mixed construct types: reflective, formative and multidimensional constructs. PLS supports all types of constructs, while covariance-based SEM supports only

reflective constructs. Although formative constructs can be indirectly analysed by covariance-based SEM, determining which model to use requires a more complex procedure: comparing chi-square for each model (Jarvis, MacKenzie & Podsakoff 2003; Petter, Straub & Rai 2007). PLS, therefore, is the better choice because it supports all types of constructs (Gefen, Straub & Boudreau 2000).

3) PLS is less rigorous about the distribution of variables and error terms (Henseler, Ringle & Sinkovics 2009). Multivariable normal distribution is the crucial assumption required for covariance-based SEM, whilst PLS merely requires an assumption of free multivariable normal distribution (Chin 1998). This study uses Likert-scale data, which, by definition, is not normally distributed (Kaplan 2009). Additionally, a Likert-scale questionnaire is particularly problematic for covariance-based SEM analyses, as the majority of respondents select the same scale point, leading to a score distribution that would be extremely peaked (Byrne 2010). In terms of non-normal distributed data, parameter estimation of PLS is better than parameter estimation of covariance-based SEM, as a goodness-of-fit and parameter estimate in covariance-based SEM can be biased with a non-normal distribution like Likert-scale data (Henseler, Ringle & Sinkovics 2009). Thus, PLS is the better choice for this study.

However, PLS has some weaknesses. PLS estimators tends to be sub-optimal in terms of statistical criteria such as bias and consistency (Fornell & Bookstein 1981), and can be subject to multicollinearity problems (Henseler, Ringle & Sinkovics 2009). Moreover, PLS does not support some analysis capabilities such as rigorous analysis of all the variance components of each observed variables (common, specific and error) as an integral part of assessing the structural model, and overall goodness-of-fit measures (Hulland 1995).

As discussed above, PLS represents a reasonable alternative to covariance-based SEM for theory testing when sample sizes are small, or when assumption about multivariate normal distributions and interval scales data cannot be made (Fornell & Bookstein 1981). However, they differ from a statistical point of view (Henseler, Ringle &

Sinkovics 2009). Gefen, Straub and Boudreau (2000) suggest that the selection of an analysis method, based on the research objective and the limitations imposed by the sample size and distribution assumption, is crucial in the positivist research method.

Therefore, PLS is applied in this study. PLS can be practically applied to three sets of tasks (Hulland 1995): assessing the quality of the measurement model (in other words, the reliability and validity of measures); determining the quality of the structural model (determining the nature of the relationship between measures and constructs); and interpreting each structural regression or path coefficient. PLS is assessed in the next section.

8.3 Component-Based Structural Equation Model (Partial Least Square)

PLS path modeling was developed by Joreskog and Wold (1982). PLS is a family-regression-based method designed for the analysis of high- dimensional data in a low-structure environment (Dijkstra 2010). PLS involves two approaches: (i) a measurement model relating the manifest variables or indicators, also called the outer model, as presented in Chapter 7; and (ii) a structural model relating some endogenous latent variables to other latent variables, known as the inner model, as described in this section (Tenenhausa et al. 2005). Model identification is not required for PLS, unlike covariance-based SEM, because it employs both iterative least squares and ordinary least squares (Hulland 1995).

8.3.1 Model Structure

PLS consists of two sets of equations. The first set represents the measurement equations, which relates the observable measures (manifest variables) to their underlying constructs. The second set is the structural equations, which describe relationships between the constructs (latent variables) (Hulland 1995).

The reflective measurement equations reproduce the factor analysis model, in which each manifest variable is related to a corresponding latent variable by a simple regression model (Vinzi, Trinchera & Amato 2010):

$$x_{pq} = \lambda_{p0} + \lambda_{pq}\xi_q + \varepsilon_{pq}$$ Equation 8-1

where:

x_{pq} is the pth manifest variable in the qth latent variable,

λ_{pq} is the loading (regression coefficient) associated to the pth manifest variable in the qth latent variable,

ξ_q is the generic qth latent variables,

ε_{pq} is the imprecision in the measurement error on x_{pq},

p = 1, 2, 3, …, pq, that is, the number of manifest variable of the qth latent variable, and

q = 1, 2, 3, …, Q, that is, the number of latent variables.

$E(\varepsilon_{pq})=0$, for all p and q

$Cov(\varepsilon_{ij}, \varepsilon_{pq}) = 0$, for i ≠ p and j ≠ q

The formative measurement equations express that the latent variable (ξ) is a linear function of its manifest variables plus residual term (Tenenhausa et al. 2005):

$$\xi_q = \sum_{p=1}^{Pq} \omega_{pq} x_{pq} + \delta_q$$ Equation 8-2

where:

ω_{pq} is the coefficient linking the pth manifest variable in the qth latent variable, and

δ_q is the error term representing the fraction of the corresponding generic qth latent variable.

The structural model can be written in linear equations relating the latent variables:

$$\xi_j = \beta_{0j} + \sum_{q:\xi q \to \xi j} \beta_{qj}\xi_q + \varsigma_j$$ Equation 8-3

where:

ξ_j (j = 1, …, J) is the endogenous (dependent) latent variable,

ξ_q is the qth exogenous (independent) latent variables,

β_{qj} is the generic path coefficient interrelating the qth exogenous (independent) latent variable to the jth endogenous latent variable, and

ς_j is the error in the inner relation (i.e. disturbance term in the prediction of the jth endogenous latent variable from its explanatory latent variables).

The predictor specification hypothesis is applied to Equation 8-3.

8.3.2 Path Coefficients and Model Fit

- Path coefficients (β_{qj})

Path coefficients, partial regression coefficients calculated by PLS, are standardised beta (β_{qj}) coefficients that measure the strength associated with each path by which one variable influences another (McDonald 1985). The t-value of each path should be determined to assess the statistical significance of the estimated path coefficients. The threshold value should be above 1.96 (Fornell 1982; Chin 1998).

- Model fit: R^2

Model fit for component-based SEM with PLS differs from covariance-based SEM. PLS has as its primary objective the minimisation of error, or equivalently the maximisation of variance explained in all endogenous constructs (Fornell & Bookstein 1981). Unlike covariance-based SEM, PLS has no proper overall goodness-of-fit measure (Tenenhausa et al. 2005).

Accordingly, examining the R^2 value for endogenous constructs is the main objective of PLS. The R^2 value indicates whether a particular PLS model accomplishes the objective of maximising the variance explained (Hulland 1995). In other words, the power of exogenous constructs in forecasting the endogenous constructs is demonstrated through R^2, which indicates a model's effectiveness

(Fornell & Bookstein 1981). The individual R^2 value must be above the minimal threshold of 0.10 (Chin 1998). Table 8-2 presents an overview of typical PLS criteria.

Table 8-2: Assessing PLS Structural Models

Criterion	Description
R^2 of endogenous latent variables	R^2 values of 0.67, 0.33, or 0.19 for endogenous latent variables in the inner path model are described as substantial, moderate or weak (Chin 1998).
Estimate for path coefficients, β_{qj}	The estimated values for path relationship in the structural model should be evaluated in terms of sign, magnitude and significance via bootstrapping (Henseler, Ringle & Sinkovics 2009).

8.3.3 Model Estimation

The basic approach in PLS is to construct proxies in the form of linear compounds for the latent variables, using a sequence of alternating least squares algorithms, each time solving a local, linear problem, to extract the predictive information in the sample (Dijkstra 2010). The PLS algorithm is essentially a sequence of regressions in term of weight vectors (Henseler, Ringle & Sinkovics 2009) that includes three stages (Lohmoller 1989):

Stage 1: Iterative estimation of latent variable scores, consisting of a four-step iterative procedure that is repeated until convergence is obtained:

1) Outer approximation of the latent variable scores,
2) Estimation of the inner weights,
3) Inner approximation of the latent variable scores, and
4) Estimation of outer weight.

In Chapter 7 of this study, Stage 1 is estimated in terms of reliability and validity tests employing the bootstrap procedure; that is, a nonparametric statistical technique. It is used in PLS path modeling to calculate confidence intervals for all parameters (Henseler, Ringle & Sinkovics 2009).

Stage 2: Estimation of the outer weights/loading and path coefficients

Stage 3: Estimation of the location parameters.

To clarify the PLS path modeling algorithm, it is very helpful to review the study of Tenenhausa, Vinzia et al. (2005), who clearly explain Wold's PLS algorithm and Lohmoller's PLS algorithm. In this study, SmartPLS software has particular strengths, such as user-friendliness and helpful export options. Thus, it is employed in this study. SmartPLS software (Ringle, Wende & Will 2005) uses Wold's PLS algorithm in its PLS algorithm procedure option.

8.3.4 Model Validation

Although the reliability and validity tests are explained in Chapter 7, model validation in terms of communality, redundancy and goodness-of-fit should be measured to ensure the quality of the measurement models before assessing the structural model (inner model).

- Communality

  The communality index measures the quality of the measurement model for each block of latent variables. However, the algorithm does not try to optimise any global variables, but is a set of ordinary least squares regressions that maximise the variance explained by the individual regressions. The communality index measures the goodness-of-fit for each block of latent variables and their indicators (Parkkila 2010).

  $$Communality_j = \frac{1}{p}\sum_{h=1}^{p_j} cor^2(x_{jh}, y_j) \qquad \text{Equation 8-4}$$

  (where p is the total number of measurement models.)

  A cut-off value of 0.5 for communality in the PLS approach is suggested by Fornell and Bookstein (1981). The communality index is considered in

reflective measurement models only, not in formative measurement models. The average communality is calculated for goodness-of-fit.

- Redundancy

  The redundancy index measures the quality of the structural model for each endogenous latent variable (Tenenhausa et al. 2005). It is the capacity of the model to predict its manifest variables from the indirectly connected latent variable (Tenenhausa et al. 2005; Turkyilmaz et al. 2010). However, there is no criterion for redundancy interpretation. For a complex model, redundancy results above 0.0 can be considered satisfactory (Stone 1974).

$$redundancy_j = communality_j \times R^2(y_j, \{y_{j'}'s\ Explaining\ y_j\})$$

Equation 8-5

- Goodness-of-Fit (GoF)

  The total criterion for goodness-of-fit (GoF) is the geometric of the average communality and the average of R^2 value (Tenenhausa et al. 2005). The GoF index is conceptually appropriate for reflective measurement models, but can also be applied to formative measurement models because it is partly based on the average communality. Therefore, communalities can be computed and interpreted in both formative and reflective measurement models.

$$GoF = \sqrt{\overline{Communality} \times \overline{R^2}}$$

Equation 8-6

  GoF criteria for small, medium and large effect sizes are 0.1, 0.25 and 0.36 respectively (Wetzels, Odekerken-Schroder & van Oppen 2009). A GoF around 0.5 is considered to be a ‘moderate’ fit (Ringle, Wende & Will 2009).

- Resampling methods in SmartPLS

  Since PLS path modeling does not rest on any distributional assumption such as normal distribution, information about the variability of the parameter

estimates and their significance must be generated by mean of resampling procedures (Temme, Kreis & Hildebrandt 2010).

The SmartPLS software allows the user to choose between two resampling methods: blindfolding and bootstrapping. Blindfolding omits part of the data matrix for the construct being examined, then estimates the model parameters; this is done a number of times based on the blindfold omission distance (Fornell 1982). In bootstrapping, samples are built by resampling with replacements from the original sample, producing samples with the same number of units (Tenenhausa et al. 2005). Bootstrapping is considered to be superior to other methods (Temme, Kreis & Hildebrandt 2006). Ringle, Wende and Will (2005) suggest that the number of resamples must be specified at 1,000 or higher to allow for a more reasonable standard error estimates.

In this study SmartPLS software is used to run PLS algorithm to determine communality, redundancy, R^2 and path coefficient, and to run the bootstrapping method to evaluate the t-values for the path coefficient. The next section present the hypothesised path statistical significances evaluated among their t-values (above 1.96).

8.4 Component Based SEM for the Proposed Structural Model

The previous section introduced the basic concept of component-based SEM also known as PLS path modeling. This section evaluates the PLS path modeling relating to relationship among uncertainty factors, supply chain practices, and supply chain performance. As described in Chapter 5, 162 useable questionnaires (pooled from those received form Thai rice millers and rice exporters, as analysed in Chapter 6) are used as data for analysis in SmartPLS software. This section is concerned with the path model and the equations of the proposed structural model in this study. The next section evaluates the model validation. The final section identifies a number of hypotheses relating to the PLS path modeling in this thesis and presents the results of hypothesis testing.

8.4.1 The Proposed Structural Model

Based on the literature review in Chapter 3 and the conceptual framework development in Chapter 4, this section proposes and tests a number of structural equation models. Figure 8-2 presents the manifest variables and latent variables investigated in this study. In the model, these seven latent variables – supply uncertainty, demand uncertainty, process uncertainty, planning and control uncertainty, competitor uncertainty, government policy uncertainty, and climate uncertainty – are the primary exogenous (independent) variables. Strategic purchasing, LEAN principles, CRM, efficiency and rice quality are the endogenous (dependent) variables. In addition, strategic purchasing, LEAN principles and CRM are the exogenous variables with efficiency and rice quality as the endogenous variables.

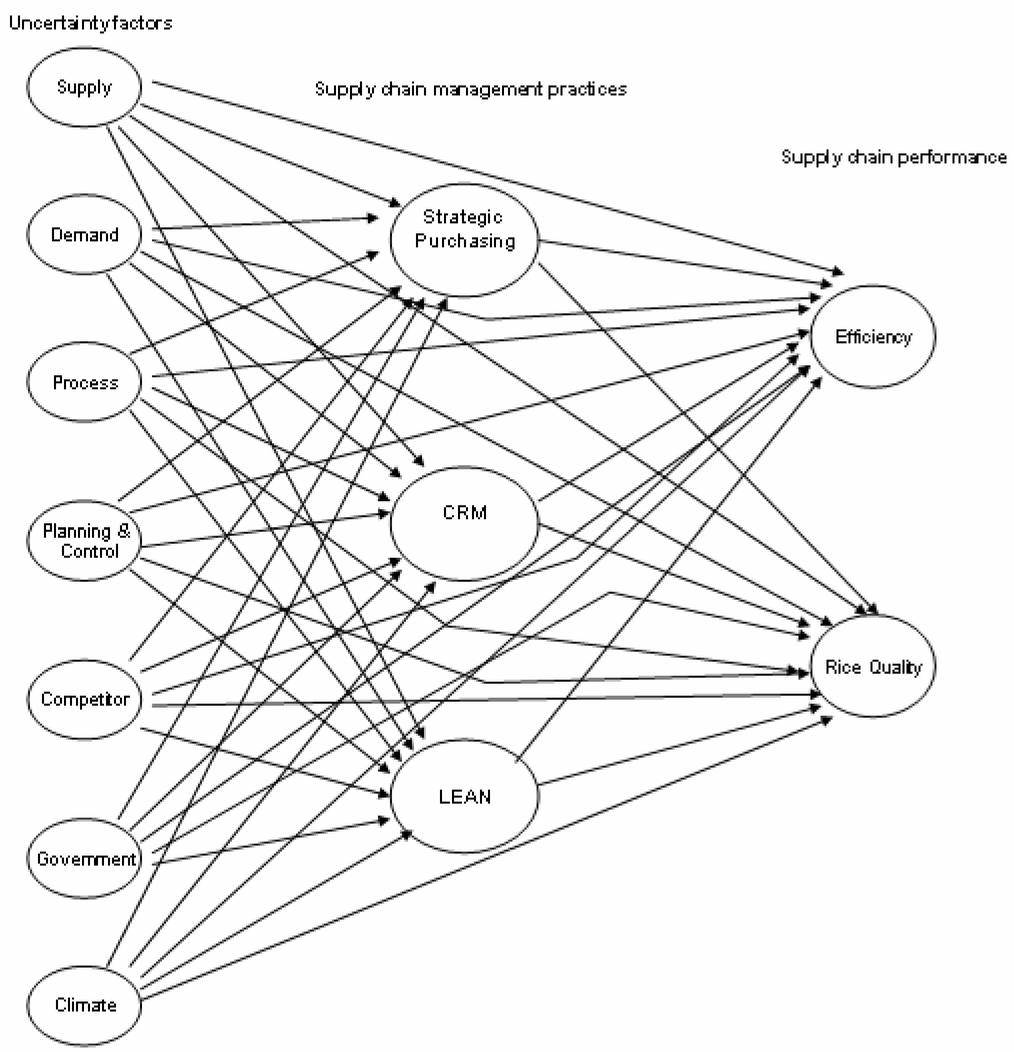


Figure 8-2: Initial PLS Path Modeling

8.4.2 Model Validation

Model validation in this study is assessed by communality, redundancy and GoF, as presented in Tables 8-3 and 8-4.

Table 8-3: Communality Index Measure of All Constructs

Construct Names	Type of Construct	Communality
Supply uncertainty	Formative	0.2404
Demand uncertainty	Formative	0.2396
Process uncertainty	Formative	0.4214
Planning and control uncertainty	Formative	0.4733
Competitor uncertainty	Formative	0.4926
Government uncertainty	Formative	0.6635
Climate uncertainty	Formative	0.3376
Strategic purchasing	**Reflective**	**0.5808**
LEAN principles	**Reflective**	**0.5923**
Customer-relationship management	**Reflective**	**0.7589**
Rice quality	Formative	0.5663
Efficiency	**Reflective**	**0.6656**
Cost	**Reflective**	**0.8285**
ROI and profit	**Reflective**	**0.8960**

The communality index is examined only for reflective constructs. The communality index of the reflective constructs in this study exceeds the cut-off value of 0.5, indicating the quality of the measurement models.

The average communality is 0.5541, which will be used to calculate the GoF.

Table 8-4: Redundancy of Endogenous Constructs

Endogenous Construct Names	Redundancy
LEAN principles	0.0666
Customer-relationship management	0.0369
Strategic purchasing	0.0332
Rice quality	0.0490
Efficiency	0.0906
Cost	0.6912
ROI and profit	0.6255

The redundancy of each endogenous construct is above 0.0 which is considered satisfactory.

The $\overline{R}^2$ (average R^2) is 0.4586 (see in Table 8-5).

According to Equation 8-6, $GoF = \sqrt{0.5541 \times 0.4586} = 0.5041$.

For the current model, the GoF is 0.5041, indicating a moderate fit of the model to the data. It clearly exceeds some researchers' proposed cut-off value of 0.36 (Wetzels, Odekerken-Schroder & van Oppen 2009) and its value matches the value of 0.5 proposed by others (Ringle, Wende & Will 2009).

