Supply Chain Disruption Costs Study in International Containerised Maritime Transportation

Zeyan Zhang

A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

Institute of Transport and Logistics Studies

The University of Sydney

Business School

2014

ABSTRACT

The global economy relies highly on international trade, and the international maritime transport system acts as the lifeblood carrying and transporting materials and goods globally, realizing the economy globalization in an effective and efficient way. However, globalization increases the interdependence and complexity of global supply chains and drives it to be more vulnerable to disruptions. Meanwhile, the international marine transport system is a complex and intertwined system exposed to high risks and decreased safety due to its very accessibility and operational flexibility. Thereby, global supply chains integrated with international maritime transportation systems are inherently vulnerable to various disruptions. Studies of supply chain disruptions particularly quantifying transport related disruption costs are becoming increasingly important. However, research on maritime transport related supply chain disruptions, in particular, quantifying its disruption costs is under-represented in the transport literature, due largely to the features of supply chain disruptions, but also because of the complexity of maritime related supply chains. Current research in transportation has tended to concentrate on shippers' transport mode choice and port selection. In the context of a global market, however, the behaviour of maritime containerised shippers has to be viewed as a complex decision and an integral element of the supply chain management strategy. Those shippers' transportation choice decisions should be emphasized and studied to reveal their behaviour changes between normal operations and disruption circumstance.

This research adds to the paucity work on investigating the maritime transport related supply chain disruptions and quantifying its disruption costs based on shippers' maritime transportation choice behaviour. It presents the results of a microanalysis of freight transport choice decisions in an international containerised maritime transport chain context. The Latent Class Model (LCM) is applied to identify the key service attributes and its preference heterogeneity in maritime transportation and to estimate the marginal values for the quality of maritime transport service with and without a disruption, simultaneously, quantifying the disruption costs through comparing each attribute's marginal value difference between normal and disruption operations. The Seemingly Unrelated Regression model (SURE) is utilized to explore the sources influencing shippers' preference heterogeneities. In doing so, we are able to gain an understanding as to where and how much should be invested in order to facilitate recovery in the case of a disruption based on the view of the maritime participants' perspectives. The research results confirm freight rate, transit time, reliability, damage rate, and frequency as the key service attributes influencing shippers' transport choice. They also reveal shippers' VOT increase by more than four-times, VOR nearly double, and VOD increase about twenty percent if a disruption takes place, and identify shippers' transport decisions vary with its product, shipment, company and supply chain characteristics no matter with or without a disruption. This research quantifies the costs of supply chain disruption in containerised maritime transport context for the first time, and its results provide useful industrial implications for maritime transport chain related parties.

ACKNOWLEDGEMENTS

The journey of studying for a PhD is like running a marathon, which requires tremendous energy, patience, firm perseverance, time, and wisdom. The completion of this dissertation is the result of immeasurable effort and support from many individuals. Their contributions are appreciated sincerely and must be recognised.

Firstly, I wish to thank my husband, daughter, and parents who have always been, and always will be there for me. They have been through my entire journey, giving their boundless love, encouragement, and support.

Secondly, I would like to thank my two supervisors, Professor John Rose and Professor David Hensher. I am much indebted to Professor John Rose in ways that words cannot convey. This thesis would not have been accomplished without John. From a zero knowledge base, John guided me step by step in understanding the discrete choice modelling and the seemingly unrelated regression modelling. His generous guidance helped me tremendously to gain analytical skills. His super efficiency and continuous support to my work motivated me to carry out quality work until the end. Beyond that, I would also like to express my deep-hear thanks for his patience in correcting my writing. Professor David Hensher never stopped giving help and offering priceless advice and valuable comments to my research. His depth and breadth of knowledge is unequal to any I have met before. Professor David Hensher is more than just a supervisor. His intelligence, academic achievement, and leadership always inspire me to follow in my academic pursuits, as well as in life in general. And thanks to John and David's encouragement in all-pervasive, I will always carry wisdom and confidence that I could have obtained nowhere.

I owe an eternal debt of gratitude not only to my official supervisors, but also to my unofficial third supervisor, Dr. Miguel Andres Figliozzi now at Portland State University. Dr. Miguel Andres Figliozzi was my former supervisor in the University of Sydney and suggested this research topic for me. He provided me with the great opportunity to start my doctoral research, and introduced me to the interesting fields of supply chain disruption and marine transportation studies. He have been enormously helpful, very supportive and very patient, and guided me through in the early stage of my PhD study. After he left the University of Sydney for family reasons, selflessly he still offered me the boundless generosity with time, effort, and compassion in assisting my research and answered my questions in very detail. He has been not only a supervisor, but also a mentor and a friend.

I wish to acknowledge the support of my PhD colleagues, colleagues and friends in ITLS over those years. In particular, I would greatly thank Andrew Collins, my peer in his doctoral program in ITLS. This thesis would not have been possible without his support and assistance in the development of the CAPI software. I am grateful to Dr. Ada Suk-Fung Ng who has offered valuable advice in maritime and logistics to my study and always been there like a friend of mine. I also wish to thank Jun Zhang who has offered moral support throughout my studies in ITLS just like an elder brother. My other supportive PhD colleagues, Matthew Beck, Chinh Quoc Ho, Adrian Ellison, Claudine Moutou, Li Shen, Alejandro Tirachni, and Chi-hong Tsai should be also praised. The contributions from support staffs at ITLS including Jo Dumergue, Annette Thomas, Bart Ahluwalia, and Kaylene Bodell are unforgettable. In addition, special thanks goes to Kamy Ooi, faculty liaison librarian for her suggestions during my endnote library editing.

I would like to express my deep-felt appreciation to my Lijuan aunt and her families in Sydney. They have been looking after my family and me whenever I studied in Sydney throughout these years. The accomplishment of this thesis would not have been possible without their support, selfless tolerance, love, and care. In particular, I would like to thank my cousin, James and his wife Tina. They were always keen to provide advice and assistance and listened to my rehearsals with patience and enthusiasm.

Finally, I wish to acknowledge all of those organisations and respondents that participated in this study. I am also very grateful to my brother and sister. Their special love, caring, and understanding have always given me power during the PhD journey.

STATEMENT OF ORIGINALITY

I certify that this work has not previously been submitted for a degree or diploma in any university. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

Zeyan Zhang

Institute of Transport and Logistics Studies

The University of Sydney Business School

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1 INTRODUCTION

1.1 Economic Globalization, Global Supply Chains, and International Maritime

Economic globalisation is a process that increases the flows of knowledge, resources, goods and services among nations to facilitate and exploit each nation's comparative advantage and enhance their strengths. The global economy relies highly on international trade that multinational supply chains (SCs) work within via global transactions involving purchasing, manufacturing, and selling. The international maritime transport system is an integral component of global SCs. It acts as the lifeblood, carrying and transporting materials and goods globally and realizes economy globalization in an effective and efficient way. Thus, economic globalization, global SCs, and international maritime are interdependent and supplementary to each other.

Shipping is the primary mode of transportation for world trade. According to International Maritime Organization (IMO) (2005), more than 90 percent of global trade by volume is carried by sea domain via containerised cargo. As economic globalization has expanded, the demand for maritime transportation derived from international trade has increased significantly, especially for maritime container trade. Thus, the maritime industry experienced a steady and healthy growth in the last two decades. Global container trade recorded an estimated 10 percent annual growth rate on average over the last two decades. The value of world maritime container trade increased from USD $2 trillion in 2001 to USD $4 trillion in 2008. There was a total of 7.9 billion tonnes of seaborne trade in 2009 and 15.3 percent of it was containerised cargo (Clarkson Research Services 2009).

Therefore, global SCs and maritime transportation systems are extremely important to economies throughout the world. Any disruption to global SCs or the international maritime transport system could have immediate and momentous impact upon the world economy (Organisation for Economic Co-operation and Development (OECD) 2003).

1.2 Supply Chain Disruptions

In this thesis, supply chain disruption (SCD) is defined as an unanticipated occurrence that could interrupt the upstream and downstream efficient flows and result in an abrupt cessation of movement of goods, services, information, and cash flows within a global supply network with either insignificant or far more likely large scale operational and financial consequences (Svensson 2000; Kleindorfer and Saad 2005; Craighead et al. 2007).

Global SCs are exposed ever-increasingly to uncertainty and vulnerability by the following drivers: (1) economic globalization lengthen global SCs, in turn increase interdependence and complexity of global SC network; (2) Just-In-Time (JIT) or lean management approaches add more complexity on SCs; (3) centralization of production and distribution, the introduction of outsourcing strategies, and a reduction of supplier bases expose SCs to greater levels of uncertainty; (4) the explosion of new products and shortened product life cycles increase SC vulnerabilities; and (5) the complexity of modern-day transportation systems alongside growing transport security issues increase transport uncertainty and unreliability, thereby increasing the risk of SCDs (Christopher 2005; Peck 2005). Hence, modern-day global SCs are complex and interconnectivity networks, and inherently vulnerable to various disruptions.

Given the above, SC managers now face an unprecedented level of risk and anxiety in relation to possible SCDs. Recent global events have heightened this anxiety, such as the Nisqually 2001 and Sichuan China 2008 earthquakes; Hurricanes Katrina and Rita in 2005; Seattle's Hanukkah Eve Wind Storm of 2006; the credit bubble burst in 2007; Minneapolis' 35W bridge collapse in 2007; and the 2010 eruptions of volcanos in Iceland; the Fukushima Daiichi nuclear power plant explosion and Europe's ongoing economic crisis. Therefore, sources that have been identified as possible causes of SCD have increased whilst at the same time also diversified. Natural disasters, terrorist attacks, potential for wars, political instability and upheaval, economical instability, infrastructure failure, labour disputes, as well as disruptions in supply, transportation, facilities, market demand, cash flow, communication, government regulation, and human resources are now all viewed as potential sources of SCD (Wilson 2007) . At the same time, many of the sources leading to SCDs, in particular political turmoil, market turbulence, exchange rate fluctuations and pending regulatory changes are occurring with increasing frequency (KPMG, 2011).

Any disruption to a SC will potentially be very costly and harmful to its commercial relationships, depending on the length and severity of the disruption. For example, the October 2002 U.S. West Coast longshoremen's lockout costed USD $1 billion per day, damaging the US economy in the first week and grew to USD $2 billion per day in the second week, and halted enormous flow of containers through the 29 West Coast ports. Further, this labour dispute involving 10,500 longshoremen endangered the jobs of some four million US workers, and factories' productivity (Sheffi 2005).

However, the features of SCDs make it difficult to measure or quantify their economic impacts. First, a disruption is a conflagration event with a degree of high unpredictability and may result in impacts which are unfathomable and incalculable. Second, a disruption can have ripple effect that is disproportionate to the actual event, given the increasing interconnectedness of various partners in modern SC networks. Further, disruption impacts can be transferable. An accident could occur anywhere in the world, but its impacts may well go beyond the location of the occurrence. Finally, the longer-term or delayed impact of a disruption is hard to estimate, and it could be larger than the direct immediate impact. It takes time for companies to recover and return to equilibrium after a disruption. Thus, indirect damages from disruptions could affect SC economic performance adversely during the recovery period (Massachu-setts Institute of Technology (MIT) Center for Transportation & Logistics 2008).

Modern global SCs operate in a world with growing crises and uncertainties. Business managers throughout the world have become more sensitive to the vulnerabilities of their global SCs. They start to question what to do to improve SC resilience to prevent and mitigate the possible huge impacts from an unexpected disruption, and of how much it is worth investing in it without pain.

1.3 The Maritime Transportation Security

The international marine transport system is a complex and intertwined system with intrinsic vulnerabilities. The international marine transport system is a complex network equipped with various facilities and infrastructures from factories to terminals, to distribution centres, to markets with different transport modes (Braathens 2010). It involves movement of diverse cargoes involving numerous participants including but not necessarily limited to exporters/importers, freight forwarders, customs brokers, transporters and shippers, and ultimately the final customers (Willis and Ortiz 2004). Any physical movement in a containerised marine chain represents a potential vulnerability that may result in a prolonged disruption. Thus, the international maritime transport system and its shipments are being increasingly exposed to higher levels of risks and lower safety levels due to increasing accessibility and operational flexibility.

Historically, maritime security was less concerned than is currently the case about cargo damage and loss, stowaways and smuggling. This changed however after September 11, 2001 when pressure and greater scrutiny were brought to bear on the areas of maritime and SC. Further concerns have been raised about the possibility of ships and the containers they carry being used to smuggle weapons of mass destruction (WMD), or other dangerous materials. Indeed, shipping has been identified as the most suitable and accessible areas within the transportation sector for the illicit transport of conventional and unconventional terrorist weapons (Tzannatos 2003). In addition, marine transportation carries more than 90 percent of global trade, meaning that any attack, or even the threat of an attack, could be vulnerable points in the maritime chains. Thus, terrorism becomes the new dimension of maritime security and gains ever-increasing attention in recent years.

The issue of maritime security has also been brought to the forefront recently as a major concern on the international maritime agenda due to a surge in piracy incidents. The overall annual cost of piracy to the maritime industry is estimated to be between USD $1 and $16 billion, more if the costs of implementing mitigation efforts are also included. In addition, a war risk insurance coverage at USD $20,000 per ship, per voyage (excluding injury, liability, and ransom coverage) was imposed on ships that transit via the Gulf of Aden and the Suez Canal. Compared with the USD $500 required previously to purchase additional insurance coverage, the incremental cost of war risk insurance premiums for the 20,000 ships passing through the Gulf of Aden is estimated at USD $400 million (United Nations Conference on Trade and Development (UNCTAD) 2009).

Other challenges that affect maritime transport security and seaborne trade safety are energy security, energy prices, bunker fuel costs, as well as climate change. Thus, the safety of maritime transportation systems and containerised trade are facing ever-increasing challenges.

Understanding the unfathomable potential impacts of disruptions to maritime transportation operations, governments and policy makers have designed and executed more initiatives and legislations to strengthen maritime security over the past decade than at any other time in history.