8.4.3 Assessment of the Proposed Structural Model: R^2

The evaluation of the structural model (inner model) is connected to the path of measurement indicators, which presents R^2 from the bootstrapping approach. The R^2 is evaluated for endogenous latent variables that confirm the existence of any substantive effect through an exogenous hidden variable on a endogenous hidden variable (Fornell & Bookstein 1981). Table 8-5 shows the $R^2$of the endogenous variables in this study as measurement of GoF.

Table 8-5: Variance Explained by R^2

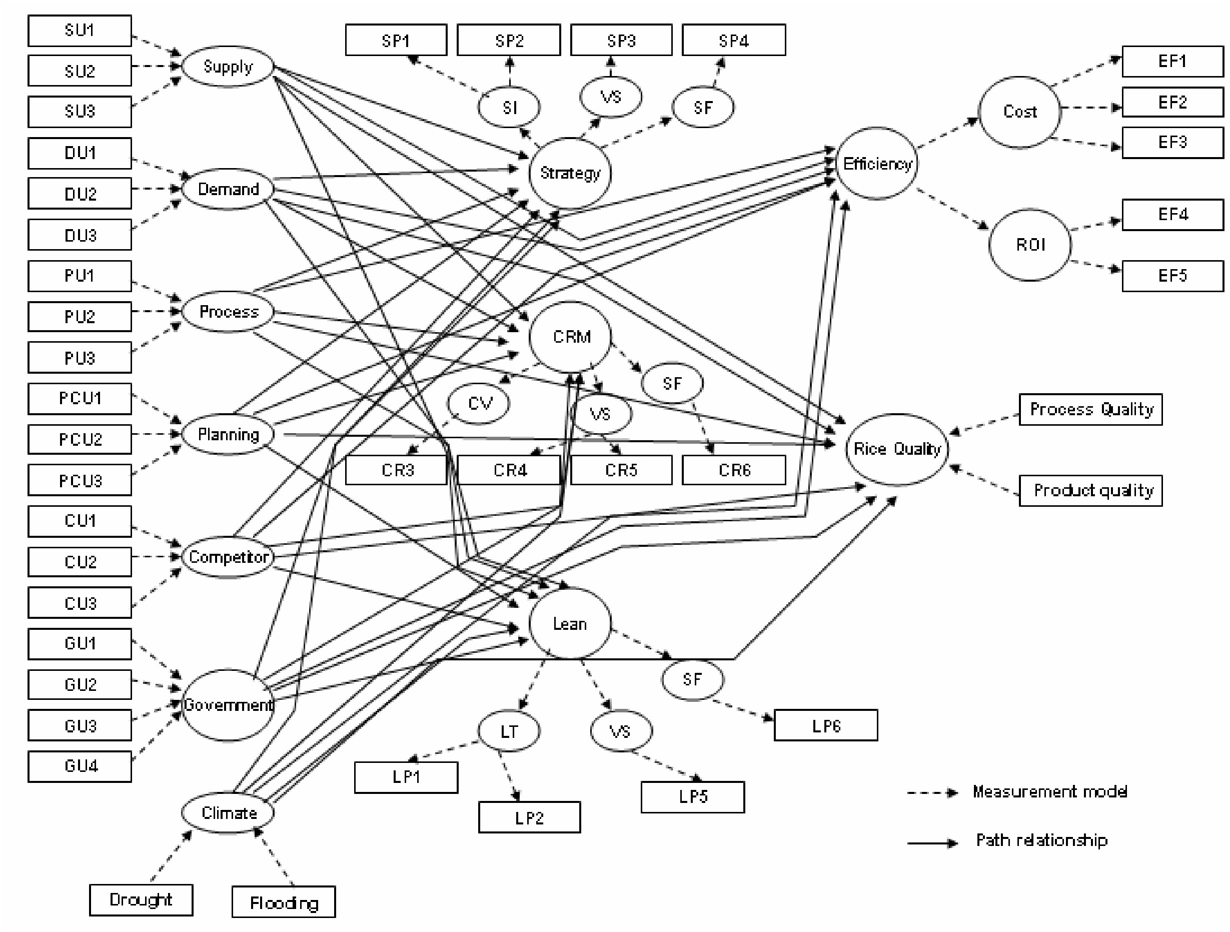
Endogenous Construct Names	R^2	Implementation
LEAN principles	0.1976	Weak
Customer-relationship Management	0.1980	Weak
Strategic purchasing	0.4641	Moderate
Rice quality	0.5040	Moderate
Efficiency	0.3110	Moderate
Cost	0.8369	Substantial
ROI and profit	0.6985	Substantial

The average of R^2 is 0.4586.

Table 8-5 shows that all endogenous constructs in this study are above 0.10. According to criteria in Table 8-2, the R^2 of the LEAN principles and customer-relationship management latent variables are considered to be weak, whilst the R^2 values for cost and for ROI and profit are considered substantial. The R^2 of the strategic purchasing, rice quality and efficiency latent variables is moderate. In summary, this model demonstrates a good fit. The quality of all constructs is satisfied and ready for hypothesis testing in the next section.

8.4.4 Hypotheses Testing

The three main hypotheses proposed in Chapter 4 are presented through the 35 causal relationships in the model (Figure 8-3). The PLS algorithm and bootstrapping methods provided in SmartPLS software are applied to experiment with the hypotheses. The results show the path coefficients of exogenous constructs on the endogenous constructs and their t-values. The next section presents the structural model findings, including the path coefficient, hypothesis sign, t-value and implementation of all hypotheses.



Note: Table 7-19 contains the variable codes.

Figure 8-3: The Proposed Model - PLS Path Modeling

8.4.4.1 Hypothesis 1: The Higher the Level of Uncertainty Factors, the Lower the Level of Rice Supply Chain Performance in Thailand

Hypothesis 1 (Hypotheses 1.1 to 1.14 in Chapter 4) tests the relationship between the seven uncertainty factors and the two supply chain performance measures. Table 8-6 shows that three sub-hypotheses are significantly supported, whilst the others are not. The causal relationships of process uncertainty and efficiency (β = -0.2941, t = 2.4920), and competitor uncertainty and efficiency (β = -0.3993, t = 3.9754) are found to be significantly negative. In addition, the relationship between demand uncertainty and supply chain performance in term of rice quality (β = -0.3364, t = 1.8247) is revealed to be a significantly negative relationship.

Table 8-6: Result for Proposed SEM: Hypothesis 1

Hypothesis	Relationship	Path Coefficient	Sign	t-value	Results
H1.1	SU → RQ	0.0971	+	0.6516	
H1.2	SU → EFF	0.0579	-	0.4373	
H1.3	DU → RQ	0.3364	-	1.8247*	Supported
H1.4	DU → EFF	0.1054	+	0.9329	
H1.5	PU → RQ	0.0740	-	0.3457	
H1.6	PU → EFF	0.2941	-	2.4920**	Supported
H1.7	PCU → RQ	0.1276	-	1.0538	
H1.8	PCU → EFF	0.0893	-	1.0096	
H1.9	CU → RQ	0.0826	-	0.9854	
H1.10	CU → EFF	0.3993	-	3.9754***	Supported
H1.11	GU → RQ	0.0334	+	0.1866	
H1.12	GU → EFF	0.1400	+	0.7334	
H1.13	CMU → RQ	0.1510	+	1.0137	
H1.14	CMU → EFF	0.0682	+	0.5950	

Note: * significant at $p < 0.1$, ** significant at $p < 0.05$, *** significant at $p < 0.01$ (two-tailed test). Table 7-19 contains the variable codes.

8.4.4.2 Hypothesis 2: The Higher the Level of Uncertainty Factors, the Higher the Level of Supply Chain Practices

Hypothesis 2 (Hypotheses 2.1 to 2.21) tests the relationship between the seven uncertainty factors and the three supply chain practices. Table 8-7 shows that seven sub-hypotheses are significantly supported, whilst the others are not. The causal relationships of demand uncertainty and strategic purchasing ($\beta = 0.1896$, $t = 1.7242$), process uncertainty and LEAN principles ($\beta = 0.2403$, $t = 2.0450$), planning and control uncertainty and strategic purchasing ($\beta = 0.2445$, $t = 2.4389$), competitor uncertainty and strategic purchasing ($\beta = 0.3310$, $t = 3.7756$), competitor uncertainty and customer-relationship management ($\beta = 0.2880$, $t = 2.3016$), climate uncertainty and strategic purchasing ($\beta = 0.1681$, $t = 1.6643$) and climate uncertainty and LEAN principles ($\beta = 0.3452$, $t = 3.2935$) are found to be significantly positive.

Table 8-7: Result for Proposed SEM: Hypothesis 2

Hypothesis	Relationship	Path Coefficient	Sign	t-value	Results
H2.1	SU → SP	-0.1320	-	1.0368	
H2.2	SU → CR	-0.0436	-	0.5028	
H2.3	SU → LP	-0.0151	-	0.1530	
H2.4	DU → SP	0.1896	+	1.7242*	Supported
H2.5	DU → CR	0.0886	+	0.9376	
H2.6	DU → LP	0.0726	+	0.7426	
H2.7	PU → SP	0.1626	+	1.3388	
H2.8	PU → CR	0.0949	+	0.8288	
H2.9	PU → LP	0.2403	+	2.0450**	Supported
H2.10	PCU → SP	0.2445	+	2.4389**	Supported
H2.11	PCU → CR	0.1316	+	1.0867	
H2.12	PCU → LP	-0.0346	-	0.2819	
H2.13	CU → SP	0.3310	+	3.7756***	Supported
H2.14	CU → CR	0.2880	+	2.3016**	Supported
H2.15	CU → LP	0.1698	+	1.3021	
H2.16	GU → SP	0.2102	+	1.6056	
H2.17	GU → CR	0.0427	+	0.3805	
H2.18	GU → LP	-0.0696	-	0.4786	
H2.19	CMU → SP	0.1681	+	1.6643*	Supported
H2.20	CMU → CR	0.1816	+	1.5928	
H2.21	CMU → LP	0.3452	+	3.2935***	Supported

Note: * significant at $p < 0.1$, ** significant at $p < 0.05$, *** significant at $p < 0.01$ (two-tailed test). Table 7-19 contains the variable codes.

8.4.4.3 Hypothesis 3: The Higher the Level of Rice Supply Chain Practices, the Higher the Level of Rice Supply Chain Performance

Hypothesis 3 (Hypotheses 3.1 to 3.6) tests the relationship between three supply chain practices and two supply chain performance measures. Table 8-8 shows that four sub-hypotheses are significantly supported, whilst the others are not. The causal relationships of strategic purchasing and rice quality (β = 0.3341, t = 2.1939), strategic purchasing and efficiency (β = 0.3311, t = 2.8584), customer-relationship management and efficiency (β = 0.3821, t = 3.7194) and LEAN principles and rice quality (β = 0.2673, t = 2.2457) were found to be significantly positive.

Table 8-8: Result for Proposed SEM: Hypothesis 3

Hypothesis	Relationship	Path Coefficient	Sign	t-value	Results
H3.1	SP → RQ	0.3341	+	2.1939**	Supported
H3.2	SP → EF	0.3311	+	2.8584***	Supported
H3.3	CR → RQ	0.0984	+	0.7175	
H3.4	CR → EF	0.3821	+	3.7194***	Supported
H3.5	LP → RQ	0.2673	+	2.2457**	Supported
H3.6	LP → EF	-0.1481	-	1.3861	

Note: * significant at $p < 0.1$, ** significant at $p < 0.05$, *** significant at $p < 0.01$ (two-tailed test). Table 7-19 contains the variable codes.

8.5 Chapter Summary

PLS path modeling is a statistical methodology primarily intended for causal-predictive analysis. PLS is suitable where there is a highly complex framework but low theoretical information. In addition, PLS is useful when theory and/or data are weak, and the sample size is small. PLS has been used to identify the positive and negative significance effect among uncertainty factors, supply chain management practices and supply chain performance in the TRSC. The hypothesised model was tested statistically in a simultaneous analysis using SmartPLS software.

The structural model analysis shows a number of interesting results. First, the model validation indicates a moderate fit of the model to the data before the hypotheses were tested. Second, supply uncertainty and government policy uncertainty are revealed to have no relationship with supply chain practices and supply chain performance. Third, supply chain performance in the case of efficiency is influenced negatively by demand, competitors and process of uncertainty, but influenced positively by customer-relationship management and strategic purchasing. Fourth, supply chain performance in terms of rice quality is increased by strategic purchasing and LEAN principles, but it is reduced by demand uncertainty. Fifth, demand, planning and control, competitor and climate uncertainty have a positive impact on strategic purchasing. Finally, LEAN principles are positively influenced by process and climate uncertainty, whereas customer-relationship management is also positively influenced by competitor uncertainty.

From Chapters 4 to 8 of this study, a number of hypotheses related to uncertainty factors, supply chain practices and supply chain performance in the Thai rice supply chain have been developed and investigated. The next chapter will evaluate the results to answer the research questions of this study.

CHAPTER 9

EVALUATION AND APPLICATION OF THE RESULTS

9.1 Introduction

Chapter 8 discussed the testing of this study's hypotheses using the partial least square (PLS) method. This chapter evaluates the results of hypothesis testing to answer the three research questions posed in Chapter 1 and Chapter 4. This study's main objectives have been to examine the impact of uncertainty factors on supply chain management practices and supply chain performance, and the impact of supply chain practices on supply chain performance, specifically from the perspectives of Thai rice millers and rice exporters.

This chapter contains three sections, which evaluate and apply the empirical results that link to the hypotheses relating to each research question.

9.2 Research Question 1: Effects of Uncertainty Factors on Supply Chain Performance

Research question 1 of this study is *'In the rice supply chain in Thailand, what is the key uncertainty factor having the greatest impact on the supply chain performance?'*. This relates to Hypotheses 1.1 to 1.14: the higher the level of uncertainty factors, the lower the level of rice supply chain performance in Thailand.

This study considers a total of seven distinct sources of uncertainty: supply, demand, process, planning and control, and competitor uncertainty. Uncertainty in these areas is exacerbated throughout the food supply chains and generic supply chains by two additional uncertainty factors in the TRSC: government policy and climate uncertainty. Quality and efficiency are the two most important performance indicators for rice supply chain performance in Thailand.

As discussed in Chapter 4, Hypotheses 1.3 (demand uncertainty and rice quality), 1.6 (process uncertainty and efficiency), and 1.10 (competitor uncertainty and efficiency) were supported by the results of this study.

Competitor unpredictability is the uncertainty factor with the greatest negative impact on efficiency in the TRSC ($\beta = -0.3993$). Process uncertainty is a key factor negatively affecting efficiency in the TRSC ($\beta = -0.2941$). This result confirms the critical role of process and competitor behaviors on efficiency in the TRSC. These hypotheses have been proposed in previous literature such as Davis (1993), van der Vorst and Beulens (2002) and Childerhouse and Towill (2004) for process uncertainty factors, and Min and Mentzer (2000) for competitor uncertainty factors. However, they have not previously been empirically tested in agricultural supply chains.

9.2.1 Competitor Uncertainty and Efficiency

As already pointed out in the literature review in Chapter 2, intensive competition in either the domestic or international market will force competitors to undertake unpredictable activities (Mentzer, Min & Zacharia 2000). In addition, competitor uncertainty is expressed in unpredictable behaviour such as reducing the price of products, decreasing the amount of time to the market, and increasing product quality and variety (Li 2002). This uncertainty can both directly and indirectly affect the business performance of firms along the entire supply chain (Min & Mentzer 2000). For example, when competitors such as Vietnam introduce high-quality rice into the international market at a lower price than Thai rice, the Thai rice industry can lose market share, harming the efficiency of this supply chain.

9.2.2 Process Uncertainty and Efficiency

The relationship between process uncertainty and efficiency is found to be significantly negative. This demonstrates that process uncertainty directly harms the efficiency of the TRSC. This confirms the study of Childerhouse and Towill (2004), van der Vorst (2000), and Davis (1993), all of whom found that process uncertainty can lead to uncertain order-cycle times or yield of processing. These, in turn, can directly increase costs relating to high levels of safety stock for raw materials, work in process and

finished goods, which firms will tend to keep as protection against unpredictable output. This also leads to a decrease in profits for the supply chain members, thus harming their efficiency.

9.2.3 Demand Uncertainty and Rice Quality

In addition, the relationship between demand uncertainty and supply chain performance in terms of rice quality (β = -0.3364) is revealed to be significant. The relationship between demand uncertainty and supply chain performance in the food supply chains is supported in van der Vorst and Beulens's case study (2002). The relationship between demand uncertainty and product quality is supported by the service industry study undertaken by De Vany and Saving (1977). The current study makes a new contribution to knowledge by showing that demand uncertainty can negatively affect rice quality in the TRSC, specifically in terms of its impact on effective quality-control systems. If unexpected customer orders when there is a shortage of product force urgent production, products may be produced that are inefficient in quality (Goering 1993). Producers may allow the low-quality product to be delivered to customers to meet urgent customer orders.

Contrary to expectation, uncertainties in supply, planning and control, government policy and climate do not have a significant relationship with supply chain performance in terms of either efficiency or rice quality. Process and competitor uncertainty do not have a significant relationship with rice quality, while demand uncertainty does not have a significant relationship with efficiency. These non-significant relationships may be explained as follows: some uncertainty factors play lesser roles in supply chain performance when they are identified and controlled. Identifying and controlling sources of uncertainty have become a common practices to improve supply chain performance (Davis 1993). For example, van der Vorst and Beulens (2002) suggest that identifying and managing the sources of uncertainties should be focused to enable effective supply chain redesign strategies. Although the TRSC is in instability of supply, planning and control, government policy and climate factors (Thongrattana & Perera 2010), the effect of these uncertainties on the performance of the supply chain is still not significant. It is possible that the members of the TRSC may have some degree of control (such as specific management strategies) over the impact of environmental

factors on their performance. This control is achieved by understanding, anticipating and responding wisely to environmental factors by managing them effectively (Johnson, Scholes & Whittington 2008). Therefore, the Thai rice industry under these particular uncertainty factors can stabilise its efficiency.

Uncertainty factors not only affect TRSC performance, but also affect supply chain management practices that will be discussed in the next section.

9.3 Research Question 2: Effects of Uncertainty Factors on Supply Chain Management Practices

To answer research question 2, *'How do uncertainty factors affect supply chain practices on the upstream side, on the downstream side and in internal supply chain processes in the Thai rice supply chain?',* the second hypothesis, relating to Hypotheses 2.1 to 2.21, is tested. Some of these hypotheses are supported:

9.3.1 Strategic Purchasing and Uncertainty Factors

Strategic purchasing is positively influenced by demand (β = 0.1896), planning and control (β = 0.2445), competitor (β = 0.3310) and climate uncertainty (β = 0.1681); these refer to Hypotheses 2.4, 2.10, 2.13 and 2.19 respectively.