1.4 Maritime Security Initiatives and Its Implement Costs

Since the terrorist attack of September 11, 2001, extensive initiatives have been undertaken to improve and enhance the security of maritime transport systems and global containerised SCs: The Customs-Trade Partnership Against Terrorism (C-TPAT) in November 2001; The International Ship and Port Security Code (ISPS) 2002; The Container Security Initiative (CSI) announced by the US Customs and Border Protection (CBP) 2002; The Advanced Manifest Rule (AMR, also called the 24-hour Rule) 2004; the Security and Prosperity Partnership (SPP)2005; the Security and Accountability for Every (SAFE) Port Act 2006; the Secure Freight Initiative (SFI) 2006; "10 + 2" Initiative 2008; and the "Implementing Recommendations of the 9/11 Commission Act of 2007" – Section 1701 (9/11 Act).

The implementation of these new security regimes and initiatives require continuous investment in security equipment, procedures, and the recruitment and training of security personnel. More additional costs are needed to carry out the new security measures, including detailed reporting, further inspections, and other operational requirements (Bichou 2008). The extra cost of implementing new maritime security regimes has been studied extensively elsewhere. For example, the United Nations Conference on Trade and Development (UNCTAD) conducted a global survey on initial and annual costs for ISPS Code compliance. Its results revealed that the ISPS Code compliance costs, for each ton or TEU handled, would be USD $0.08 and USD $3.6 respectively (United Nations Conference on Trade and Development (UNCTAD) 2007). The implementation and operating costs of C-TPAT are reported to be USD $38,471 and USD $69,000, respectively (Diop, Hartman and Rexrode 2007). The additional costs to comply the 24-hour rule are estimated up to USD $6 per shipped container and USD $40 per bill of lading. If missing or inaccurate data are submitted to the CBP, a fine of USD $5000 for the first time and USD $10000 thereafter will be imposed to ocean carriers and NVOCCs (Bichou 2008).

Furthermore, the investment on upgrading security infrastructures at ports is very costly. It ranged from USD $10 million to $50 million per port in USA even prior to September 11. A total amount of grants application for improving port security infrastructure, technology and personnel reached USD $697 million (United States General Accounting Office (GAO) 2002), and USD $650 million was provided by Congress through FY2005 in direct federal grants (Congressional Research Service (CRS) 2005).

1.5 Motivation

Although there is an increased awareness and recognition among managers, consultants, and academics that SC performance is increasingly important to business success, the implementation of measures to prevent or minimize the costs of disruptions is not widespread. Recent survey results indicate that 82 percent of companies are concerned with SC resiliency and disruptions, however, only 11 percent of companies are actively taking action to avoid or minimize disruptions (Klie 2006).

A large number of studies reported in the literature have centred on identifying sources of uncertainty, risks, and vulnerability related to supply chain management (SCM) (e.g. Smelzer and Siferd (1998); Zsidisin and Ellram (1999); Hallikas et al. (2000); Ritchie et al. (2000); Svensson (2000); Lindroth and Norrman (2001); Johnson (2001); Lamming et al. (2001); Christoper et al. (2002)). However, little research appears to have been conducted examining SCDs, specifically, quantifying the disruption costs is limited (Brindley 2004). Furthermore, the methodologies of quantifying the costs of SCDs are still in their infancy due to the complexity of disruptions.

Discrete choice techniques have been applied successfully to study shippers' choices of freight transport/logistics services in a diversity of contexts. Swait, Louviere and Williams (1994) combined stated preference (SP) and revealed preference (RP) data to understand how shippers chose carriers or transport service providers. Kawamura (2000) collected RP data in California to estimate the value of time for trucking shipments as a function of company and shipment characteristics. Wigan et al. (2000) estimated truckers' value of time per pallet per hour in metropolitan multidrop services using SP data in Australia. Kurri, Sirkiä and Mikola (2000) conducted a SP freight road and rail study in Finland. Bolis and Maggi (2003) surveyed 22 firms in Italy and Switzerland and found that transit time and reliability were dominant factors for companies using Just in Time (JIT) principles or serving the consumer market directly. Frequency of service was also significant, and cost was particularly important for low value commodities. However, a comprehensive survey of methodologies and empirical studies conducted by Zamparini and Reggiani (2007) revealed that the large majority of the empirical studies aimed at determining shippers' willingness to pay (WTP) to reduce the travel time of a specific shipment were conducted in the early 1990s. The values of time, reliability, damage, and frequency in international containerised maritime transportation with and without a disruption have not been addressed and studied specifically in the literature.

Quantifying the disruption impact on containerised supply chains is becoming increasingly important and imperative due to the importance of global containerised SCs and maritime security, the fatal consequence of SCDs and the enormous costs to enhance maritime security. Nevertheless, little has been done to measure the consequences of an interruption only with a handful of studies looking specifically at SCDs. Particularly, research looking at quantifying transport related SCD costs is rare, especially in terms of studying the value changes of transport attributes comparing normal operation and disruption circumstance from the shippers' perspectives.

This research focuses on addressing this gap. It utilises advance discrete choice techniques to identify the important service attributes in containerised maritime transportation and estimate its value of travel time, reliability, damage rate, and frequency of sailing under normal operations. Moreover, the transport related disruption costs are estimated through contrasting the different values of transit time, reliability, damage between normal operation and a disruption scenario. Furthermore, in order to identify shippers' preference heterogeneities in maritime transportation, this research also investigates the discrepancy in the values of maritime service attributes and its variations with individual shipper's geographical location, production, specific shipment, and company/SC characteristics.

1.6 Contributions to the Literature

This thesis offers original and significant contributions to the academic and research literature in the following areas: Firstly, real industrial data on container shipping were collected in three cities regarding how companies perceive transport related SCDs and what they are doing to respond and address them. This research adds to the paucity of existing work on investigating transport related SCDs and their associated costs to the international containerised maritime transportation industry. Secondly, this research proposes the use of advance discrete choice techniques to estimate the value of maritime transport service attributes, including travel time, reliability, damage rate, and sailing frequency under normal operations. The results of this research are applicable and useful for companies' international maritime trade transport planning. Thirdly, this research quantifies the maritime transport related SCD costs in terms of the value of travel time, reliability, and damage through econometric analysis of choice data under scenarios with and without disruptions. Fourthly, apart from estimating the value of important maritime service attributes with and without a disruption, this research also examines how the values of maritime service attributes vary with individual shipper's products, shipments, and company/SC characteristics. To the best of the author's knowledge, this is the first research effort that studies and quantifies how the characteristics of production, shipments, companies, and SCs interact and impact on the value of maritime service attributes. The results distinguish and highlight the difference of the value of maritime service attributes in different industries, companies, and SC characteristics. Lastly, this is also the first research addressing security issues in the choices of maritime transportation organizations, including SC integration, such as contingency plan, JIT inventory policy, and prevention of maritime security threats, into maritime transportation choice decisions. The previous major studies on maritime security focused on preventing and mitigating terrorist attack at ports or on vessels. Shippers' priority needs of maritime transport attributes under disruptions were excluded at the maritime security policymaking level. However, shippers are the primary driver of the maritime industries. Costly expenses related to maritime security improvement will ultimately be passed on to shippers in forms of freight rate or taxation, hence governments and policy makers should consider the preferential and primary needs under disruptions from the shippers' perspective. This research has provided a quantitative value of maritime transport service attributes under normal and disruption scenarios, thereby, providing a benchmark of investment in improving transport service attributes under disruptions.

1.7 Thesis Outline

This thesis is organized as follows. Chapter Two provides a literature review. Chapter Three presents the methodology to be used and the hypotheses to be tested. Chapter Four describes the survey design and the collection of the data used. Chapter Five provides a description of the analysis undertaken based on the data captured from the respondent companies, as well as the disruption costs and disruption management strategies they employ. Chapter Six presents the tests of the hypotheses outlined in Chapter Three and the analytical framework utilized to estimate the value of maritime service attributes and related disruption costs, as well as value variations associated with geographical locations, production, shipment, and company/SC characteristics. Chapter Seven discusses the industry implications of the findings after which. Chapter Eight draws conclusions.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

Globalization increases interdependence and complexity of global SCs, making them more vulnerable. SCs are exposed to higher risks by increasing uncertainties from the external environment, the related operation network, and the internal SC itself. It is necessary to study SCDs, especially disruptions in international containerised maritime transport chains, transportation disruption costs, and impacts on SC performance, as well as on a national or global economy. The broad impact of delays on international SCs has not been researched adequately within the transportation and logistics literature. This research will explore the impact of transport delays on containerised maritime importer and exporter SCs.

New maritime security initiatives conducted by international organizations and different countries are designed to improve maritime industry security and prevent terrorist and criminal threats on containers and its SCs. However, they also add huge monetary and administration burdens on stakeholders of international containerised maritime transport chains. Debate exists over who should bear the burden of security investment and running/maintenance costs: industry, government, or service receivers. Thus, it is important to quantify disruption costs in containerised maritime transport chains for investigating how much is worth investing, and of what should be done to improve the maritime transportation logistics service and enhance the ability of recovering from disruptions.

China and Australia are very important trading partners to many countries in Asia and the Pacific and account for 40 percent of the global seaborne trade good loadings.

This chapter reviews the existing literature and focuses on the following aspects: the first section summarizes the features of contemporary SCs and SC management, and reviews studies in SC risk management. The second section reviews studies in transport related SCDs and builds a conceptual framework for identifying SC vulnerabilities. The third section, based on the theoretical framework, identifies the vulnerabilities in a containerised maritime transport chain, reviews the impacts of disruptions in a containerised maritime transport chain, and the needs of studying maritime transport disruptions. The fourth section outlines the extant international maritime security initiatives/regulations post-September 11, 2001 attack, reviews the implementation costs and impacts of new maritime security initiatives. The fifth section points out the important roles of China and Australia to global economy. The last section identifies the research gap and research questions of this thesis and draws a conclusion for this chapter.

2.2 Supply Chain Disruptions

2.2.1 Features of Supply Chains and Supply Chain Management

A SC is a complex system or network that (i) involves three or more interdependent organizations (from vendors, service providers, to ultimate customer), which (ii) links directly or indirectly through upstream and downstream flows of unprocessed raw materials, components, finished goods, services, finances, and information, and (iii) produces/adds value on its products or services in different processes and activities from ultimate supplier to ultimate customer (see Figure 2-1) (Christopher 1992; Cooper and Ellram 1993; Londe and Masters 1994; Lambert, Stock and Ellram 1998; Mentzer et al. 2001; Peck 2006; Craighead et al. 2007; Council of Supply Chain Management Professionals (CSCMP) 2010a).

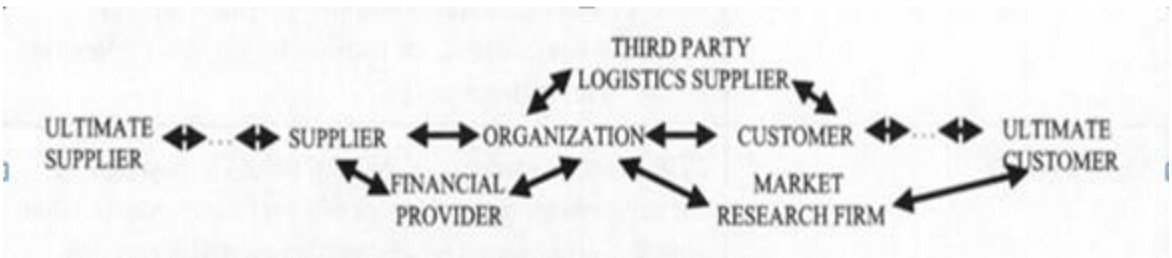


Figure 2-1: Ultimate Supply Chain
Source: Mentzer et al. (2001)

Over the last two decades, organisations operating within SCs, no matter how large or small, have concentrated on improving their SC efficiency and performance. Thereby, Supply Chain Management (SCM) has become a key component of an organisation's or SC's competitiveness and effectiveness (Womack and Jones 2005).

The concept of SCM is a combination of strategy and activities (Mentzer et al. 2001; Gihson, Mentzer and Cook 2005; Mentzer, Stank and Esper 2008; Council of Supply Chain Management Professionals (CSCMP) 2010b). First, SCM seeks to plan and manage all activities involved in sourcing, procurement, manufacturing operations, logistics, marketing, sales, production design, finance, and information technology (IT) of the business operating throughout the whole of the SC. Second, SCM is strategic-level recognition of co-ordination and collaboration throughout the SC network. It integrates supply and demand management, business functions, and business processes within and across organizations. Ultimately, the goals of SCM are to eliminate wastes, increase customer value and satisfaction at lowest costs, to create a cohesive and high-performing business model and improve SC efficiency and ultimately provide a competitive advantage (Mentzer et al. 2001; Council of Supply Chain Management Professionals (CSCMP) 2010b). However, Hendricks and Singhal (2005) point out that modern-day SCs emphasize cost reduction and efficiency, but ignore the increasing risks of SCDs.

The very nature of SC and SCM concepts imply that SCs and organizations within them are inherently open to a number of vulnerabilities. This is because (i) SCs are typically not a linear chain but a complex network made up of multiple organizations. The strong inter-connectivity and inter-dependence among SC partners drives SC vulnerability if any joint point disconnects (Craighead et al. 2007). (ii) SC networks link via the flow of goods/services, finance, and information. Any obstacle to any of these flows has the potential to disturb and disrupt the normal operations/processes of the entire SC network. (iii) The goals of SCM impel SC vulnerability. SCM theories such as JIT, supplier concentration, single sourcing, global sourcing, mass customization, time compression, Vendor Managed Inventory (VMI) and virtual organizations aim to eliminate SC waste and improve efficiency. These SCM concepts however tend to reduce redundancy and promote resilience of SC, but leaves little to no room for error. It also promotes interdependence and in some cases complexity which, in turn exacerbates potential vulnerabilities that can lead to SCD (Harland, Brenchley and

Walker 2003; Christopher and Peck 2004; Hendricks and Singhal 2005; Zsidisin, Ragatz and Melnyk 2005).