The result confirm that in the context of the TRSC, strategic purchasing as a supply-based management practice is more affected by environmental uncertainties than are customer-based management practices like CRM and internal supply chain processes like LEAN principles. For a firm to experience a consistent level of success in today's rapidly changing environment, purchasing operation and activities must be synchronised with the strategy of the firm and adjusted with changes in external forces (Freeman & Cavinato 1990). Chen, Paulraj et al. (2004)agree that strategic purchasing can play a vital role in engendering long-term, strategic and cooperative relationships with a limited number of dedicated suppliers. Under conditions of uncertainty, firms attempt to interact closely with their supply partners to manage the repercussions (Paulraj & Chen 2007). In this study, higher levels of demand, planning and control, competitor and climate uncertainty lead to higher levels of strategic purchasing. This

evidence supports the work of Johnson, Klassen et al. (2002) and Paulraj and Chen (2007), who found that the purchasing function in many organisations has shifted from clerical to strategic because of fluctuations in both external and internal uncertainty factors.

As expected, demand, planning and control, competitors and climate uncertainties drive organisations to implement strategic purchasing because of perceived risk and uncertainty. This risk and uncertainty has a significant influence on the flow of the whole buying process, and on the structure of the buying centre (Juha & Pentti 2008, p.254). This forces top managers to view their purchasing strategy as important in coping with uncertainty.

Competitor uncertainty is the factor having the greatest positive impact on strategic purchasing. Thongrattana and Perera (2010) found that there are high levels of competition in both domestic and international markets, leading to high unpredictability of competitor behaviours in the Thai rice industry. For example, the international rice market is unsteady because of many factors such as unstable weather in rice-production countries, market thinness and fragmentation, international regulations and rice-petroleum market linkages (Jayne 1993). These situations have forced Thai rice competitors such as Vietnam (the second top exporter in the world) to introduce unique products such as low-priced fragrant rice (Nielsen 2002). Beginning in 2005, this has shifted the terms of trade in favour of Vietnam (Jamora et al. 2010). Thus, Thai rice market shares are down, especially in the ASEAN market as Thai producers lose their market leadership to Vietnam and Cambodia (The Center for International Trade Studies 2010). To maintain the Thai rice industry's competitive advantages in an intensively competitive market, rice exporters and millers try to triumph over competitor uncertainty by implementing strenuous strategic purchasing. More and more evidence demonstrates that strategic purchasing can play a vital role in the implementation of long-term supplier relationships and in fostering close working relationships with a limited number of dedicated suppliers (Chen, Paulraj & Lado 2004; Paulraj & Chen 2005; Paulraj, Chen & Flynn 2006).

Planning and control uncertainty is another important driver that encourages rice supply chain members to implement a higher level of strategic purchasing. Planning and

control uncertainty measurement is concerned with information related to the availability and accuracy of throughput times (van der Vorst 2000). A lack of information technology can result in incomplete information (Albani et al. 2003; Tansey 2003). Because most Thai rice millers and exporters are small businesses (see Chapter 6), information technology may not be fully implemented in the Thai rice industry, leading to perceived highly planning and control uncertainty in this industry (Thongrattana & Perera 2010). Incomplete information can create difficulties for the whole buying-process flow because this process flow requires more real-time information than merely data on existing and potential suppliers (Albani et al. 2003). This supports the idea that strategic purchasing should change from being merely a purchasing function to a purchasing strategy that supports the corporate strategic planning process (Ellram & Carr 1994) and enables coordination with supply partners to focus on longer-term issues of risk and uncertainty.

The statement that organisations operating under demand uncertainty are likely to have a greater need for a higher level of strategic purchasing, while not supported in the context of organisations in the United States (Li 2002; Paulraj & Chen 2007), is supported in the context of the TRSC. Thai organisations may already be aware of the threat or prevalence of demand uncertainty. In addition, United States organisations already implement a high level of strategic purchasing in any demand conditions. This leads to different findings from the Thai rice industry, where unexpected demand together with distorted demand data can create longer lead times, released safety stock, larger backlogs, enlarged shortage (Charu & Sameer 2000) and, ultimately, unsatisfied customers (Stadtler & Kilger 2002). Therefore, when organisations can discern the threat of demand uncertainty, the higher skills involved in the purchasing process, such as clear communication, supplier selection, transaction management and relationship management (Fawcett 2007), are necessary to manage adequate raw material and meet unexpected customer requirements.

Climate uncertainty is a new area of concern in the management field, and it has become a key determinant in strategic purchasing. Climate uncertainty is the unpredictable occurrences of serious weather events; in the rice industry, these can lead to decreased rice yield, rice supply shock, delay times of paddy rice to market or transportation disruption (Cruz et al. 2007). Thailand is particularly susceptible to

climate uncertainty (Thongrattana & Perera 2010). Thailand's severe floods in the last five decades have spread across half the country (The Office of Natural Resources and Environmental Policy and Planning 2008). For example, in 2010, Thailand's floods spread to 38 provinces, affecting at least 3.8 million people. About 1.6 million acres of agricultural land was affected, leading to the failure of rice production (Suwannakij 2010).The adverse weather conditions are set against the trend of slower growth in agricultural production and more rapid growth in demand (Trostle 2008) to raise the price of paddy rice, thus increasing the raw material cost for rice millers and exporters. To cope with this difficult situation, TRSC partners need to pay more attention to strategic purchasing. This requires a high amount of collaboration with their suppliers to ensure an adequate amount of paddy rice at the proper price and to reduce the total supply chain cost. Moreover, to handle climate uncertainty, organisations can work with their suppliers to employ strategic purchasing by focusing on longer-term issues associated with the risk of climate uncertainty.

9.3.2 Customer-relationship Management and Uncertainty Factors

Competitor uncertainty is the important driver for implementation of customer-relationship management (CRM) ($\beta = 0.2880$, Hypothesis 2.14).

Competitor uncertainty is the only factor that is a driving force for the implementation of CRM. This findings support the study of Min and Mentzer (2000), who found that the threat from competitors will impel organisations to implement different supply chain practices to increase customer satisfaction and loyalty.

As discussed above, there is a high level of competition in both domestic and international markets, which leads to high unpredictability of competitor behaviour in the Thai rice industry (Thongrattana & Perera 2010). One purchasing strategy alone may not be sufficient to cope with competitor uncertainty. Thai rice millers and exporters need another strategy: CRM. They can choose strategies that build on insightful customer information to understanding customer needs and expectations in each customer segment. They can then develop the right products and services to attain a higher level of customer satisfaction (Winer 2001; Dull et al. 2003). CRM requires customer value equity (quality, price and convenience) to motivate customers to make

repeat purchases (Richards & Jones 2008). In international markets, there is high competition in terms of price. For example, the average gap between the price of the comparable Vietnamese and Thai 5 percent broken variety of rice was USD 12 per ton in 2007; this gap had widened to USD 123 per ton by 2009 (FAO 2009b). This led to an increase in Vietnam's share in the world market from 16 to 20 percent in 2009. Thus, the amount of Thai rice exported to the international market slightly decreased in 2009 (FAO 2009). The Thai rice industry must implement CRM to deliver better value, such as higher-quality jasmine rice to customer segments like the US and Europe. Efficient and effective CRM can keep Thai rice brands ranked first in the world market (Department of Export Promotion 2010).

9.3.3 LEAN Principles and Uncertainty Factors

The relationships between LEAN principles and process uncertainty (Hypothesis 2.9), and LEAN principles and climate uncertainty (Hypothesis 2.21) are found to be positively significant ($\beta = 0.2403$, and $\beta = 0.3452$, respectively).

Process uncertainty could harm the Thai rice industry to the point where it forces rice millers and exporters to apply LEAN principles. LEAN principles are developed from LEAN production, which focuses on eliminating all waste (Shingo 1989; Jones, Hines & Rich 1997; Teo Chung 1998). Moreover, LEAN principles are concerned about continuous quality improvement and close relationships with suppliers (Teo Chung 1998). Although LEAN principles may not reduce the level of process uncertainty, they can help organisations control its adverse effects by reducing or eliminating production of goods not yet ordered, waiting times, the need to rectify mistakes, excess processing, excess movement and excess transport. When yield and throughput time of rice processing vary and cannot be controlled, minimising all waste in production can curtail the unfavorable consequences of process uncertainty.

Climate uncertainty is an important factor in agricultural production (Yoshida 1981). Adverse weather conditions can affect the supply side as slower growth in agricultural production, and the demand side as faster growth in demand (Trostle 2008). Climate uncertainty becomes a driving force for the implementation of LEAN principles, since it may reduce the negative effect of climate uncertainty through close relationships with

suppliers. For example, when flood destroys a rice-crop area, this could create a rice-supply shortage in the near future. Rice producers could use their close relationship with their customers, such as rice millers and/or rice exporters, to warn them about this difficult situation.

Supply uncertainty and government policy uncertainty do not influence all three supply chain management practices in this study. It is possible that these factors are not irrelevant for decision-making in their strategic implementation. In addition, supply chain management has become a popular practice that many industries are interested in implementing even without driving forces such as uncertainty factors. Supply chain management practices have become a common practice for organisations regardless of their environmental conditions (2002, p183). Likewise, organisations have been motivated to implement supply chain management practices not by pressure from environmental uncertainty, but by the desire to improve organisational performance. Similarly, in this study supply uncertainty and government policy uncertainty do not influence supply chain management practices. However, many researchers have demonstrated uncertainty factors as an important driver for the implementation of supply chain management practices (Davis 1993; Levy 1995; van der Vorst 2000; Childerhouse & Towill 2004; van Donk & van der Vaart 2005; Paulraj & Chen 2007; Juha & Pentti 2008). Some uncertainty factors are also supported by this study. Hence, these factors may play this vital role differently for different business types and supply chain contexts.

Although many studies support that supply chain management practices can improve supply chain performance, the next section will present this relationship in the TRSC.

9.4 Research Question 3: Effects of Supply Chain Management Practices on Supply Chain Performance

Research question 3, *'How do different supply chain practices in the Thai rice supply chain affect its performance?'*, is answered by testing Hypotheses 3.1 to 3.6.

9.4.1 Rice Quality and Supply Chain Management Practices

Rice quality is positively influenced by strategic purchasing (Hypothesis 3.1), and LEAN principles (Hypothesis 3.5), with β values of 0.3341 and 0.2673 respectively.

This empirically confirms the theoretical notion that a well-managed and well-executed supply chain leads to improved supply chain performance (Li 2002). Strategic purchasing can improve supply chain performance indirectly through buyer-supplier relationships (Paulraj & Chen 2005). The findings of this study support the study of Paulraj and Chen (2005) that strategic purchasing can lead to improved rice quality as a part of TRSC performance. Buyers and suppliers who attempt to maintain the outstanding quality of Thai rice (Roumasset & Setboonsarng 1988) create a win-win situation. Through strategic focus, strategic involvement and the integrative nature of the purchasing function (Paulraj & Chen 2005, p13), strategic purchasing can create two-way communication and knowledge exchange among the rice supply chain members associated with rice-quality improvement that meets end-customer requirements.

Likewise, LEAN principles are an important supply chain management practice to achieve a higher level of quality performance in the TRSC. There are several tools to achieve the goals of LEAN principles, such as a continuous quality improvement system, eliminating the waste associated with defects in a process, and close relationships with suppliers and customers (Levy 1997; Marosszeky & Karim 1997; Jamshed 2005), and so increase product quality (Taylor 2005). The result empirically confirms previous research that LEAN principles have been successful in improving rice quality in the TRSC.

9.4.2 Efficiency and Supply Chain Management Practices

Efficiency is positively influenced by strategic purchasing (Hypothesis 3.2), and CRM (Hypothesis 3.4), with β values of 0.3311 and 0.3821 respectively.

As expected, effective implementation of strategic purchasing can improve supply chain efficiency. Strategic purchasing is critically responsible for more than half of the

production cost for a organisation's product (Carr & Smeltzer 1999). Effective strategic purchasing, therefore, directly reduces costs, mainly those relating to efficiency of the supply chain. However, cost minimisation might improve efficiency only in a particular organisation, not for every supply chain partners. Strategic purchasing requires true supply management and partner relationships to gain a competitive advantage (Freeman & Cavinato 1990). Consistent with evidence from Chen, Paulraj et al. (2004), strategic purchasing can improve financial performance through buyer-supplier communication, a close relationship with a limited number of suppliers and long-term buyer-supplier relationships. The expectations from basic financial planning to strategic purchasing management are minimisation of costs, purchase for quality, contribution through value analysis and line of business results (Freeman & Cavinato 1990). Therefore, there is no doubt that effective strategic purchasing can lead not only one organisation, but also every partner in the supply chain to achieve high efficiency. In the Thai rice industry, since there is high competition in terms of the price of rice (Nielsen 2002; Agricultural Futures Trading Commission 2003), supply chain members need to pay attention to the implementation of a high level of strategic purchasing to achieve cost reduction and efficiency improvements.

To improve the efficiency of the TRSC, implementing only strategic purchasing as supply-side management is not enough. This study found that CRM is also positively related to efficiency in the context of the Thai rice industry. Understanding customer needs and expectations in each customer segment, and developing the right products to attract a higher level of customer satisfaction by maintaining profitable customers in the long term (Winer 2001; Dull et al. 2003) can lead to customised products and services, an efficient sale force, customer service efficiency and optimal pricing (Richards & Jones 2008). Thai jasmine rice makes up over 25 percent of the total amount of rice exported by Thailand in each year. Meanwhile, growers in the United States have developed the "Jazzman" rice brand (Sha 2009). Competitive practices like this could imperil Thailand's market share of jasmine rice exports (Peerenboom & Gillespie 2009). A close relationship with customers can avoid misunderstandings about jasmine and other rice products, and help to maintain Thailand's market share in jasmine rice exports and sustain high profits from this product, thus reflecting high efficiency.

9.5 Chapter Summary

This chapter discussed the results of testing the relationship among uncertainty factors, supply chain management practices and performance in the context of the TRSC.

The findings from the TRSC samples showed that supply, planning and control, government policy and climate uncertainty do not reduce supply chain performance. In contrast, demand, process and competitor uncertainty lessen supply chain performance. These results are inconsistent with those of previous studies. Hence, it can be concluded that uncertainty factors may play this vital role differently for different business types and supply chain contexts.

Uncertainty forces organisations to employ higher-level supply chain management practices. Interestingly, climate uncertainty, a new uncertainty factor considered in the empirical examination of agri-food supply chains, also plays this role, influencing rice millers and rice exporters to implement strategic purchasing. Finally, the results that the supply chain management practices improving supply chain performance are consistent with previous research.

The final chapter presents the summary and conclusion of the study, and discusses its academic and managerial contributions. The chapter closes with the limitations of the study and recommendations for future research.

CHAPTER 10

CONCLUSION

10.1 Introduction

This study has investigated uncertainty factors, supply chain management practices and performance in the Thai rice supply chain (TRSC). The TRSC had unique characteristics make it different from generic and other agri-food supply chains studied in previous research. Thus, the findings from this study can contribute new knowledge. Section 10.2 of this chapter summarises the findings; Section 10.3, highlights the study's contributions, both academic and managerial; Section 10.4 discusses limitations; and and Section 10.5 proposes some directions for future research.

10.2 Summary of Main Findings

Chapter 1 outlined the research background, problem, questions and objectives. This thesis developed and applied a conceptual framework to investigate whether TRSC performance could be improved by applying supply chain management practices or reducing uncertainty factors. To accomplish this, the thesis attempted to investigate all possible uncertainty factors that could affect the TRSC.

Chapter 2 presented the fundamentals of supply chain management and supply chain performance measurement as a background to examining the characteristics of agri-food supply chains. It found that they differ in a number of ways from generic supply chains. Thus, supply chain performance measures and some uncertainty factors for agri-food supply chains differ from those described in previous research. The uncertainty factors in the TRSC literature that stand out are government policy and climate uncertainty; these are investigated with the other five uncertainty factors (supply, demand, process, planning and control, and competitor uncertainty). The literature exploring supply chain performance measurement for agri-food supply chains and the Thai rice industry demonstrated that it mainly focuses on product quality (sensory properties and product safety and health) and efficiency (cost, return on investment and profit). Of the various

supply chain management practices that organisations implement, three supply chain management practices (strategic purchasing, LEAN principles and customer-relationship management) were investigated as important in both generic and agri-food supply chains. Because the TRSC was chosen in this study to represent agri-food supply chains, its characteristics were reviewed in Chapter 3.

Chapter 3 provided the background of global rice scenario, the Thai rice industry and the TRSC as the research context. Rice plays an important role in many developing countries in terms of food security, economic value and culture. The supply side of the TRSC primarily depends on the amount of rainfall in each crop year. Thus, rice output varies from year to year. Moreover, Thai rice yield is low when compared with Vietnamese, Chinese and Philippines rice yields. On the demand side, the domestic demand for rice is stable, but, as Thailand is the world's largest exporter, the international demand for rice is very important to the Thai rice industry. International demand fluctuates depending on many factors such as world population, eating behaviour and competitors' behaviours. The chapter presented an overview of the organisations within this context that comprised the sample for this study.

The literatures that discussed the links among uncertainty factors, supply chain management practices and supply chain performance were reviewed to develop a conceptual framework in Chapter 4, which then discussed the three main hypotheses regarding to the relationship between uncertainty factors and supply chain management practices, uncertainty factors and supply chain performance, and supply chain management practices and supply chain performance. These three main hypotheses were developed to answer the three research questions stated in Chapter 1.

The aim of Chapter 5 was to explain the choices of methodology for answering the research questions and testing the hypotheses outlined in Chapter 4. Quantitative research methods collect verifiable empirical evidence in support of theories or hypotheses, establishing reliability and validity by focusing on objectivity, measurement and statistics. A quantitative research approach was applied in this study, and Chapter 5 presented the details of the data collection procedure and survey instrument development. Rice millers and exporters were nominated for data collection because their dealings with suppliers and customers were related to supply chain management,

and they could therefore provide the data from a supply-chain perspective. (Additionally, the researcher's access to the addresses of potential survey respondents was limited to the member firms of the Thai Rice Mills Association and the Thai Rice Exporters Association).

The process of developing the survey resulted in the use of that formative measurement models for the uncertainty-factor constructs and rice-quality construct. The reflective measurement model was used for the efficiency construct, while multidimensional measurement models were developed for the supply chain management practice constructs. After translating the questionnaire from English to Thai, the pilot study was performed and the questionnaire was improved following the comments from the pilot-study participants. Data for the larger study was collected from the targeted rice millers and exporters in Thailand using posted mail questionnaires and the key-informant technique.

The returned questionnaires provided data for the exploratory analysis in Chapter 6. It was found that 70 to 90 percent of the rice-milling and rice-exporting firms surveyed were small businesses that employed fewer than 50. Non-response bias test was performed to ensure that non-response bias was not a concern in this study. The sample size of rice exporters was increased by collecting data in two rounds; the two data sets were tested using non-parametric tests, which determined that they could be pooled. Then, to pool data from rice millers and rice exporters, the non-parametric tests were performed on the pooled data from rice exporters along with the data from rice millers, which determined that these two sets, in turn, could be pooled for validity and reliability testing. This increased the sample size for confirmatory tetrad analysis (CTA), which examined whether the constructs were formative or reflective. With the exception of the government-policy and climate-uncertainty construct, the constructs defined in Chapter 5 were found to be supported. However, after being reconceptualised as formative constructs, both unsupported constructs were then supported. Lastly, exploratory factor analysis (EFA) was used to test the score validity of the supply chain management practice constructs as reflective constructs. This led to the deletion of the indicator LP3 (an indicator of LEAN principles) to improve the reliability and validity of the construct.

Chapter 7 reported on the reliability and validity of the measures according to construct type. This led to the removal of some items (CMU5, CR1, CR2 and LP4) to improve the reliability and validity of the constructs. After the indicators were removed, the final measurement instrument for all 12 constructs was found to be valid and reliable, as shown in Table 7-19. Therefore, they were employed in structural equation modeling for hypothesis testing in Chapter 8.

Chapter 8 explained the background of structural equation modeling (SEM). There are two types of SEM: covariance-based SEM and partial least squares (PLS). PLS was used to analyse the data because PLS is more accurate than covariance-based SEM when small sample sizes are small; problem. PLS can handle both reflective and formative measurement models; and PLS is less rigorous about the distribution of variables and error terms, which was useful for this study, as the data was gathered using a Likert- scale (which, by definition, is not normally distributed). Chapter 8 then reported the empirical results from SmartPLS software. The results showed the path coefficients of exogenous constructs on the endogenous constructs by linking to the hypotheses and their t-values.

Chapter 9 evaluated these results for significant, insignificant and unexpected outcomes. The main findings are summarised below:

Competitor unpredictability is the key uncertainty factor that has the greatest impact on the TRSC, clearly demonstrating that it harms its efficiency. Intensive competition in either domestic or international markets has forced competitors to undertake unpredictable activities. These behaviours can reduce the Thai rice industry’s market share, causing efficiency reduction in this supply chain. In addition, process uncertainty is a key factor that decreases efficiency in the TRSC. The uncertainty processes in the rice supply chain may lead to uncertain order cycle times or processing yield. This can increase production cost and inventory cost.

Contrary to expectation, supply, planning and control, government policy and climate uncertainty do not affect supply chain performance. Moreover, they play lesser roles in supply chain performance when they are identified and controlled.

Strategic purchasing as a supply-based management practice is more influenced by environmental uncertainties than customer-based management practices, such as CRM, and internal supply chain processes, such as LEAN principles. Demand, planning and control, competitors and climate uncertainty drives organisations to implement strategic purchasing. Under these unpredictable conditions, organisations attempt to interact closely with their supply partners to manage the repercussions of uncertainty. Competitor uncertainty is the only factor that is a driving force for the implementation of CRM. Strong relationships with customers can mitigate the adverse effects of competitor behaviours. Customer satisfaction and loyalty can maintain customers' orders from particular organisations even when competitors try to offer a better deal.

Process uncertainty causes problems for the Thai rice industry, but eventually forces firms to apply LEAN principles. LEAN tools, such as eliminating all waste in production, can help organisations control the adverse effects of process uncertainty. Moreover, climate uncertainty is an important factor in agricultural production for both supply and demand. Climate uncertainty becomes a driving force for the implementation of LEAN principles, as it may reduce its negative effects close relationships with suppliers.

Strategic purchasing can improve supply chain performance indirectly through buyer-supplier relationships. Strategic purchasing can lead to improved rice quality as a part of the TRSC performance. LEAN principles lead to a higher level of quality in the TRSC through such measures as implementing a continuous quality improvement system and eliminating the waste associated with defects in a process.

As expected, effective implementation of strategic purchasing can improve the efficiency of the supply chain. The expectations from applying strategic purchasing throughout the firm, from basic financial planning to strategic purchasing management, are minimisation of costs, purchasing for quality, contribution through value analysis and avoidance of long-term risk. Therefore, effective strategic purchasing directly decreases costs relating to efficiency of the supply chain.

Finally, this study found that CRM improves efficiency in the TRSC. Understanding customer needs and expectations in each customer segment, and then developing the

right products to attract a higher level of customer satisfaction, can retain profitable customers in the long term. Moreover, CRM can help firms identify and cut any costs that are not involved in delivering the right products to their customers.

The summary of findings from Chapter 1 to Chapter 9 can conclude about contributions of this research in the next section.

10.3 Research Contributions

This study contributes to knowledge of supply chain management in a number of ways.

1) One of the major contributions of this study is the development and application of a conceptual framework that provides a comprehensive study of uncertainty factors, supply chain management practices and performance for the TRSC. More specifically, it determines how uncertainty factors foster supply chain management, and affect supply chain performance; this question has not previously been investigated for an agricultural supply chain. The conceptual framework in this study was adapted from previous studies (such as van der Vorst 2000; Li 2002; Paulraj & Chen 2007). It can be positively confirmed that the conceptual framework is a solid model that provides a foundation for this research.

2) The study is unique in providing a valid and reliable measurement of uncertainty factors as formative measurements. Previous studies, such as Li (2002), developed a valid and reliable measurement of environmental uncertainty as a reflective first/second-order measurement construct; however, the environmental uncertainty construct in that study suffered from the researcher's inability to verify the impact of environmental uncertainty on supply chain management practices (Li 2002, p202). This suggests that the reflective measurement construct of environmental uncertainty may not be an appropriate construct and needs to be revised. In response, this study develops a formative measurement construct. All scales are shown to meet the requirements for reliability and validity, and thus, can be used in future research.

3) Earlier studies investigated the effects of various environmental uncertainties, including supply, demand, process, planning and control, and competitor uncertainties, on supply chains. This study is the first to add government policy in examining the effects of uncertainty on agri-food supply chains. A previous study by Badri, Davis et al. (2000) addressed the effects of government policy in developing countries on operation strategy and firm performance, but not on supply chain performance. Interestingly, the current study finds that government policy uncertainty in Thailand influences neither supply chain management practices nor rice supply chain performance. This finding is different from the previous studies; this suggests that the impact of government policy on particular organisations is different for supply chains and in different countries.

4) This study adds to academic research by including climate uncertainty as part of environmental uncertainty in the TRSC, determined using an empirical approach. The study of climate uncertainty has been examined as long-term change in the statistical distribution of weather patterns, but not in terms of management practices and decision-making. The lack of climate uncertainty measurements covering the agricultural business area has created the need for a focused, empirically based research study; a need that is, in part, met by this study.

5) The development of this climate-uncertainty construct highlights the critical role of climate uncertainty in facilitating strategic purchasing and LEAN principles in the context of the TRSC. The results demonstrate that a higher level of climate uncertainty will lead to a higher level of strategic purchasing and application of LEAN principles. Not only can strategic purchasing and the LEAN principles help firms cope with planning and control, process, demand and competitor uncertainty, but they can also deal with difficulties caused by changing climate conditions. The results also further confirm that managers in agri-business are well aware of the dangers posed for their firms by climate uncertainty, and are choosing to employ strategic supply chain management to remedy its adverse effects.

6) This study provides supports evidence from existing conceptual and prescriptive research about the previously untested impacts of supply chain management practices on the performance of the TRSC. In other words, a higher level of supply chain management practices will lead to a higher level of supply chain performance not only for a general supply chain, but also for the TRSC. It can be concluded that supply chain management practices are a very effective in dealing with high environmental competition.

As discussed in Chapter 3 of this thesis, the rice industry in Thailand has been looked upon as the solution to the development of the Thai agricultural business, economy and society. In addition to this study's contributions to academic research, its results have several important implications for practitioners as they outline their business plans and policy development:

1) *Uncertainty Factors and Supply Chain Performance*

This thesis has confirmed that environmental uncertainty can harm supply chain performance in the TRSC. Especially, competitor behaviour, demand, and process uncertainty adversely affect rice quality and supply-chain efficiency. Policy-makers should encourage practitioners in the Thai rice industry to be aware of uncertainties in competitor behaviour, demand, and process. There are many methods that policy-makers, owners, and managers can adopt to reduce or prevent these uncertainties. For example, the government can share information with the members of the rice supply chain about international competitors' behaviours. Additionally, government agencies should offer the assistance of agricultural scholars to consult with the rice supply chain members about reducing process uncertainty. The government can designate research and development on Thai rice production and variety, which can reduce its production costs and maintain a high quality level for Thai rice.

2) *Uncertainty Factors and Supply Chain Managemen Practice*

The empirical results in this thesis have shown the importance of implementing supply chain management practices not only for improving supply chain performance but also in for dealing with uncertainty factors in the TRSC. The findings also highlight the importance of strategic purchasing implementation, as this can cure the adverse effects of uncertainties in demand, planning and control,

competitor behaviour, and climate. Therefore, as most of the TRSC members are small to medium-sized enterprises, which might place a limitation on several supply chain management practices being implemented at the same time, managers should consider first employing strategic purchasing.

3) Supply Chain Practices and Supply Chain Performance

This thesis identifies the three key dimensions (supply side, demand side and internal supply chain) of supply chain management practices that Thai rice organisations can adopt. In addition, the results confirm the importance of supply chain practices in enhancing the TRSC performance. LEAN principles and strategic purchasing can improve rice quality, and strategic purchasing and customer-relationship management can enhance efficiency. In fact, many organisations in Thailand do attempt to implement supply chain management practices, but they often do not understand exactly what to implement, or how to start. Thus, government agencies can encourage and help the Thai rice industry to employ supply chain management practices by providing opportunities for education and training in supply chain management implementation for owners and managers.

Some uncontrollable factors and conditions that disclaim this research will present in the next section.

10.4 Limitations of the Study

Like all other studies, this study has some limitations.

First, the target samples of this study are rice millers and rice exporters in Thailand. Accessing the addresses of the more than 30 million people engaged in rice production, wholesale and retail, and distributing a mail survey to them, was unfeasible for this study. Although this study is limited to surveying (and thus examining) only a part of the TRSC, rice millers and exporters are the crucial members of the milling and marketing sector (as discussed in Chapter 1).

Second, the use of survey data in this study could affect the quality of findings. The response rate from rice millers was quite low (18.43 percent), thus making the sample

less random, and potentially too small a sample size for structural equation modeling. Thus, robust statistical analysis was chosen carefully to compensate for the small sample size. The partial least square method showed this sample size to be sufficient to validate the measurement models and produce significant results for the empirical analysis in Chapters 6, 7 and 8.

Third, the cross-sectional model employed in this study does not explain trend changes in organisational behaviour through time. For example, the Thai government often changes policies; for example, it changed the rice-price guarantee through changes in the rice mortgage policy during the period of this study. Such changes could affect rice supply chain members' behaviour differently. Further research using a longitudinal model could help in identifying any changes in organisational behaviours.

Fourth, the results of this study could not be reported separately for rice exporters and rice millers because the data from both samples was pooled to obtain a sample size large enough for robust statistical analysis. Further distinctions between different categories of rice supply chain members would require larger sample sizes.

Thare still are some gaps of research in this thesis. Thus, future research will be recommended in the next section.

10.5 Recommendations for Future Research

The limitations of the study are reveal guidelines for recommended future research. These can be largely categorised into measurement issues and structural issues.

10.5.1 Measurement Issues

To study the overall TRSC, data from rice retailers, rice wholesaler, rice distributor and rice producers should be collected in specific regions or groups. Although the sample size of 162 is adequate, a larger sample will provide more confidence in the results.

Limitations stemming from respondents' backgrounds or levels of education can lead to some response error. There has been no study to confirm that TRSC members

understand common language of supply chain management. A face-to-face survey may be a good choice for data collection, as interviewers have a chance to explain unknown terms and answer interviewees' questions, thus ensuring they clearly understand what is being asked. To get a clear picture of the results, mixed-method research should be employed in future studies. The qualitative research method should be applied after the quantitative research method to support a deeper understanding of the how and why of the relationships among constructs that has been set forth here.

10.5.2 Structural Issues

The TRSC is subject to various uncertainty factors, such as technology uncertainty, or other external business uncertainties, that should be added to this study's uncertainty-factor constructs in future research. The more uncertainty factors that can be identified and controlled, the better the members of the TRSC can foresee and mitigate their adverse effects.

Future research can hypothesise and test the impact of supply chain management practices on supply chain performance with uncertainty factors as moderator. This relationship is not hypothesised originally. The test of such hypothesis will further reveal the nature and role of the implement of supply chain management practices on supply chain performance under uncertainty situations.

Future research should conduct an independent analysis for each category of rice supply chain members. Assuming an adequate sample size in each TRSC member, structural analysis may be done by each TRSC member. This would reveal either TRSC member-specific structural relationships or invariance of structural relationships across them. This will allow the comparison of the relationships in different TRSC sector.

Future studies can also examine the proposed relationship by bringing some other supply chain performance variables such as customer satisfaction, reliability, responsiveness or flexibility. By adding these variables to sub-construct level, these variables could be an important supply chain performance metric in TRSC.

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APPENDICES

APPENDIX 1: CHARACTERISTICS OF RICE MILLERS

Several general questions in the mailed questionnaire elicited general information about rice-miller characteristics, including the job title of the respondent, years the respondent had been employed by the organisation, the number of employees, average annual sale volumes over the last five years, the organisation's market (domestic, international, or both), the mill's production capacity, the average annual amount of paddy rice milled over the last five years, the average annual inventory level of paddy rice, the joining rice mortgage policy, the number of suppliers, and whether the supply chain functions were partially or fully integrated. Each variable is analysed in detail below.

1) Job title

As shown in Figure A1-1, more than half of the respondents (65%) were managing directors, while 16% of them were supply chain managers – high-level positions that require experience in business operations and supply chain activities. This supports the accuracy of the data in the returned questionnaires.

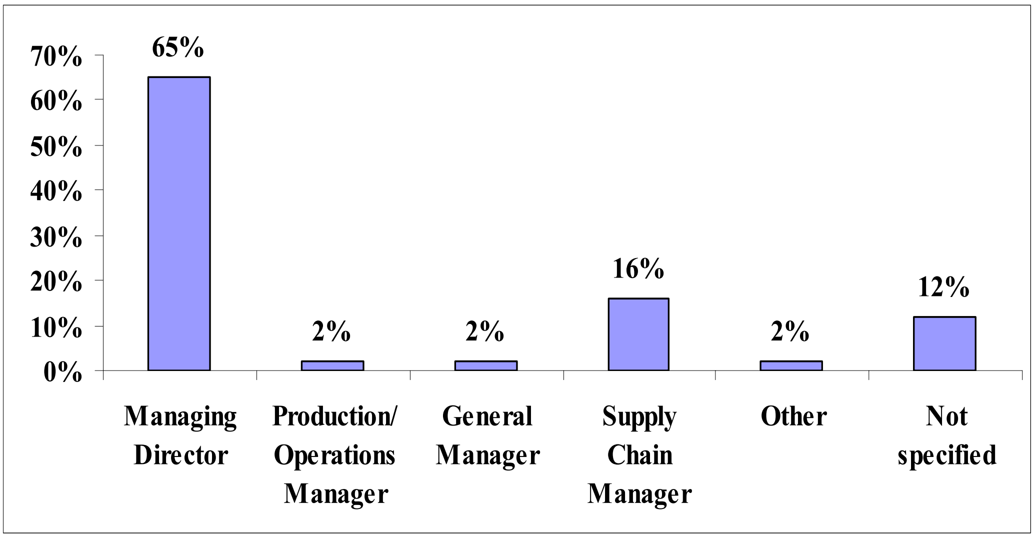

Figure A1- 1: Respondents by Job Title (Rice Millers)

2) How long ago the company was established. Most rice-milling firms surveyed were well-established businesses. Figure A1-2 shows that 62% of the rice-milling firms were established more than 20 years ago, and 23% of them were established between 10 and 20 years ago. Additionally, just 10% were established five to nine years ago, and 4% were established two to four years ago. But no respondents' firms were established more recently than two years ago.

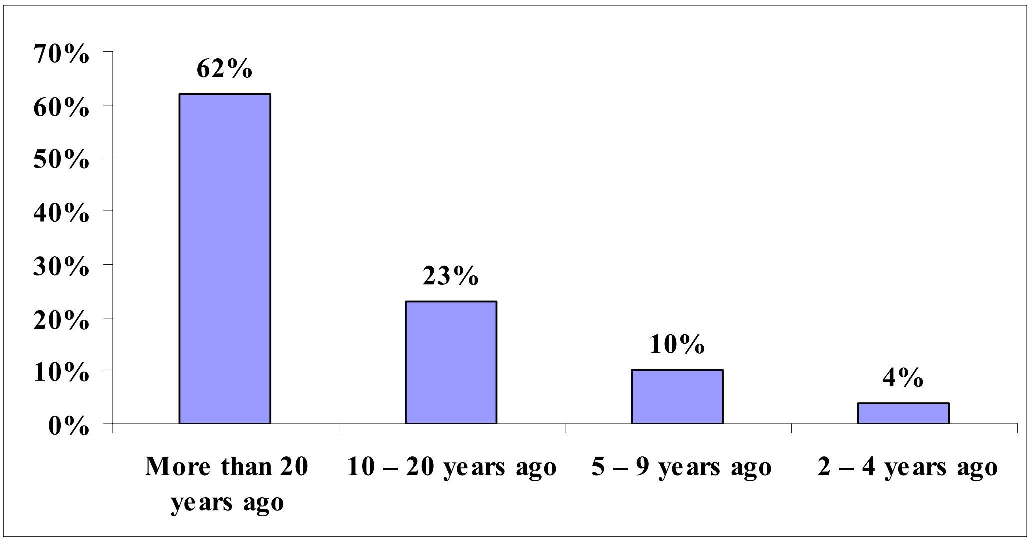

Figure A1- 2: When Company was Established (Rice Millers)

3) The number of employees

Most rice-milling firms surveyed (92%) were small to medium-sized enterprises; that is, they employed fewer than 50 employees (Christodoulou 2009). As shown in Figure A1-3, about half (43%) employed between 26 and 50 employees. However, just 2% employed more than 50 employees, while about 49% employed fewer than 20 employees (20% employed fewer than 10 employees and 29% employed between 11 and 25 employees). The remaining (6%) did not specify the size of their workforce.