In addition, SCs are typically complex networks closely inter-connected to industrial, economical and social environments. Therefore, drivers of SC vulnerability not only arise from a specific partner relationships, a specific activity within a specific firm or SC, but also from the external environment (Olson and Wu 2010). First, disasters and terrorism have increased dramatically over the last decades (Wagner and Neshat 2010). Second, the rapid development of globalization and the advent of new technologies, especially high end IT technology, enables and boosts SCs to operate competitively in a global market (Wagner and Bode 2006). Distance and interdependence on IT technologies increase vulnerability however. Third, economic and political instability, as well as government/security regulations add to the vulnerability of SCs.

2.2.2 Definition of Supply Chain Disruptions

With growing awareness of the vulnerabilities faced by SCs and the impacts of SCM operations under abnormal operational circumstances, coupled with an ever increasing unpredictability and increasingly uncertain business environment, SC risk, vulnerability, and disruption have become a major issue in SCM attracting growing attention from academics and industrial practitioners alike. Indeed, over the past 15 years there has been a surge in articles addressing these issues (Svensson 2001; Chapman et al. 2002; Harland, Brenchley and Walker 2003; Brindley 2004; Kleindorfer and Saad 2005; Peck 2005; Sheffi 2005; Peck 2006; Tang 2006a; Tang 2006b; Wagner and Bode 2006; Khan and Burnes 2007; Stecke and Kumar 2009; Wagner and Neshat 2010).

In order to define SCD in this thesis, it is important to understand the definition of risk. The study of risk began in the seventeenth century. French mathematicians Blaise Pascal and Pierre de Fermat first apply mathematics to gambling and built a foundation for the development of probability theory in risk analysis (Frosdick 1997). Moore (1983) defines risk as encompassing both the probability of loss and the hope of gain. A more standard definition of risk is “the chance, in quantitative terms, of a defined hazard occurring. It combines a probabilistic measure of the occurrence of the primary events with a measure of the consequences of those events" (Royal Society 1992). Risk is defined more operationally in SC contexts as being "perceived to exist when there is a relatively high likelihood that a detrimental event can occur and that event has a significant associated impact or cost" (Zsidisin et al. 2004). These definitions illustrate the common features of risk: possibility/unpredictability and potential loss. Therefore, risk could be expressed as Risk = Probability (of the event) × Consequence (of the event).

SC risk, vulnerability, and disruption have been defined broadly in the literature, for example Svensson (2000), Kleindorfer and Saad (2005), and Craighead et al. (2007) (see Table 2-1). Practitioners perceive "risk" as a multi-dimensional construct (Zsidisin 2003). For the purpose of this study, differences between SC risk, vulnerability, and disruption have not been distinguished, and they are reconciled and integrated into SCD. Based on the definitions in the literatures, SCD in this thesis is defined as an unanticipated occurrence that could interrupt the upstream and downstream efficient flows and result in an abrupt cessation of movement of goods, services, information, and cash flows within a global supply network with either insignificant or far more likely large scale operational and financial consequences.

Table 2-1: Definition of SC Risk, Vulnerability and Disruption in the Literature

Authors	SCR	SCV	SCD
Andersson and Norman (2003)	Risk=Probability (of a given event)×Severity (negative business impact)		
Kilsperska-Moron & Klosa (2003)			
Jüttner, Peck and Christopher (2003)	"The variation in the distribution of possible SC outcomes, their likelihood and subjective values." SC risk is anything that presents a risk (i.e., an impediment or hazard) to information, material and product flows from original suppliers to the delivery of the final product to the ultimate end-user.	The propensity of risk sources and risk drivers to outweigh risk mitigating strategies, thus causing adverse SC consequences	
Harland, Brenchley and Walker (2003)	Is associated with the chance of danger, damage, loss, injury, or any other undesired consequences		
Christopher and Peck (2004)		An exposure to serious disturbance	
Kleindorfer & Saad (2005)			The disruption is associated with a certain probability of occurrence and characterised by its severity, as well as direct and indirect effects
Wagner & Bode (2006)	As the negative deviation from the expected value of a certain performance measure, resulting in negative consequences for the focal firm. Hence, risk is equated with the detriment of a SCD, i.e., the realised harm or loss.	SC vulnerability is a function of certain SC characteristics and that the loss a firm incurs is a result of its SC vulnerability to a given SCD.	SCD is an unintended, untoward situation, which leads to SC risk, depending on its severity other terms might be applied, e.g. glitch, disturbance, or crisis.
Wagner and Bode (2009)			A SC disruption is the trigger that leads to the occurrence of risk. It is not the sole determinant of the final loss. It seems consequential that also the susceptibility of the SC to the harm of these situations of significant relevance. This leads to the concept of SC vulnerability. The basic premise is that SC characteristics are antecedents of SC vulnerability and impact both the probability of occurrence as well as the severity of SCDs.

2.2.3 Identify Supply Chain Disruptions

Factors causing SCDs are ubiquitous. Disruptions may arise as a result of something as simple as a small plant fire, shortage of supply, uncertain demand, transportation delay, man-made catastrophes or natural disasters. Over the last 10 years, the occurrence of natural and man-made catastrophes have risen dramatically alongside an average cost increase of 10 times that compared to the 1960s (Tang 2006a; Stecke and Kumar 2009) . For example, the following unforeseen catastrophes in recent years have demonstrated this: the 2002 US West Coast longshoremen's lockout; utility failures in the US and Europe in 2003; the Madrid bombing and the tsunami in 2004; the Nisqually 2001 and Sichuan China 2008 earthquakes; Hurricanes Katrina and Rita in 2005; Seattle's Hanukkah Eve Wind Storm of 2006; Minneapolis' 35W bridge collapse in 2007; and the 2010 eruptions of volcanos in Iceland; the Fukushima Daiichi nuclear power plant explosion and Europe's ongoing economic crisis.

Risk identification is the first step in a risk management process (Manuj and Mentzer 2008). Sheffi (2005) points out that *a priori* assessment of SC vulnerability is becoming increasingly important and difficult in the modern global economy. Along this line, more researchers and practitioners have recognized the importance and need for a typology and framework to identify potential sources of SC risks.

Many studies have addressed and classified the sources of supply chain risk (SCR), supply chain vulnerability (SCV), and SCD, although the form of typologies or taxonomies differs. Davis (1993) classifies shippers, manufacturing and customers as the main sources of manufacturing uncertainty. Built on the concept of Davis, Mason-Jones and Towill (1998) add to the three main sources of SC uncertainty, the supply side, in particular the manufacturing process, control systems, and the demand side. Apart from supplier side and demand side factors, Handfield and McCormack (2007) hold that risks may arise from within a company, such as its management principles, price and demand forecasts while Wagner and Neshat (2010) consider SC structure vulnerabilities another factor of risk identification and analysis. Vorst and Beulens (2002) develop a typology of SC uncertainty based on three dimensions related to the various sources of uncertainty: quantity, quality and time. Peck et al. (2003) add a dimension of exogenous events to the sources of SC uncertainty. Sources of SC risks were divided into internal, external (Jüttner, Peck and Christopher 2003; Cucchiella and Gastaldi 2006), and network related risks (Jüttner, Peck and Christopher 2003). Cavinato

(2004) and Sinha, Whitman and Malzahn (2004) suggest very different dimensions for the categorization of SC risks as physical, financial, informational, relational, and innovational. Based on SC failure modes, Sheffi (2005) classifies sources of SCDs as disruptions in supply, transportation, facilities, communications, demand, and freight breaches (see Table 2-2).

SC vulnerability should be considered not only to include intra-organization influences, but also inter-organization, as well as the external infrastructure and environmental surrounding the entire SC network. Peck (2005) built a conceptual integrated multi-level framework to analyse SC risks, which suggests that SCs strongly connect to enterprises, industries, and economies. Neiger (2009) proposes a value-focused process engineering methodology to identify process-based SC risks. This study used a generic SC scenario example to illustrate how to identify and uncover SC risks in a holistic business framework, and of how to integrate risk issues, business goals, and business activities through value-focused process engineering.

Although a substantial amount of literature has dealt with SC risk management, Rao and Goldsby (2009) argue that attention to SC risk identification remains limited. Based on an in-depth review of risk literatures, they developed a detailed comprehensive typology of SC risks (see Figure 2-2). Five factors that contributed to overall SC risk were identified: Environmental risk, Industry risk, Organizational risk, Problem specific risk, and Decision Maker risk. Figure 2-2 shows a detailed description of each type of risk.

Table 2-2: Classifications of Supply Chain Disruptions

SCR Classification		Comments	Reference
Internal SC	Supply (side) SCD	Reside in the supply base, the supplier portfolio, the supplier network, the characteristics of individual suppliers, the flow of goods in a certain activity cell is not on time/ the required quality and quantity; Disruption of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes. Breakdown of operations; inadequate manufacturing or processing capability; high levels of process variations; changes in technology/in operating exposure; equipment malfunctions and systemic failures.	Bogataj & Bogataj (2007), Manuj & Mentzer (2008), Wagner & Neshat (2010), Wagner & Bode (2006), Caniato (2003)
	Transportation or distribution SCD	Include transportation delay, congestions, port stoppage, high levels of handling or inspection while crossing border, and interruption in changing transportation modes.	Bogataj & Bogataj (2007), Caniato (2003)
	Demand (side) SCD	The customer, the product and its characteristics, the physical distribution of products to the end-customer, the uncertainty surrounding the random demands of the customers; the risk that the product will not be in demand, planned and realised delivery will be lower than the demand, the risk of shortage. New product introductions; variations in demand (fads, seasonality, and new product introductions by competitors); chaos in the system (the Bullwhip Effect on demand distortion and amplification)	Bogataj & Bogataj (2007), Manuj & Mentzer (2008), Wagner & Neshat (2010), Wagner & Bode (2006), Caniato (2003)
Network related	SC structure vulnerabilities	Stems to a large degree from the disintegration of SCs and the globalization (and off-shoring) of value-adding activities	Wagner & Neshat (2010)
	Systemic failures of human systems		Olson & Wu (2010)
External SC	Security risks (terrorism/ Malicious acts)	Information systems security; infrastructure security; freight breaches from terrorism, vandalism, crime, and sabotage	Manuj & Mentzer (2008), Kleindorfer & Saad (2005), Olson & Wu (2010)
	Environmental risk, Macro Risks (social and economic environment)	Economic shifts in wage rates, interest rates, exchange rates, and prices; Competitive Risks: Lack of history about competitor activities and moves	Manuj & Mentzer (2008), Kleindorfer & Saad (2005), Bogataj & Bogataj (2007)
		Actions of national governments like quota restrictions or sanctions; Resource Risks: Unanticipated resource requirements; policy instability risks, political environment; legal environment, operational environment, economic environment, cognitive environment	
	Catastrophic risk	Natural hazards (force majeure earthquakes, hurricanes, and storms), socio-political instability, civil unrest, economic disruptions, and terrorist attacks	Wagner & Bode (2006), Stecke & Kumar (2009), Kleindorfer & Saad (2005), Olson & Wu (2010)
		Non-terrorist intentional acts	

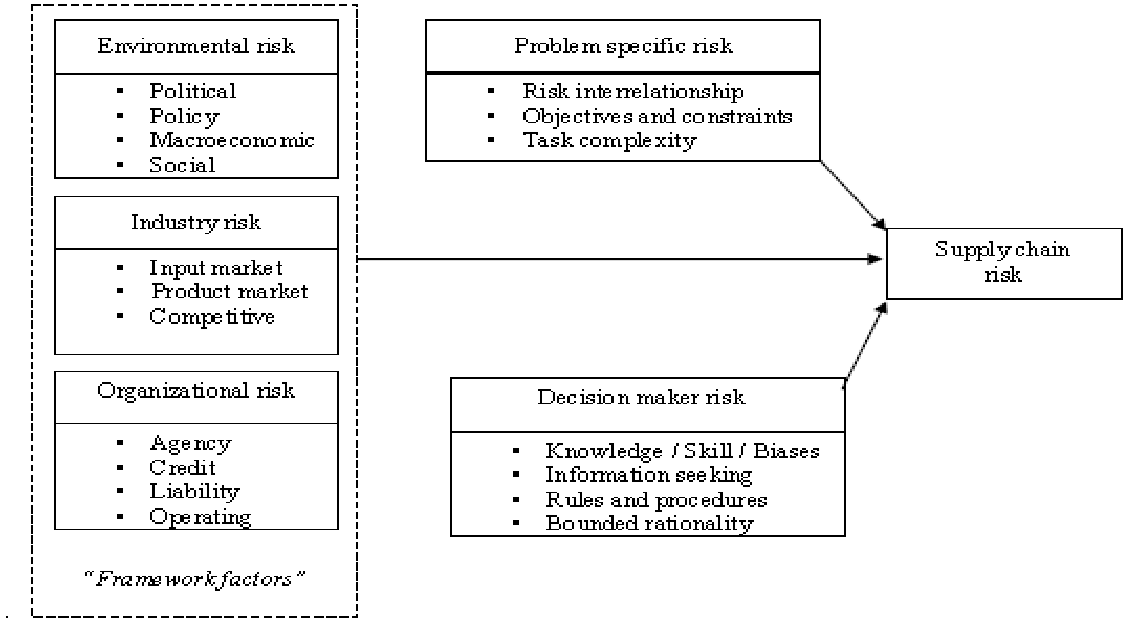


Figure 2-2: Sources of Supply Chain Risk
Source: Rao and Goldsby (2009)

2.2.4 Relationship between Supply Chain Characteristics and Supply Chain Disruptions

The design of a SC, its structural characteristics and decision making will heavily affect SCD occurrences and severity. Craighead et al. (2007) found that SC design characteristics (density, complexity, and node criticality, i.e. the importance of a node within a SC) are positively related to SCD severity. That is, the denser and more complex a SC is and the more critical nodes found therein, the greater the potential severity of a SCD. Craighead et al. (2007) also found that the SC mitigation capabilities (recovery and warning capabilities) possessed within a SC are negatively related to SCD severity, or in other words, as a SC's capability of recovery and/or the ability to detect problems early increases, the potential severity of a SCD decreases. Further, SC mitigation capabilities may also interact with and moderate the impact that SC density, complexity and node criticality have upon SCD severity. Stecke and Kumar (2009) also identify that the probability of SCD will increase if the number of exposure points to SCD and distance or time from the ultimate supplier to ultimate customer increases. Decreasing SC flexibility and redundancy will also elevate SC vulnerability and accelerate SCD severity.