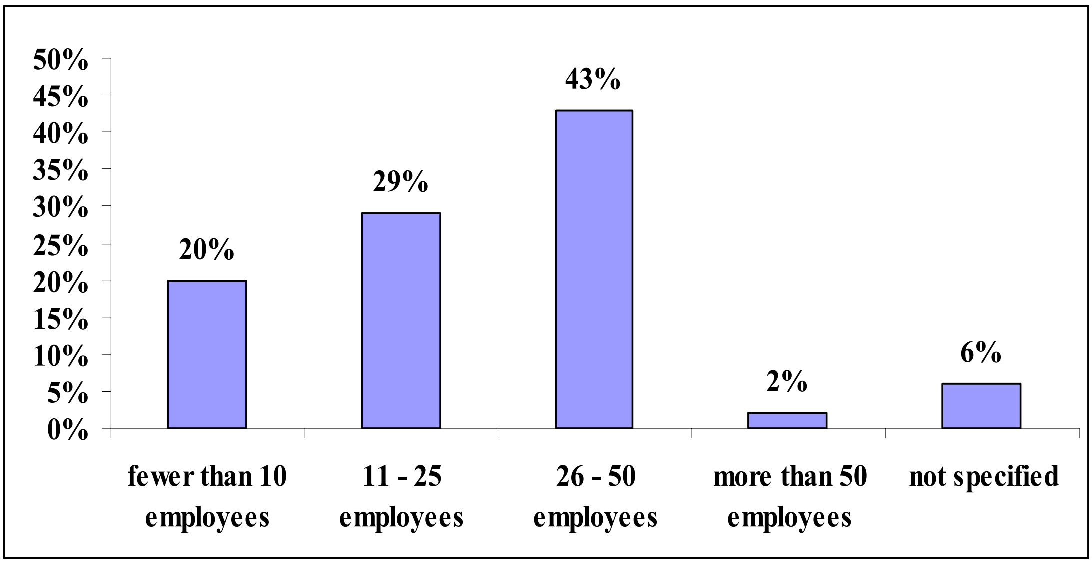

Figure A1- 3: Number of Employees (Rice Millers)

4) Average annual sale volume

Most rice-milling firms surveyed (61%) had an average annual sales volume of less than 50 million Baht (US$ 1.6 million), which categorises them as small businesses. As shown in Figure A1-4, about 33% of surveyed rice millers reported that their average annual sales volume over the last five years, was between 1 and 10 million baht (US$ 30,000 to 300,000) (Figure A1-4), and around 21% reached an average annual sales volume of over 50 million Baht (US$ 1.6 million). Roughly 23% achieved an average annual sales volume between 10 and 50 million baht (US$ 0.3 to 1.6 million). However, 18% did not provide their organisation's average annual sales volume, probably because they considered it to be sensitive data.

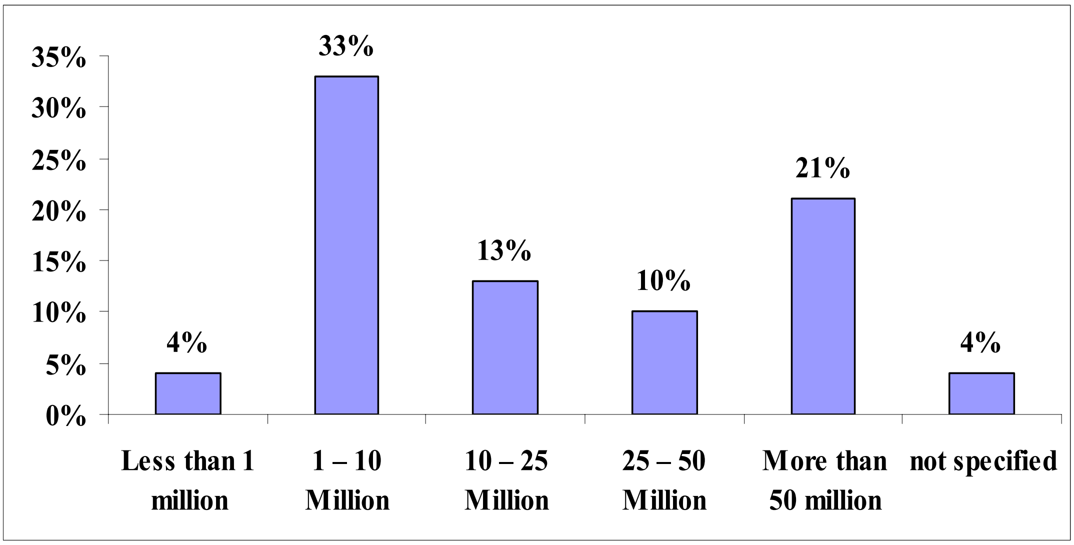

Figure A1- 4: Average Annual Sales Volume over Last Five Years (Rice Millers)

5) Capacity of milling (tonnes per 24 hours)

On the whole, Thai rice-milling firms had a relatively high milling capacity, and required relatively few employees. As shown in Figure A1-5, over half (55%) had a large capacity to mill (more than 60 tonnes per 24 hours), even though their employee size placed them in the category of small businesses. Meanwhile, approximately 34% had a medium capacity size (12 to 60 tonnes per 24 hours), and only 8% could mill less than 12 tonnes of paddy rice per 24 hours.

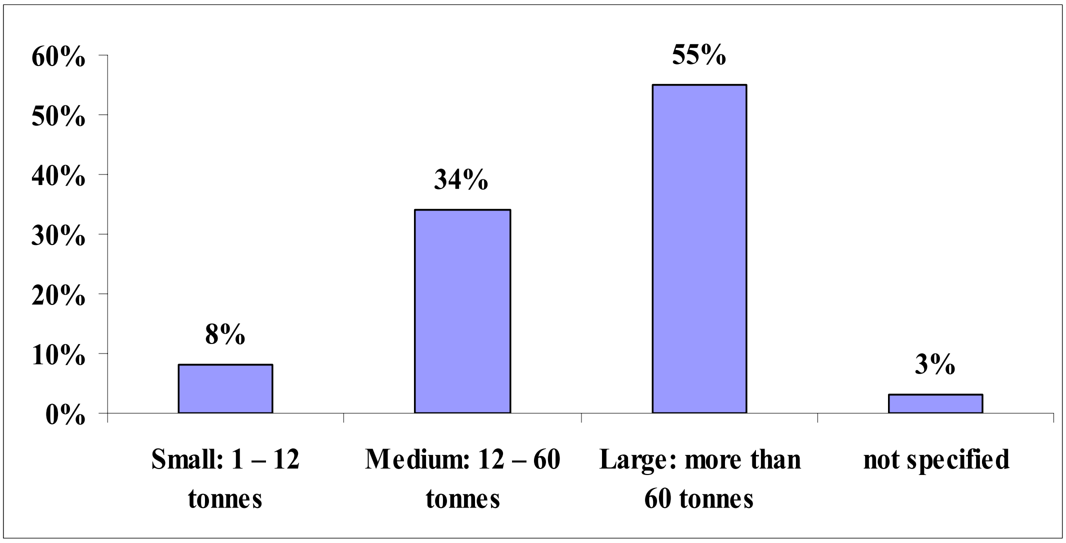

Figure A1- 5: Milling Capacity (Rice Millers)

6) Average annual paddy rice milled over the last five years (production output)

About 38% of rice-milling firms surveyed milled an average of less than 10,000 tonnes of paddy rice per year. Around 18% milled between 10,000 and 24,999 tonnes per year, and around 17% milled between 25,000 and 49,999 tonnes per year (Figure A1-6). Approximately 16% of them milled 50,000 tonnes or more per year.

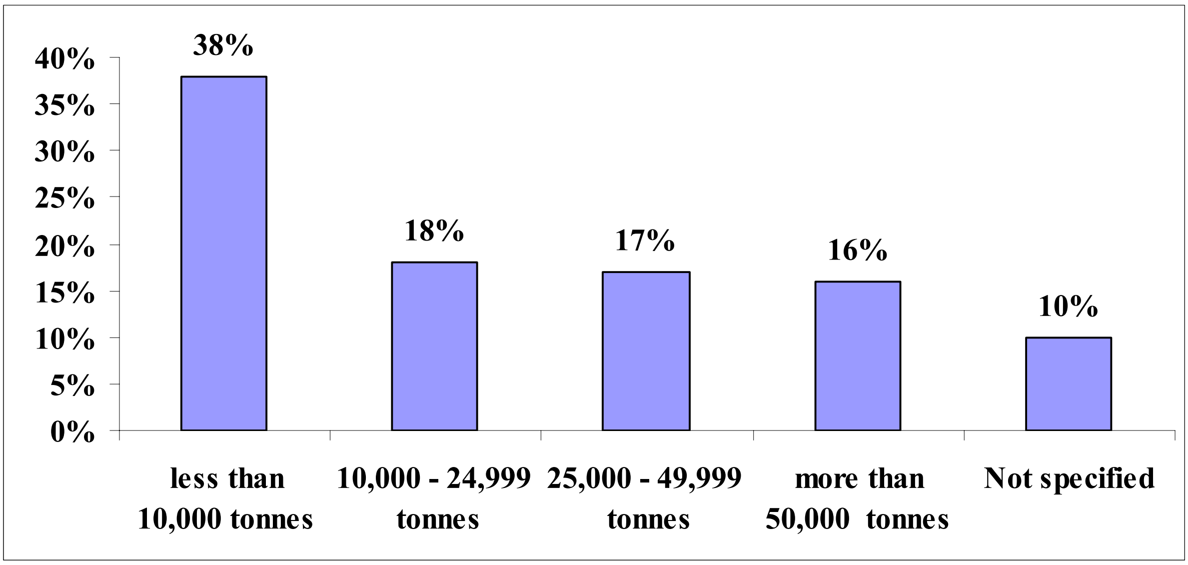

Figure A1- 6: Average Annual Paddy Rice Milled over the Last Five Years (Rice Millers)

7) Average annual inventory level of paddy rice

Of the sampled rice millers, around half (46%) stored less than 5,000 tonnes of paddy rice a year, whilst 9% of them stored over 25,000 tonnes a year (Figure A1-7). Additionally, 15% and 14% had an annual inventory level of 5,000-9,999 tonnes and 10,000-24,999 tonnes respectively. It should be noted that 15% of respondents did not provide data.

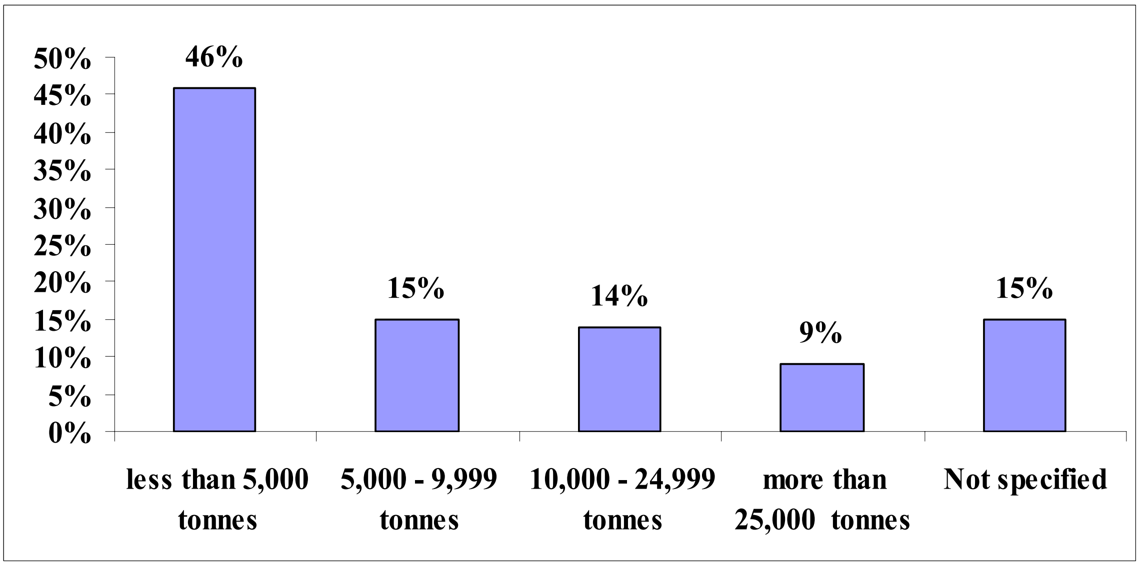

Figure A1- 7: Average Annual Inventory Level of Paddy Rice (Rice Millers)

8) Joining rice mortgage policy

Around 69% of the surveyed rice millers joined the government's rice mortgage policy within the last five years, suggesting that this policy has a vital role in the rice-milling industry () Figure A1-8)

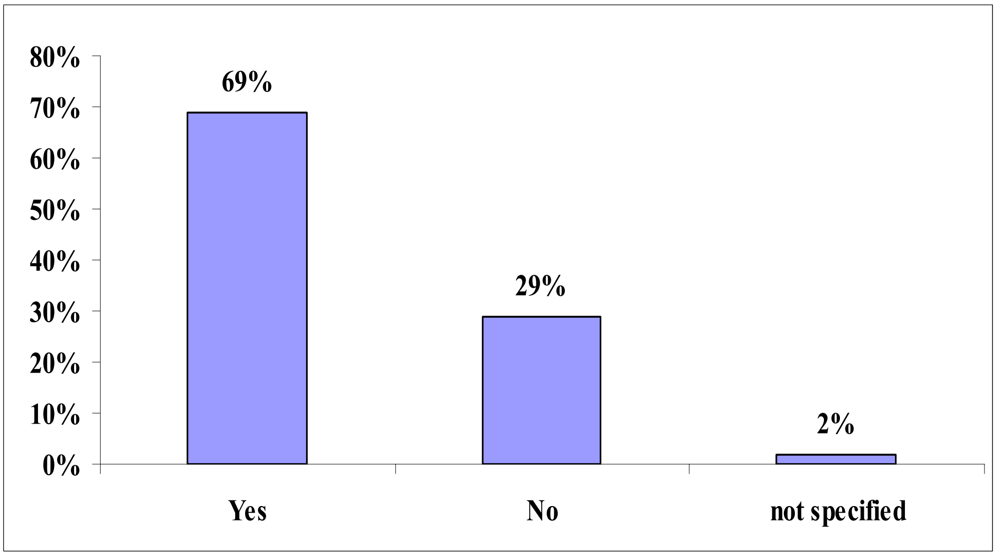

Figure A1- 8: Participation in the Government's Rice Mortgage Policy over the Last Five Years (Rice Millers)

9) The number of suppliers

Figure A1-9 shows that around 21% of the rice-milling firms surveyed had fewer than 10 suppliers, and a similar number had between 10 and 25. Only 7% had 26-50 suppliers, while 14% had over 50 suppliers. A quite high percentage (37%) did not provide this information.

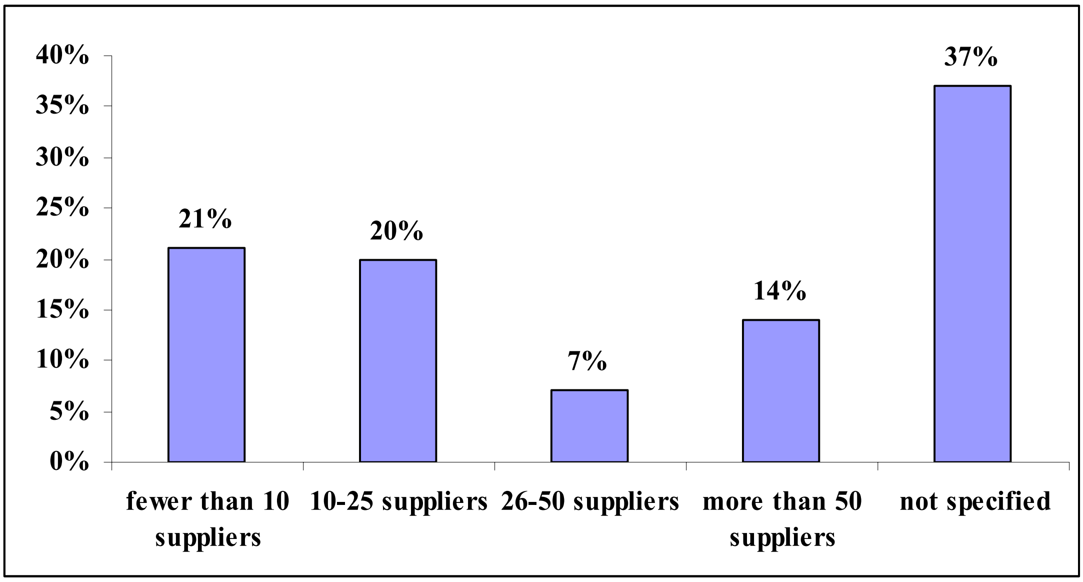

Figure A1- 9: Number of Suppliers (Rice Millers)

10) Rice mill's supply chain function (partially or fully integrated)

More than half of the rice-milling firms surveyed (59%) had partially integrated supply chains (*your firm's supply chain activities are only from milled rice to end customers or your main business is only with rice retailers*) (Figure A1-10), whilst 28% had fully integrated supply chains (*paddy rice moves from rice farms to millers, who transform paddy rice into milled rice and organize delivery into the hands of end customers*).

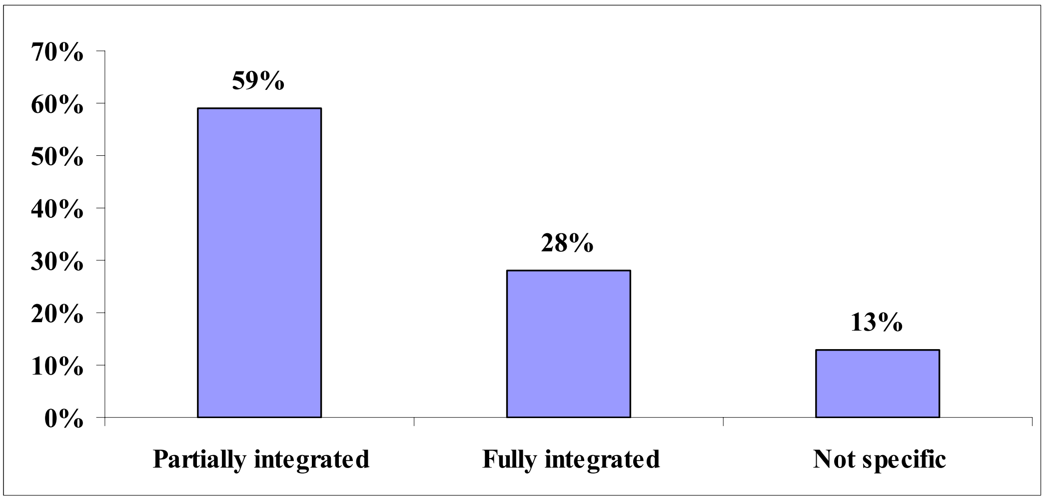

Figure A1- 10: Integration of Rice Supply Chain Function (Rice Millers)

APPENDIX 2: CHARACTERISTICS OF RICE EXPORTERS

Several general questions in the mailed questionnaire elicited general information about rice-exporter characteristics, including the respondent's job title, years the respondent had been employed by the organisation, employee size, the average annual sales volume over the last five years, the organisation's market (domestic, international or both), the average annual rice processed (e.g. cleaning and packaging) over the last five years, the average annual inventory level of their rice products, the signup rate for the rice mortgage policy, the number of suppliers, and whether their supply chain functions were partially or fully integrated Each variable is analysed in detail below.