SC characteristics, such as interdependence, sourcing strategies, etc., influence organization or the SC vulnerability. Wagner and Bode (2006) collected data from 760 German industrial organisations and estimated a three stage ordinary least squares regression model to test the relationship between drivers of SC vulnerability and SC risk. The results of the models indicate that the drivers of SC vulnerability explain 13 percent of the variance of supply-side risk, seven percent of the variance of demand-side risk, and three percent of the variance of catastrophic risks. This study also identified drivers of vulnerabilities such as supplier dependence, single sourcing, global sourcing, and strong customer dependence have positive impact on SC risks. The study further revealed that SC interdependence and sourcing strategies have an impact on organizational and/or SC vulnerability, but does not address how SCDs actually influence organization/SC performance.

Supplier selection strategies and risk portfolio affect SC vulnerability and revenues. Lockamy and Mccormack (2010) apply a Bayesian network approach to develop risk profiles for a given supplier and analyse the supplier's external, operational, and network risk probabilities and associated revenue impacts. This study was designed to assist practitioners to examine or determine their current and future outsourcing strategies. The study also allows firms to determine their risk profile which can be used to determine the risk exposure and implications on revenue for its supplier base.

Firms from different industries are exposed to different levels of SC vulnerability. Based on graph theory, Wagner and Neshat (2010) use data to model and measure SC vulnerability. Their study seeks to enable managers to assess the SC vulnerability faced by their firm quantitatively and mitigate any vulnerabilities in a more proactive and collaborative manner. The application of graph theory in the Wagner and Neshat study revealed that firms operating within the automotive industry have the highest SC vulnerability index, followed by firms producing and selling information and communication technology (ICT), and finally manufacturing firms; the common drivers of SC vulnerability were identified as SC structure within the above three industries; in the ICT industry, firms are exposed to greater risks related to demand side vulnerabilities, whilst, for the automotive and process manufacturing industries, vulnerability stemming from supply side factors appear to be of greater concern than demand side factors. The study also revealed that firms from the logistics, food and consumer goods, and engineered products industries have, on average, approximately the same level of vulnerability; wholesaler and retailer firms in the study had the lowest vulnerability index, and hence trade firms should on average be less concerned with SC vulnerabilities than manufacturing and logistics service focused firms.

2.2.5 Impacts of Supply Chain Disruptions

Any form of a disruption has the potential to cause tremendous impact on the economic performance of countries, regions, organisations and supply chains. The September 11, 2001 terrorist attack on the World Trade Centre (WTC) led directly to the deaths of more than 3000 people, damage or destruction of more than 30 million square feet of office space in Lower Manhattan, damage to transportation and communication infrastructure, and disruption to business operations and residents' lives (Bram, Orr and Rapaport 2002). The overall economic impact to New York City of the WTC is estimated at USD $82.8-$94.8 billion being made up of the wealth and capital losses (USD $30.5 billion) and losses to the four-year Gross City Product (GCP) of USD $52.3 billion to USD $64.3 billion (William and Thompson 2002). The October 2002 US West Coast longshoremen's lockout cost USD $1 billion per day in the first week which grew to USD $2 billion per day in the second week, and resulted in the cessation of an enormous amount of container flows through the 29 West Coast ports. Further, the jobs of some four million US workers and factories' productivity were threatened by this strike. Foot and mouth disease (FMD) was spread with the contagion lasting 221 days in Essex, England in 2001. An estimated 6.5 million cattle, pigs, and sheep were slaughtered and burned during that period. It is reported that the agricultural sector suffered a monetary loss of nearly £2.4 billion pound as a direct result of this. At the same time, the European Commission, the US, Ireland, and South Korea banned all exports of British meat, milk and livestock products. The British agriculture industry, its customers, suppliers, and SC partners were impacted severely by these actions. FMD also had other effects on the British economy, including but not limited to a downturn in the British tourism industry (Sheffi 2005).

The very features of a SCD however often make it difficult to measure or quantify their economic impact. First, disruptions typically have a low probability of occurrence and as such estimating their impact is difficult due to their unpredictability. Thus, often the impact of a disruption is incalculable, at least prior to the event. Second, a disruption can have ripple effect throughout the SC which can result in disproportionate effects as a result of increasing interdependency of SC participants. A small, unplanned emergency can have negligible economic consequence on a node within a global supply network, but it can cause another business to collapse elsewhere within the network. Further, disruption impacts could be transferable. An accident can arise anywhere in the world, but its impact may well beyond the location of the occurrence. Finally, longer-term or delayed impacts resulting from a disruption can be hard to estimate, and quite often can be larger than the direct short term impact experienced. It may take time for companies to recover and return to level of performance equilibrium after a disruption occurrence. Thus, indirect damages from disruptions can affect an organization's economic performance adversely during the recovery period (Massachu-setts Institute of Technology (MIT) Center for Transportation & Logistics 2008).

Although there is an increased awareness and recognition among managers, consultants, and academics that SC performance is important to business success, the implementation of measures to prevent or minimize the costs of disruptions is not widespread. According to the Aberdeen Group (2006), recent survey results indicate that 82 percent of companies are concerned about SC resiliency and disruptions, however only 11 percent of companies have actually taken action to avoid or minimize disruptions.

Studies measuring or quantifying SCD costs are also rare. One study estimated the cost impact would be USD $50 million to $100 million for each day of disrupted supply network for a given firm (Sheffi et al. 2003). Hendricks and Singhal (2003) analyse a sample size of 519 companies that experienced SCDs. They found that shareholder value decreased by an average of 10.28 percent after publicly announcing SCD resulting in potential production and/or shipping delays. In 2005, Hendricks and Singhal undertook a similar study on how long-run stock price performance is impacted upon by SCDs. Based on 827 disruption announcements spanning the years 1989 to 2000, their investigation found the average abnormal stock return of sampled firms was about –40 percent in a time period that begins one year before and two years after the disruption announcement date (Hendricks and Singhal

2005). Furthermore, the methodologies of quantifying the costs of SCDs are still in their infancy. Wu, Blackhurst and O'grady (2007) designed a Disruption Analysis Network (DA_NET) model to determine how disruptions propagate within SCs and calculate their impacts. The results of this model indicate that if the disruption event is dealt with quickly, the lead-time of the order increases five days without influencing costs and that outsourcing as a SC method may shorten the increase in delay lead-time, but result in increased costs of approximately USD $15 per unit for a reduction to three days delay. Wilson (2007) compared the different impacts between traditional SC and a vender managed inventory (VMI) systems from a transportation disruption through the use of system dynamics simulations. The results of this study suggest that in both SC systems, unfilled customer order rates and inventory levels will likely be increased due to transportation disruptions. The study results showed that transportation disruptions between the warehouse and the retailer is likely to lead to the highest unfilled customer order rates in both SC systems and that transportation disruptions between the tier 1 supplier and the warehouse is likely to create the greatest "ripple effect" through the entire SC, in turn resulting in increased unfilled orders and problems with inventory levels.