1) Job title

As shown in Figure A2-1, more than two-thirds of the respondents (73%) were managing directors, while 11% were general managers – both high-level positions that require experience in business operations and supply chain activities. This supports the accuracy of the data in the returned questionnaires. Other positions, such as supply chain managers and production/operation managers, accounted for 11% of the respondents, and only 5% did not specify their position. Managing directors and general managers are a high level position in organisations.

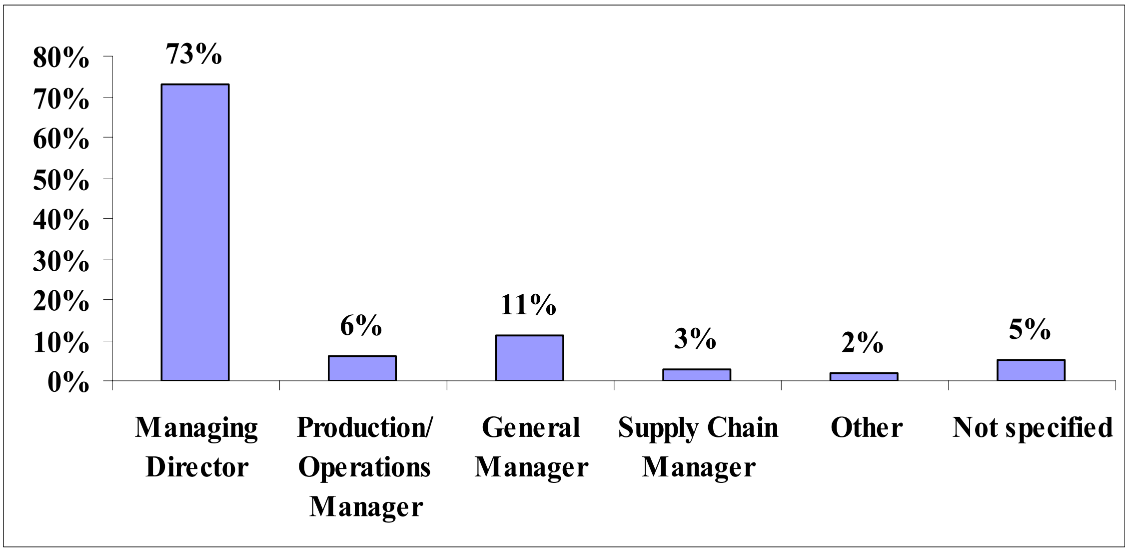

Figure A2- 1: Respondents by Job Title (Rice Exporters)

2) The number of years the company has been established

The data collected indicates that the rice-exporting industry is a mixture of old and new firms: 42% of the rice exporters surveyed were established between five and nine years ago, and 39% were established more than 20 years ago (Figure A2-2). Additionally, 16% were established 10 to 20 years ago, and 3% were established two to four years ago, but none had been established within the last two years.

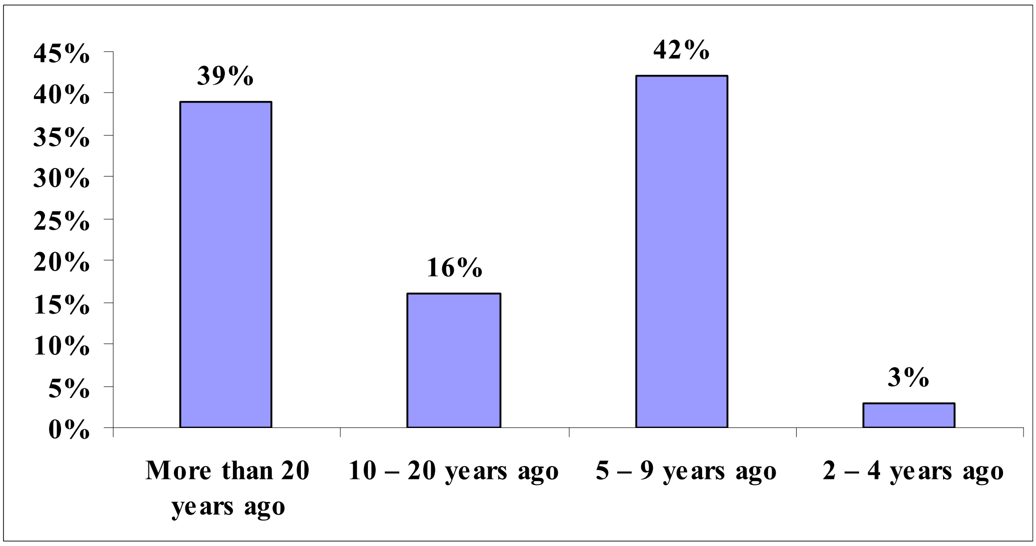

Figure A2- 2: When Company Was Established (Rice Exporters)

3) The number of employees

Like rice millers, most rice-exporters surveyed (80%) were small businesses, employing fewer than 50 people. About 39% of rice-exporting firms surveyed employed between 26 and 50 employees, and around 27% employed between 11 and 25 employees (Figure A2-3). Only 19% employed more than 50, and 14% employed fewer than 20. The rest (2%) did not specify the size of their workforce.

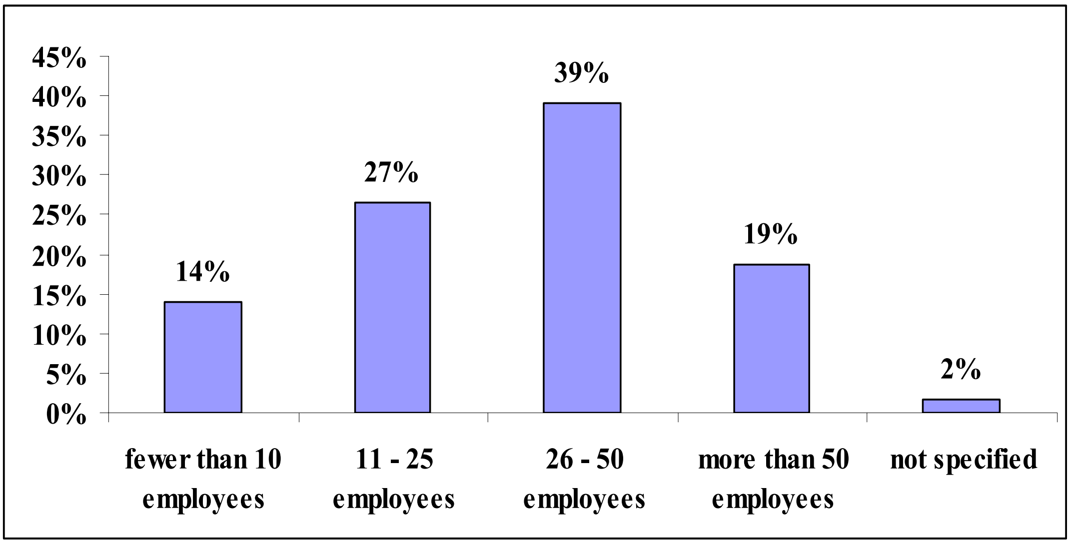

Figure A2- 3: Number of Employees (Rice Exporters)

4) Average annual sales volume

About 28% of surveyed rice exporters reported that their average annual sales volume over the last five years was between 25 and 50 million baht (US$ 0.83 to 1.6 million) (Figure A2-4), and around 25% reached an average annual sales volume of over 50 million baht (US$ 1.6 million). In addition, roughly 16% achieved an average annual sales volume between 10 and 25 million Baht baht (US$ 0.3 to 0.83 million). However, 23% did not provide their organisation's average annual sales volume, probably because they considered it to be sensitive data.

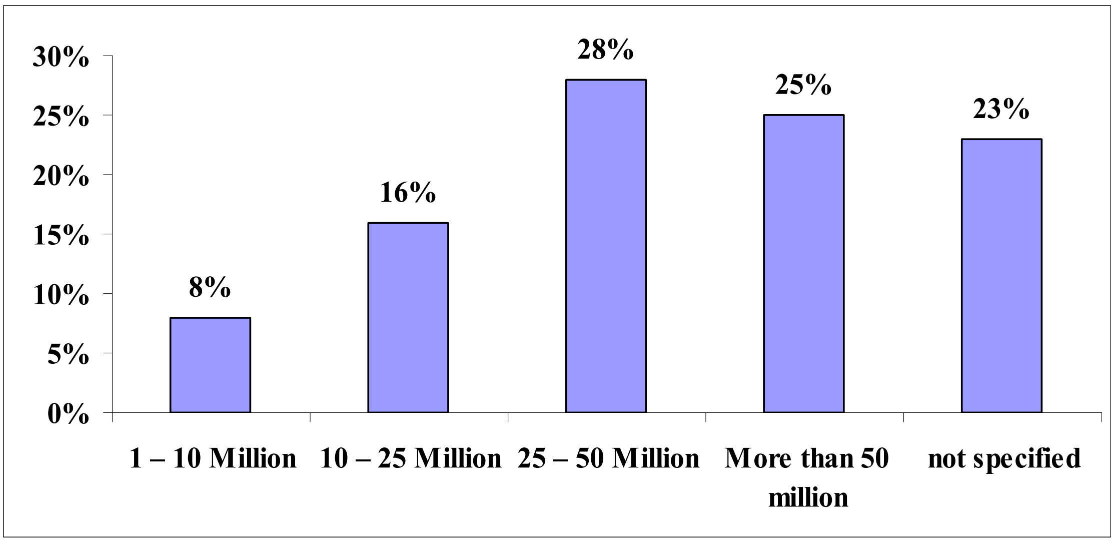

Figure A2- 4: Average Annual Sales Volume over the Last Five Years (Rice Exporters)

5) The number of countries to which organisations export

As shown in Figure A2-5, just below half (45%) of rice exporters send rice to fewer than five countries, while approximately 28% export to between five and ten countries. Quite a high percentage (27%) did not provide this data.

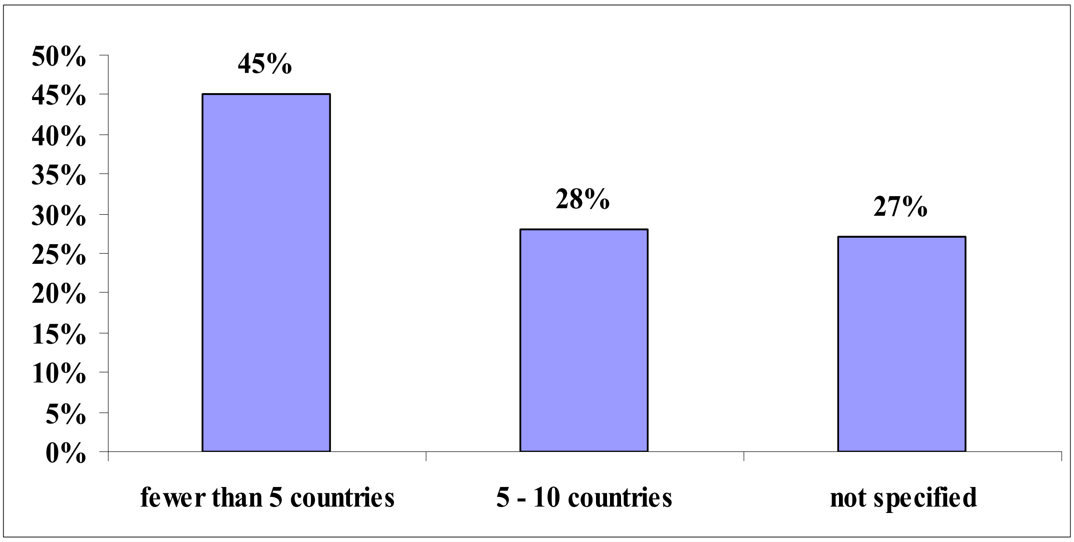

Figure A2- 5: Number of Countries to Which Rice Exporters Sell

6) Average annual milled rice processed over the last five years (production output)

More than half (56%) of the surveyed rice exporters processed an average of less than 10,000 tonnes of rice per year; and around 13% averaged between 10,000 and 24,999 tonnes per year. Only 5% processed as much as 25,000 to 49,999 tonnes per year (Figure A2-6). However, no rice exporter processed more than 50,000 tonnes per year. Unfortunately, 27% did not provide this information.

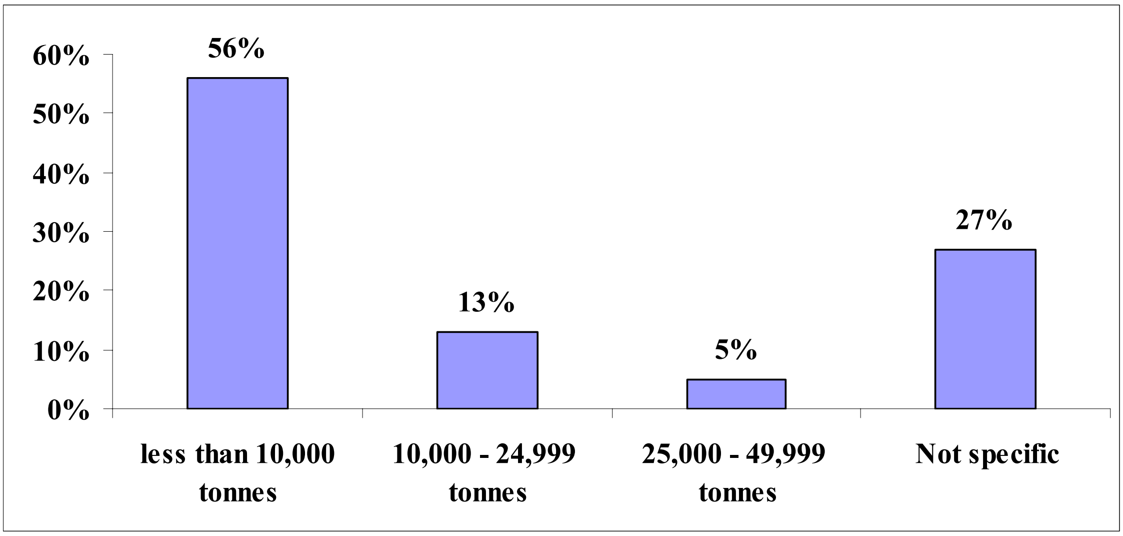

Figure A2- 6: Average Annual Milled Rice Processed over the Last Five Years (Rice Exporters)

7) Average annual inventory level of milled rice

Most of the surveyed rice exporters had relatively small inventories. Half stored less than 5,000 tonnes of milled rice per year, whilst only 3% stored a large inventory 10,000 to 24,999 tonnes per year, and another 3% stored over 25,000 tonnes per year (Figure A2-7). The data shows that 20% of rice exporters sampled had an annual inventory level of 5,000 to 9,999 tonnes. It should be noted that 19% did not specify this information.

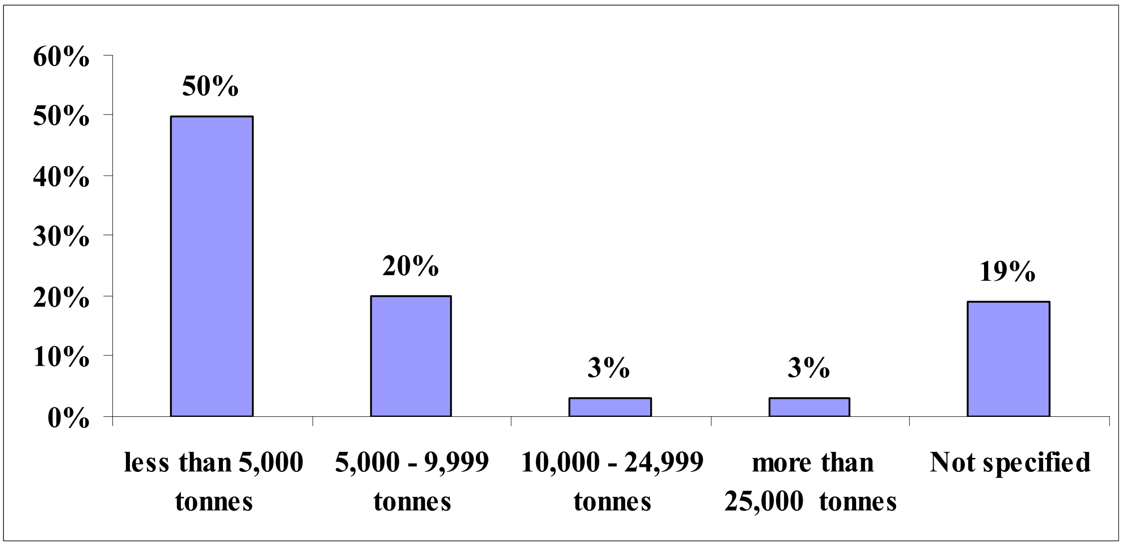

Figure A2- 7: Average Annual Inventory Level of Milled Rice (Rice Exporters)

8) The number of suppliers

Figure A2-8 shows that around 45% of rice exporters sampled have fewer than 10 suppliers; 20% have between 10 and 25; 14% have between 26 and 50; and only 6% have more than 50. Around 14% did not provide this information.

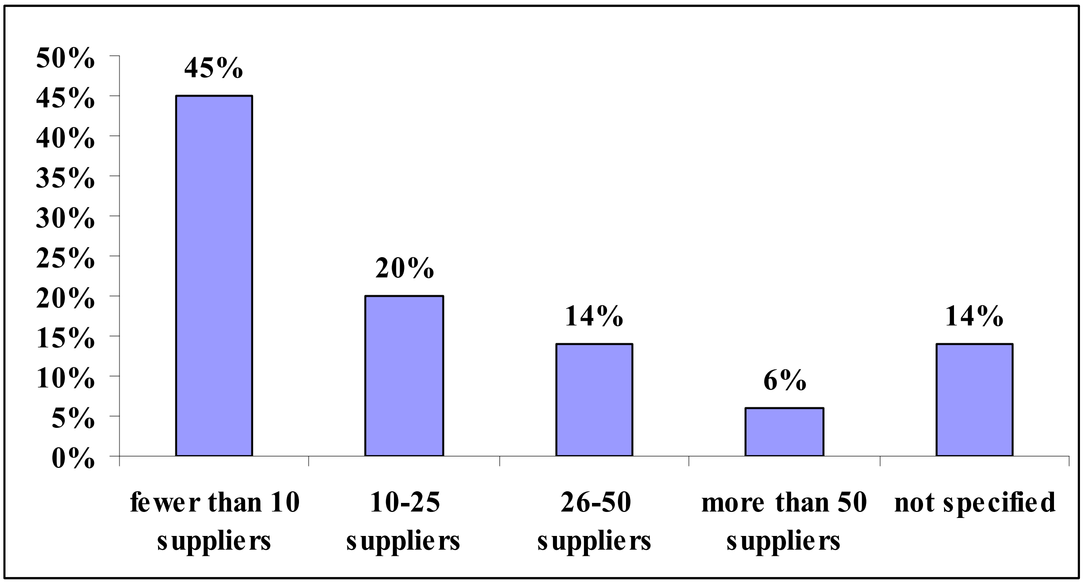

Figure A2- 8: Number of Suppliers (Rice Exporters)

9) Rice mills' supply chain function (partially or fully integrated)

About 63% of rice exporters surveyed had partially integrated supply chains, whilst 31% had fully integrated supply chains (Figure A2-9).

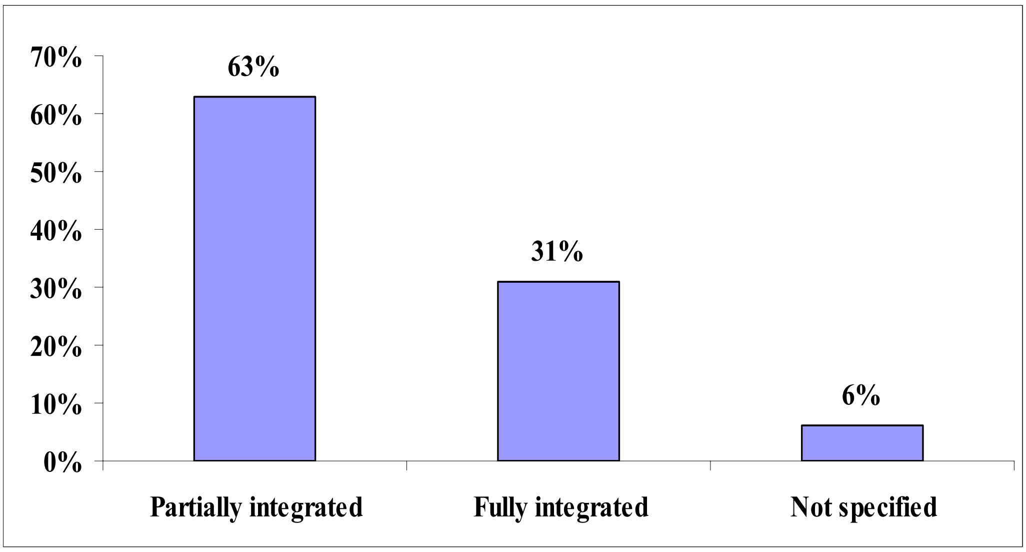

Figure A2- 9: Integration of Supply Chain Function (Rice Exporters)

APPENDIX 3: SURVEY QUESTIONNAIRE IN ENGLISH

Dear Sir/Madam,

<u>SURVEY: RICE SUPPLY CHAIN ANALYSIS IN THAILAND</u>

My name is Phatcharee Toghaw Thongrattana. I am a Lecturer in the Faculty of Engineering, Kasetsart University, Thailand, and currently doing my Ph.D. (Doctor of Philosophy) at the Sydney Business School, University of Wollongong, NSW, Australia.

The research project sets out to develop a better understanding of uncertainty as a factor in supply chain management in the Thai rice industry. This study will focus on two groups of Thai rice supply chain members: rice millers and rice exporters. In addition, this research will analyze the performance of Thai rice supply chains related to perceived uncertain factors and supply chain practices.

The survey responses will be used in the following ways:
1) to provide feedback to rice supply chain members,
2) to establish a set of indicators measuring the performance of the rice supply chain, and
3) to determine what supply chain uncertainty uncertainties exist in the Thai rice industry.

I would like to ask a senior manager or supply chain manager with experience of your business operations or supply chain activities to complete the enclosed survey and return it to me in the reply-paid envelope supplied. All participants' contributions to this research will be deeply appreciated. I shall be happy to send you the industry report.

Your contribution to this research is completely voluntary and anonymous. Information that could lead to the identification of any individual or your company will not be revealed to any other research projects or to external parties without your authorisation. All data collection and analysis will only be measurable by myself and my supervisor.

If you have any questions about this survey or need assistance in responding, this survey please does not hesitate to contact **Mrs. Phatcharee Toghaw Thongrattana**, email: <u>ptt175@uow.edu.au</u>.

Thanks and best regards,

Mrs. Phatcharee Toghaw Thongrattana, B.Eng., M.Eng.
Ph.D. Candidate, Sydney Business School,
University of Wollongong,
NSW, 2522 Australia

Part I. We would like to understand your current situation

1. What is your title/ role in the company? (please tick one only)

☐ Managing Director

☐ Production/ Operations Manager

☐ General Manager

☐ Supply Chain Manager

☐ Other (please specify)_____________________________________

2. When was your company established? (please tick one only)

☐ More than 20 years ago

☐ 10 – 20 years ago

☐ 5 – 9 years ago

☐ 2 – 4 years ago

☐ Less than 2 years ago

3. How many employees (approximately) in total does your company have? ____________

4. What is average annual turnover over the last five years (in baht)? (please tick one only)

Domestic	**Export**
☐ Less than 1 million	☐ Less than 1 million
☐ 1 – 10 Million	☐ 1 – 10 Million
☐ 10 – 25 Million	☐ 10 – 25 Million
☐ 25 – 50 Million	☐ 25 – 50 Million
☐ More than 50 million	☐ More than 50 million
	☐ nil

5. In what region of Thailand is your main business located?

Province:_________________________ Region: ______________________

Example: *State: Bangkok* *Region: Kong - Tuy*

6. Have you recently exported rice?

☐ Yes ☐ No

If YES, how long have you been exporting? ___________Years _________ Months

7. How many countries do you export your product to? ______________

8. To what major countries do you export? ______________________

If your firm is a only rice miller only, please answer Q9 to Q12

9. How much milling capacity do you have (tonnes per 24 hours)?

☐ Small 1 – 12 tonnes ☐ Medium 12 – 60 tonnes ☐ Large more than 60 tonnes

10. How many annual tonnes of paddy rice have you milled in each of the last five years (on average)? ________________________ tonnes

11. How many tonnes of paddy rice have you stored annually (inventory level)? ____________________ tonnes

12. Have you joined the government's paddy rice mortgage policy over the last five years?

☐ Yes ☐ No

If your firm is only a rice exporter, please answer Q13 to Q14

13. How many tonnes of milled rice (e.g. cleaning and packaging) have you exported annually over the last five years? ________________________ tonnes

14. How many tonnes of milled rice have you stored annually (inventory level)? ____________________ tonnes

If your firm is a rice miller and exporter, please answer Q9 to Q14

15. Please tick all of the certification of quality assurance, or food safety you have been awarded in the last five years?

☐ TACFS 4400 – 2003 ☐ TACFS 4000 – 2003

☐ ISO 9000 ☐ Other (Please specify) ______________________________

(TACFS: Thai Agricultural Commodity and Food Standard)

16. How many suppliers (approximately) do you have? ______________________

17. Is your supply chain function partially and integrated? (please tick one only and see below for a definition of these terms)

☐ Partially integrated ☐ Fully integrated

Fully integrated supply chain: paddy rice move from rice farms to millers who transform paddy rice into milled rice and organise delivery into the hands of end customers

Partially integrated supply chain: the supply chain activities are only from milled rice to end customers or your main business is only as a rice retailer.

Part II : **Uncertainty Factors in Thai Rice Supply Chain**

The objective of Part II is to get your feedback about perceived uncertainty factors (supply, demand, process, planning and control, competitor, government policy, and climate uncertainty) in your organisation.

Directions:

- *Please answer all the questions in Part II*
- *Generally the questions can be answered by circling the number that accurately reflects your organisation's current conditions.*
  - *1 = Strongly disagree (SD)*
  - *2 = Disagree (D)*
  - *3 = Slightly disagree (SLD)*
  - *4 = Neutral (N)*
  - *5 = Slightly agree (SLA)*
  - *6 = Agree (A)*
  - *7 = Strongly agree (SA)*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
18. Rice quantity from rice producers is unpredictable	1	2	3	4	5	6	7
19. Rice quality from rice producers is unpredictable	1	2	3	4	5	6	7
20. Rice producers' delivery time is unpredictable	1	2	3	4	5	6	7
21. The volume of customer demand is difficult to predict	1	2	3	4	5	6	7
22. Customers' rice preference changes over the year	1	2	3	4	5	6	7
23. The lead time[1] of customer order is unpredictable	1	2	3	4	5	6	7

[1] lead time: duration of time from custumers placing their order to product shipment

24. Yield of rice processing (e.g. milling, packing) can vary	1	2	3	4	5	6	7
25. The quality of rice after processing(e.g. milled, stored) can change	1	2	3	4	5	6	7
26. The throughput time of rice processing can vary	1	2	3	4	5	6	7

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
27. Information about stock level of rice and rice production capacity is complete at this moment	1	2	3	4	5	6	7
28. Information about stock level of rice and rice production capacity is accurate	1	2	3	4	5	6	7
29. Information about stock level of rice and rice production capacity is timely	1	2	3	4	5	6	7
30. Competitors' actions are unpredictable	1	2	3	4	5	6	7
31. Competition in the domestic market is intensifying	1	2	3	4	5	6	7
32. Competition from different countries is intensifying	1	2	3	4	5	6	7
33. Government policies in rice production directly affecting your firms are unpredictable	1	2	3	4	5	6	7
34. Government policies in rice trading (e.g. FTA, tax) directly affecting your firms are unpredictable	1	2	3	4	5	6	7
35. The guarantee price from government regulation is unpredictable from year to year	1	2	3	4	5	6	7
36. New government regulation is introduced unexpectedly	1	2	3	4	5	6	7
37. Drought occurrences affecting companies are unpredictable in each year	1	2	3	4	5	6	7
38. The duration of drought is unpredictable over the year	1	2	3	4	5	6	7
39. Flooding occurrences affecting companies are unpredictable in each year	1	2	3	4	5	6	7
40. The duration of flooding is unpredictable over the years	1	2	3	4	5	6	7
41. The warmer temperature affecting companies varies from year to year	1	2	3	4	5	6	7

<u>Part III</u>: Rice Supply Chain Practice

The objective of Part III is to get your feedback about three main supply chain practices implemented by your organisation.

Directions:

- *Please answer all the questions in Part III*
- *Generally the questions can be answered by circling the number that accurately reflects your organisation's current conditions.*
  - *1 = Strongly disagree (SD)*
  - *2 = Disagree (D)*
  - *3 = Slightly disagree (SLD)*
  - *4 = Neutral (N)*
  - *5 = Slightly agree (SLA)*
  - *6 = Agree (A)*
  - *7 = Strongly agree (SA)*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
42. Purchasing is included in the firm's strategic planning process	1	2	3	4	5	6	7
43. The purchasing function has a good knowledge of the firm's strategic goals	1	2	3	4	5	6	7
44. Top manager view purchasing strategy as an important strategy	1	2	3	4	5	6	7
45. Purchasing strategy focuses on longer-term issues involving risk and uncertainty	1	2	3	4	5	6	7
46. Customer satisfaction is frequently evaluated and measured	1	2	3	4	5	6	7
47. Future customer expectations are frequently determined	1	2	3	4	5	6	7
48. The importance of relationship with customers is frequently evaluated	1	2	3	4	5	6	7
49. A sense of fair trading with customers is shared	1	2	3	4	5	6	7
50. Top managers view satisfying customer needs as an important strategy	1	2	3	4	5	6	7

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
51. Customer focus is reflected in your business planning	1	2	3	4	5	6	7
52. A continuous quality improvement system is implemented	1	2	3	4	5	6	7
53. Rice suppliers' warehouses/farms are located nearby	1	2	3	4	5	6	7
54. Production system is based on customer demand	1	2	3	4	5	6	7
55. Inspection of outbound rice has been reduced	1	2	3	4	5	6	7
56. Top managers view closed-relationships with suppliers as an important strategy	1	2	3	4	5	6	7
57. LEAN practices are focused on the organisation 's long term plan	1	2	3	4	5	6	7

Part IV: Rice Supply Chain Performance

The objective of Part IV is to get your feedback on the actual level of the two main performance indicators (rice quality and efficiency) of your supply chain management, as a result of supply chain practices and uncertain factors in your organisation.

Directions:

- *Please answer all the questions in Part IV*
- *Generally the questions can be answered by "circling" the number that accurately reflects your organisation's current conditions.*
  - *1 = Strongly disagree (SD)*
  - *2 = Disagree (D)*
  - *3 = Slightly disagree (SLD)*
  - *4 = Neutral (N)*
  - *5 = Slightly agree (SLA)*
  - *6 = Agree (A)*
  - *7 = Strongly agree (SA)*

	Strongly disagree	*Disagree*	*Slightly disagree*	*Neutral*	*Slightly agree*	*Agree*	*Strongly agree*
58. Physical properties of rice are important performance indicators	1	2	3	4	5	6	7
59. All inspections performed present good records.	1	2	3	4	5	6	7
60. Rice safety and health are important performance indicators	1	2	3	4	5	6	7
61. Environmental management system is implemented	1	2	3	4	5	6	7
62. The number of sales increases because of marketing activities	1	2	3	4	5	6	7
63. Rice production cost is low	1	2	3	4	5	6	7
64. Distribution cost is low	1	2	3	4	5	6	7
65. Inventory cost is low	1	2	3	4	5	6	7
66. Return in investment is high	1	2	3	4	5	6	7
67. Profits are high	1	2	3	4	5	6	7

<u>Part V</u>: Personal Detail (optional)

If you would like a summary of the results of this survey, please tick here ☐ , and provide the following details.

Name:____

Address:____

____

Email address: ____

End of Survey

APENNDIX 4: SURVEY QUESTIONNAIRE IN THAI

ข้อมูลและคำแนะนำสำหรับผู้เข้าร่วมโครงการวิจัย

ชื่อโครงการ: การวิเคราะห์ ห่วงโซ่อุปทานของข้าวไทย

Rice Supply Chain Analysis in Thailand: An Empirical Approach

บริษัทของท่านมีความเกี่ยวข้องกับการซื้อขายข้าวสารและ/หรือข้าวเปลือก เราจึงใคร่ขอเชิญท่านเข้าเป็นอาสาสมัครผู้เข้าร่วมโครงการวิจัย หากท่านตัดสินใจเข้าร่วมการศึกษา เรารู้สึกยินดีที่ท่านได้สละเวลาอ่าน ข้อมูลดังต่อไปนี้

วัตถุประสงค์ของงานวิจัย

งานวิจัยชิ้นนี้เป็นส่วนหนึ่งของการศึกษาในระดับปริญญาเอก ณ มหาวิทยาลัยวูลองกอง ประเทศออสเตรเลีย ของนางพัชรี โตแก้ว ทองรัตนะ และได้รับความร่วมมือจากสมาคมโรงสีข้าวไทยและสมาคมผู้ส่งออกข้าวไทยในการให้ที่อยู่ของบริษัทของท่าน โดยวัตถุประสงค์ของงานวิจัยนี้คือ

- วิเคราะห์ห่วงโซ่อุปทานของข้าวในประเทศไทย
- ศึกษาผลกระทบจากปัจจัยต่างต่อกลยุทธ์ การบริหารของห่วงโซ่อุปสงค์-อุปทานของข้าวและประสิทธิภาพของห่วงโซ่อุปทานของข้าวในประเทศไทย

ท่านจะต้องปฏิบัติตัวอย่างไร

หากท่านตัดสินใจเข้าร่วมการศึกษา ขอให้ผู้ที่ดำรงตำแหน่งผู้จัดการของบริษัทของท่านที่มีความรู้และประสบการณ์ เกี่ยวกับการดำเนินงานของบริษัทของท่าน กรอกแบบสอบถามที่แนบมาด้วยโดยใช้เวลาไม่เกินครึ่งชั่วโมง โดยตอบคำถามทุกข้อ หากมีคำถามใดที่ท่านไม่เข้าใจ กรุณาเลือกตอบคำถามนั้นตามความเข้าใจของท่าน แล้วส่งคืนทางไปรษณีย์ ตามซองและที่อยู่ที่แนบมาให้

<u>ท่านจะทำอย่างไรหากท่านไม่ต้องการเข้าร่วมการศึกษา หรือหากท่านเปลี่ยนใจระหว่างเข้าร่วมศึกษา</u>

ท่านไม่จำเป็นต้องเข้าร่วมการศึกษานี้ หากท่านไม่สมัครใจจะเข้าร่วมการศึกษาแล้ว ท่านสามารถจะถอนตัวได้ตลอดเวลา การตัดสินใจของท่านจะไม่มีผลใดๆในอนาคต

<u>การปกป้องรักษาข้อมูล: ข้อมูลใดบ้างที่จะถูกเก็บรวบรวมไว้จากการศึกษานี้</u>

ข้อมูลส่วนตัวของท่านและบริษัทจะถูกเก็บรวบรวมไว้และนำมาใช้เพื่อวัตถุประสงค์ทางการวิจัยเท่านั้น โดยจะไม่มีการอ้างถึงชื่อท่าน/บริษัทในรายงานหรือวารสารใดๆ ข้อมูลจากแบบสอบถามจะถูกนำมาวิเคราะห์และนำเสนอผลของการวิเคราะห์ในวิทยานิพนธ์และวารสารทางการศึกษาเท่านั้น

หากท่านมีคำถามเกี่ยวกับการศึกษานี้ท่านสามารถติดต่อใครได้บ้าง

ท่านสามารถติดต่อบุคคลดังต่อไปนี้ หากท่านมีคำถามหรือมีความวิตกกังวล

นางพัชรี โตแก้ว ทองรัตนะ (อาจารย์และนักศึกษาปริญญาเอก) ได้ที่ภาควิชาวิศวกรรมอุตสาหการ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ วิทยาเขตบางเขน โทร. 0-2942-8555 ต่อ 1603-4)

ส่วนที่ 1 ข้อมูลเกี่ยวกับธุรกิจ

1. โปรดระบุตำแหน่ง/ หน้าที่ของท่านในองค์กร (โปรดเลือกเพียงหนึ่งข้อเท่านั้น)

- ☐ เจ้าของกิจการ/ผู้ร่วมทุน
- ☐ ผู้จัดการฝ่ายผลิตภัณฑ์
- ☐ ผู้จัดการฝ่ายขาย
- ☐ ผู้จัดการทั่วไป
- ☐ ผู้จัดการฝ่าย Supply Chain
- ☐ อื่นๆ โปรดระบุ________________________

2. องค์กรของท่านก่อตั้งขึ้นเมื่อใด? (กรุณาเลือกเพียงหนึ่งข้อ))

- ☐ มากว่า 20 ปี
- ☐ ระหว่าง 10 – 20 ปี
- ☐ ระหว่าง 5 – 9 ปี
- ☐ ระหว่าง 2 – 4 ปี
- ☐ น้อยกว่า 2 ปี

3. องค์กรของท่านมีพนักงานทั้งหมดประมาณเท่าไร?____________________

4. ค่าเฉลี่ยของรายได้ต่อปีของบริษัทท่านในช่วงระยะเวลา 5 ปีล่าสุดประมาณเท่าไร (คิดเป็นเงินบาท)? (โปรดเลือกเพียงหนึ่งข้อ)

ภายในประเทศ	ส่งออก
☐ น้อยกว่า 1 ล้านบาท	☐ น้อยกว่า 1 ล้านบาท
☐ ระหว่าง 1-10 ล้านบาท	☐ ระหว่าง 1-10 ล้านบาท
☐ ระหว่าง 10-25 ล้านบาท	☐ ระหว่าง 10-25 ล้านบาท
☐ ระหว่าง 25-50 ล้านบาท	☐ ระหว่าง 25-50 ล้านบาท
☐ มากกว่า 50 ล้านบาท	☐ มากกว่า 50 ล้านบาท
	☐ ไม่ระบุ

5. องค์กรของท่านตั้งอยู่บริเวณไหนในประเทศไทย?

จังหวัด:______________________ อำเภอ: ___________________

6. องค์กรของท่านส่งออกข้าวหรือไม่?

☐ ส่งออก ☐ ไม่ส่งออก

(ถ้าท่านส่งออกข้าว, ท่านได้ส่งออกข้าวมาทั้งหมดกี่ปี/ เดือน? ______ ปี ________เดือน)

7. ท่านได้ส่งออกข้าวไปทั้งหมดกี่ประเทศ? (โดยประมาณ) ______________

8. ท่านส่งออกข้าวไปยังประเทศใดเป็นหลัก? (ระบุเพียง 1 ประเทศ)_____________________

ถ้าองค์กรของท่านเป็นผู้ประกอปการโรงสีข้าวเท่านั้น, กรุณาตอบคำถามข้อ 9 ถึง ข้อ12

9. ความสามารถสูงสุดในการสีข้าวขององค์กรท่านเป็นเท่าไร? (คิดเป็นตันต่อ 24 ชั่วโมง)

☐ ขนาดเล็ก: 1-12 ตัน ☐ ขนาดกลาง: 12-60 ตัน ☐ ขนาดใหญ่: มากกว่า 60ตัน

10. จำนวนข้าวเปลือกทั้งหมดที่ทำการสีต่อ**ปี**เป็นเท่าไรในช่วงเวลา 5 ปีล่าสุด? (คิดเป็นค่าเฉลี่ยต่อปี)

_____________________ตัน

11. จำนวนข้าวเปลือกที่ทำการจัดเก็บไว้ในคลังสินค้าโดยเฉลี่ยต่อปีเป็นเท่าไร? _____________________ตัน

12. ท่านได้เข้าร่วมหรือเคยเข้าร่วมโครงการจำนำข้าวเปลือกของรัฐบาลในช่วงเวลา 5 ปีล่าสุดหรือไม่?

☐ เข้าร่วม ☐ ไม่ได้เข้าร่วม

ถ้าองค์กรของท่านเป็นผู้ส่งออกข้าวเท่านั้น, กรุณาตอบคำถามข้อ 13 ถึง ข้อ14

13. จำนวนข้าวสารที่ท่านส่งออกต่อปีกี่ตันในช่วงเวลา 5 ปีล่าสุด? (คิดเป็นค่าเฉลี่ยต่อปี) _____________________ ตัน/ปี

14. ปริมาณข้าวสารที่ถูกจัดเก็บในคลังสินค้าโดยเฉลี่ยต่อปีเป็นกี่ตัน?

_____________________ ตัน

ถ้าองค์กรของท่านเป็นผู้ประกอปการณ์โรงสีข้าวและส่งออกข้าว, กรุณาตอบคำถามข้อ 9 ถึง ข้อ14

15. กรุณาเลือกประกาศนียบัตรรับรองคุณภาพ หรือความปลอดภัยด้านอาหารที่ท่านได้รับในช่วงเวลา 5 ปีล่าสุด

☐ มกอช.4400-2546 ☐ มกอช.4000-2546

☐ ISO 9000 ☐ อื่นๆ โปรดระบุ

☐ ISO 9002 ___________________________

☐ GMP (Good Manufacturing Practice)

16. ท่านมีจำนวนผู้จัดส่งข้าวเปลือกและ/หรือข้าวสารให้ทั้งหมดเท่าไร? โดยประมาณ ____________________ราย

17. จงระบุลักษณะการจัดการห่วงโซ่อุปทาน (Supply Chain Management)หรือการบริหารจัดการสินค้าของบริษัทของท่าน (โปรดเลือกเพียงหนึ่งข้อ)

☐ บริหารแบบรวมตัวกันบางส่วน

คือ การบริหารองค์กรของท่านเพียงองค์กรเดียว เพื่อจัดส่งผลิตภัณฑ์ข้าวให้ถึงลูกค้า

☐ บริหารแบบรวมตัวกันอย่างสมบูรณ์

คือ การบริหารองค์กรของท่านเริ่มจากการบริหารผู้ผลิตข้าว (ชาวนา), โรงสีข้าว ไปจนถึงส่งผลิตภัณฑ์ข้าวให้ถึงลูกค้า

ส่วนที่ 2: ปัจจัยที่ไม่แน่นอนที่ส่งผลกระทบต่อองค์กรของท่าน

- *กรุณาตอบคำถามทุกข้อ*
- *กรุณาวงกลมหรือกากบาทตัวเลขที่สะท้อนถึงสถานะปัจจุบันขององค์กรของท่าน แต่ละตัวเลขมีความหมายดังนี้*

1 = ไม่เห็นด้วยอย่างมาก *5 = เห็นด้วยเล็กน้อย*
2 = ไม่เห็นด้วย *6 = เห็นด้วย*
3 = ไม่เห็นด้วยเล็กน้อย *7 = เห็นด้วยอย่างมาก*
4 = ปานกลาง

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
18. ปริมาณข้าวจากชาวนาหรือผู้ค้าข้าวเปลือกไม่สามารถคาดคะเนได้ในแต่ละปี	1	2	3	4	5	6	7
19. คุณภาพของข้าวจากชาวนาหรือผู้ค้าข้าวเปลือกไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
20. ระยะเวลาการจัดส่งข้าวจากชาวนาหรือผู้ค้าข้าวเปลือกไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
21. จำนวนข้าวตามความต้องการของลูกค้ายากที่จะคาดคะเนได้	1	2	3	4	5	6	7
22. คุณสมบัติของข้าวตามความต้องการของลูกค้ามีการเปลี่ยนแปลงตลอดทั้งปี	1	2	3	4	5	6	7
23. ระยะเวลาที่ลูกค้าสั่งซื้อข้าวจนถึงเวลาที่ลูกค้าต้องการให้มีการจัดส่ง ไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
24. สัดส่วนข้าวดีกับข้าวเสียหลังผ่านกระบวนการสีหรือบรรจุไม่คงที่	1	2	3	4	5	6	7
25. คุณภาพของข้าวหลังผ่านการสีหรือจัดเก็บมีการเปลี่ยนแปลงเมื่อเทียบกับก่อนผ่านกระบวนการดังกล่าว	1	2	3	4	5	6	7
26. ระยะเวลาที่ข้าวเริ่มเข้ากระบวนผลิต (การสีหรือบรรจุ) จนกระทั่งได้ผลิตภัณฑ์ข้าว ไม่แน่นอน	1	2	3	4	5	6	7

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
27. ข้อมูลเกี่ยวกับปริมาณคลังข้าวและกำลังการผลิตข้าวที่มีอยู่ **มีการบันทึกตลอดเวลา** (ข้อมูลอาจจะถูกต้องหรือไม่ถูกต้อง)	1	2	3	4	5	6	7
28. ข้อมูลเกี่ยวปริมาณคลังข้าวและกำลังการผลิตข้าวที่มีอยู่นั้น**ถูกต้อง**	1	2	3	4	5	6	7
29. ข้อมูลเกี่ยวปริมาณคลังข้าวและกำลังการผลิตข้าวที่มีอยู่เข้าถึงได้เมื่อต้องการ	1	2	3	4	5	6	7
30. การแข่งขันของคู่แข่งทางการค้าไม่สามารถคาดคะเนได้ เช่นการลดราคาสินค้า และอื่นๆ	1	2	3	4	5	6	7
31. การแข่งขันระหว่างคู่แข่งทางการค้า**ในประเทศ**เป็นไปอย่างเข้มข้น (มีการแข่งขันสูง)	1	2	3	4	5	6	7
32. การแข่งขันระหว่างคู่แข่งทางการค้าใน**ต่างประเทศ**เป็นไปอย่างเข้มข้น	1	2	3	4	5	6	7
33. นโยบายของรัฐบาลที่ส่งผลกระทบโดยตรงต่อบริษัทของท่าน ที่เกี่ยวกับ**การปลูกข้าว** มีการเปลี่ยนแปลงแบบไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
34. นโยบายของรัฐบาลที่ส่งผลกระทบโดยตรงต่อบริษัทของท่าน ที่เกี่ยวกับ**การค้าข้าว** เช่น ภาษี มีการเปลี่ยนแปลงแบบไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
35. นโยบายของรัฐบาลในการ**ประกันราคาข้าวและรับจำนำข้าว** ที่ส่งผลกระทบโดยตรงต่อบริษัทของท่าน มีการเปลี่ยนแปลงแบบไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
36. รัฐบาลออกนโยบายใหม่ๆ ที่ไม่สามารถคาดคะเนได้ส่งผลกระทบโดยตรงต่อบริษัทของท่าน	1	2	3	4	5	6	7

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
37. ความรุนแรงของความแห้งแล้งที่เกิดขึ้นในแต่ละปี และส่งผลกระทบโดยตรงต่อบริษัทของท่าน ไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
38. ระยะเวลาของความแห้งแล้งที่เกิดขึ้นในแต่ละปี และส่งผลกระทบโดยตรงต่อบริษัท ของท่าน ไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
39. ความรุนแรงของน้ำท่วมที่เกิดขึ้นในแต่ละปี และส่งผลกระทบโดยตรงต่อบริษัท ของท่าน ไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
40. ระยะเวลาของน้ำท่วมที่เกิดขึ้นในแต่ละปี และส่งผลกระทบโดยตรงต่อบริษัท ของท่าน ไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7
41. การเปลี่ยนแปลงอุณหภูมิที่ส่งผลกระทบโดยตรงต่อบริษัทของท่านในแต่ละปี ไม่สามารถคาดคะเนได้	1	2	3	4	5	6	7

<u>ส่วนที่ 3:</u> กลยุทธ์ในการบริหารงานในองค์กรของท่าน

- *กรุณาตอบคำถามทุกข้อ*
- *กรุณาวงกลมหรือกากบาทตัวเลขที่สะท้อนถึงสถานะปัจจุบันขององค์กรของท่าน แต่ละตัวเลขมีความหมายดังนี้*

1 = ไม่เห็นด้วยอย่างมาก *5 = เห็นด้วยเล็กน้อย*
2 = ไม่เห็นด้วย *6 = เห็นด้วย*
3 = ไม่เห็นด้วยเล็กน้อย *7 = เห็นด้วยอย่างมาก*
4 = ปานกลาง

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
42. กลยุทธ์การจัดซื้อข้าวกับชาวนาหรือผู้ค้าข้าวเปลือก ถูกพิจารณาร่วมกับกลยุทธ์การวางแผนการผลิต	1	2	3	4	5	6	7
43. ผู้ที่ทำหน้าที่จัดซื้อข้าวกับชาวนาหรือผู้ค้าข้าวเปลือก มีการจัดซื้อตามกลยุทธ์ของบริษัท	1	2	3	4	5	6	7
44. กลยุทธ์การจัดซื้อข้าวกับชาวนาหรือผู้ค้าข้าวเปลือก ถูกพิจารณาว่ามีความสำคัญมากต่อผู้บริหารระดับสูง	1	2	3	4	5	6	7
45. กลยุทธ์การจัดซื้อข้าวกับผู้จัดส่ง พิจารณาถึงความเสี่ยงในระยะยาวของบริษัท	1	2	3	4	5	6	7
46. บริษัทของท่านตรวจสอบความพึงพอใจของลูกค้าเป็นระยะๆ	1	2	3	4	5	6	7
47. บริษัทของท่านตรวจสอบความคาดหวังจากลูกค้าในอนาคตเป็นระยะๆ	1	2	3	4	5	6	7
48. บริษัทของท่านให้ความสำคัญกับการสร้างความสัมพันธ์ที่ดีกับลูกค้า)-	1	2	3	4	5	6	7
49. บริษัทของท่านทำให้ลูกค้ารู้สึกว่ามี การค้าขายระหว่างกันอย่างเป็น ธรรม	1	2	3	4	5	6	7

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
50. ความพึงพอใจของลูกค้า เป็นกลยุทธ์ที่ผู้บริหารระดับสูงให้ความสำคัญ	1	2	3	4	5	6	7
51. การสร้างความพึงพอใจของลูกค้า เป็นส่วนหนึ่งของแผนธุรกิจของ บริษัท	1	2	3	4	5	6	7
52. ระบบการพัฒนาคุณภาพอย่างต่อ เนื่อง (Total Quality Management) ถูกใช้ในบริษัท	1	2	3	4	5	6	7
53. ที่ตั้งของชาวนาหรือผู้จัดส่งข้าว อยู่ใกล้กับบริษัท	1	2	3	4	5	6	7
54. การผลิตข้าวของบริษัทขึ้นอยู่กับความต้องการของลูกค้าเป็นหลัก	1	2	3	4	5	6	7
55. บริษัทพยายามลดการตรวจสอบผลิตภัณฑ์ข้าวขาออก	1	2	3	4	5	6	7
56. การสร้างความสัมพันธ์ที่ดีกับชาวนาหรือผู้จัดส่ง เป็นกลยุทธ์ที่ผู้บริหารระดับสูง ให้ความสำคัญ	1	2	3	4	5	6	7
57. กลยุทธ์ตามข้อ 57 ถึง 61 ถูกพิจารณาในแผนระยะยาวของบริษัท	1	2	3	4	5	6	7

ส่วนที่ 4: ความสามารถทางธุรกิจในองค์กรของท่าน

- *กรุณาตอบคำถามทุกข้อ*
- *กรุณาวงกลมหรือกากบาทตัวเลขที่สะท้อนถึงสถานะปัจจุบันขององค์กรของท่าน แต่ละตัวเลขมีความหมายดังนี้*

1 = ไม่เห็นด้วยอย่างมาก *5 = เห็นด้วยเล็กน้อย*
2 = ไม่เห็นด้วย *6 = เห็นด้วย*
3 = ไม่เห็นด้วยเล็กน้อย *7 = เห็นด้วยอย่างมาก*
4 = ปานกลาง

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
58. บริษัทของท่านมีความยุ่งยากในการควบคุมคุณภาพทางกายภาพของผลิตภัณฑ์ข้าว (เช่น ความยาวและสีของเมล็ดข้าว)	1	2	3	4	5	6	7
59. คุณภาพของผลิตภัณฑ์ข้าวของบริษัทดีมาก	1	2	3	4	5	6	7
60. บริษัทของท่านมีความยุ่งยากในการควบคุมคุณสมบัติทางเคมีของผลิตภัณฑ์ข้าว เช่นสารปนเปื้อน	1	2	3	4	5	6	7
61. บริษัทให้ความสำคัญกับ ระบบการจัดการสิ่งแวดล้อม เช่นการใช้วัสดุใช้แล้วมาใช้ซ้ำ	1	2	3	4	5	6	7
62. จำนวนการสั่งซื้อผลิตภัณฑ์ข้าวเพิ่มขึ้นเนื่องจากกิจกรรมทางการตลาด เช่น การลดราคาเมื่อสั่งซื้อในจำนวนมากๆ	1	2	3	4	5	6	7
63. ต้นทุนการผลิตข้าวต่ำ	1	2	3	4	5	6	7
64. ต้นทุนการจัดส่งผลิตภัณฑ์ข้าวต่ำ	1	2	3	4	5	6	7
65. ต้นทุนการจัดเก็บข้าวเปลือก/ข้าวสาร/ผลิตภัณฑ์ข้าวต่ำ	1	2	3	4	5	6	7

	ไม่เห็นด้วยอย่างมาก	ไม่เห็นด้วย	ไม่เห็นด้วยเล็กน้อย	ปานกลาง	เห็นด้วยเล็กน้อย	เห็นด้วย	เห็นด้วยอย่างมาก
66. อัตราการคืนทุนของบริษัทสูง (กรุณาประมาณในอัตราส่วนกำไรต่อมูลค่าทรัพย์สินทั้งหมด)	1	2	3	4	5	6	7
67. ผลกำไรของบริษัทสูง	1	2	3	4	5	6	7

ส่วนที่ 5: ข้อมูลเกี่ยวกับผู้กรอกแบบสอบถาม (ทางเลือก)

ถ้าท่านต้องการสรุปผลการสำรวจ กรุณา √ ใน ☐ และให้ข้อมูลดังต่อไปนี้ เพื่อทางนักวิจัยจะสามารถส่งสรุปผลการสำรวจแก่ท่านได้

ชื่อ____

ที่อยู่ ____

____

Email address: ____

End of Survey