2.2.6 Strategies for Mitigating Supply Chain Disruptions

Although it is hard to predict and measure the likelihood and impact of most disruptions, researchers suggest that a suitable SCRM approach or strategy can help enterprises reduce their exposure to risk and avoid a disruption or mitigate its impact. The following sections summarise the strategies suggested within the literature (Tang 2006b; Manuj and Mentzer 2008; Stecke and Kumar 2009; KPMG 2011).

2.2.6.1 Getting it Right from the Start

Designing a strategic network enables SC managers to identify sources of unacceptable risks and deliver a framework for selecting new partners and suppliers, as well as embed the concept of risk management into their SCM strategies. Organizations can quickly react to changes and proactively manage SCDs through a well-planned, designed, executed and optimised strategic network. For example, organizations can strategically identify and select new partners and geographies that carry less potential risks both in political, economic or environmental terms if the processes to do so are in place (KPMG 2011).

To avoid and mitigate the risks of SCDs, strategies and measures should be carried out from the design stage of a product or process. For example, Cisco involves SC experts at the design or product-creation cycle phase. They find that the early integration of SCM helps to ensure that new product development and sales are resilient in the face of unexpected risks. Further, early supplier involvement in the design stage of a product assist in reducing the overall product development cycle time (Bolgar 2011).

2.2.6.2 Building Redundancies

Building redundancies into a SC can reduce the magnitude of disruption impacts, especially enabling firms to recover more quickly from disruptions. Redundant inventory and safety stock are commonly used by businesses to this effect. Safety stock protects companies from disruptions for a short-term period, as extra inventory of parts and finished goods may be able to meet supply and demand for short periods of time. However, safety stock is not a solution for protracted disruptions due to cost. The requirement to carry higher levels of inventory does not only tie up the capital of a firm, but also increases its inventory management costs such as warehousing and costs resulting from higher rates of damage. In addition, higher inventory levels also increase the risk of product obsolescence, particularly in volatile markets with short life cycles. As such, the holding safety stock represents a short-term strategy for mitigating the impacts of SCD and is applicable mainly to firms operating in markets where products are not in danger of obsolescence and/or the inventory carrying/managing costs are low (Chopra and Sodhi 2004). Instead of safety stock, Tang (2006b) recommends the use of strategic stock. Strategic stock is inventory stored at strategic locations (warehouse, distribution centres) and shared by multiple SC partners (retailers, repair centres).

Redundant capacity within a SC represents a better strategy for prolonged disruption events particularly where inventory managing costs and/or the risks of product obsolescence are high. Redundant capacity strategies include but are not limited to having additional production lines or other internal and external (from suppliers) alternative manufacturing facilities, and trained multi-skilled personnel capable of operating the redundant capacity systems. Redundant capacity can also be achieved through reducing the capacity utilization rate to less than 100 percent. Redundant capacity therefore can be used to continue manufacturing and serving customers when disruptions occur, and provide companies more space for recovery or rebuilding efforts (Sheffi 2005).

2.2.6.3 Building Flexibilities

Flexibility is "the ability to change or react with little penalty in time, effort, cost or performance" (Upton 1994). Global SCs are complex networks operating in dynamic international markets with a high level of environmental and operational uncertainty. SC flexibility means that there are available alternative resources/capacities capable of responding to disruption events and enables risk sharing amongst SC partners. SC flexibility can be achieved through standardization, postponement, having a flexible supply and transportation base, dynamic pricing/promotions, and substitutable products (Sheffi 2005; Tang 2006b; Manuj and Mentzer 2008).

Standardization allows firms to overcome disruptions by increasing SC inter-changeability, by enabling SCs to reroute flows quickly from disrupted segments to alternative segments within the network. Standardization methods include having standard facilities, standard parts, standard processes, and standard production systems across all or part of the SC (Sheffi 2005).

A strategy of postponement or mass customization via the manufacturing of common components for a group of product varieties first and finishing customization later based on orders may also result in lower costs through economies of scale, whilst at the same time strengthening competitiveness by providing a greater variety of products and higher customer service levels. In addition, a postponement strategy could provide companies with greater time-efficiency which can be used respond to a disruption event. For example, putting on labels in different languages as close as possible to the store shelf can avoid and mitigate the impacts of a disruption by allowing the rerouting of unlabelled products to affected markets in the case of some disruption. Demand customization, component costs, product life cycle, and product modularity determine the level and scope of postponement. Dell is an excellent example for using postponement strategy (Chiou, Wu and Hsu 2002; Sheffi 2005; Tang 2006b; Stecke and Kumar 2009).

Sole sourcing is cost efficient but creates vulnerabilities if there are demand fluctuations or supply disruptions. A flexible supply base strategy can enable firms to avoid demand fluctuations and supply disruptions and maintain smooth material and production flows during disruption circumstances.

Flexible transportation strategies enhance firms' flexibility to handle transport related disruptions. Flexible transportation strategies include multi-modal transportation, multi-carrier transportation, and multiple routes/expedited services (Tang 2006b). Increased transportation visibility can help transportation disruptions be avoided through prompt communication of information (Stecke and Kumar 2009).

Dynamic pricing/promotion and substitutable product strategies increase SC flexibility through enticing and guiding customers to purchase available products. This may also represent an effective way to handle supply and demand disruptions (Tang 2006b).

2.2.6.4 Collaboration

Collaboration along the SC not only develops deeper relationships between suppliers, distributors and customers, but also contributes to a reduced likelihood of disruptions. Collaboration secures a free flow of information, the sharing and heightening of communication between SC partners, and increases SC "end-to-end" visibility. With better collaboration, firms can obtain earlier warning of potential shortfalls which in turn may assist in identifying strategies to recover quickly from a disruption. In addition, collaboration increases mutual trust and commitment between SC partners, which in turn results in improved relationships. Stronger relationships with suppliers, distributors, and customers may allow companies to overcome disruptions by receiving greater levels of support from external partners. For example, the strong and trusting relationship between Toyota and its suppliers helped Toyota recovered quickly from the Aisin fire in 1997 (Sheffi 2005).

2.2.6.5 Building a Secure and Flexible Company Culture

A company's culture may influence an organization's reaction and behaviour to a disruption event. In 2000, a fire incident at a Koninklijke Philips Electronics N.V. facility affected both Sony-Ericsson and Nokia, however the disruption to Nokia was not as severe as it was for Sony-Ericsson. Indeed, Nokia was able to increase its handset market share from 27 to 30 percent as a result of the event. This was because Sony-Ericsson's company culture did not allow it to react as quickly and effectively as Nokia. After this event, Sony-Ericsson introduced a new company philosophy "everyone is a risk manager" (Norrman and Jansson 2004).

2.3 Supply Chain Disruptions in Transportation

2.3.1 Global Transport Chains

A global transport chain can be divided into three layers, these being oversight, transaction and logistics (Willis and Ortiz 2004). The logistics layer represents the delivery system consisting of roads, rail tracks, or sea-lanes where containers are transported physically through the system so as to provide demanded logistics services to producers and consumers. The second layer is the transaction layer. In this layer, connections among participants (ultimate suppliers, manufactures, distribution centres, retailers, logistics providers, and ultimate customers) are legal contracts, informational production specifications, financial transaction records, and actual physical cargo movements. The oversight layer oversees the contracts and movement of cargoes through customs, organizations, law enforcement, and national or international borders (see Figure 2-3).

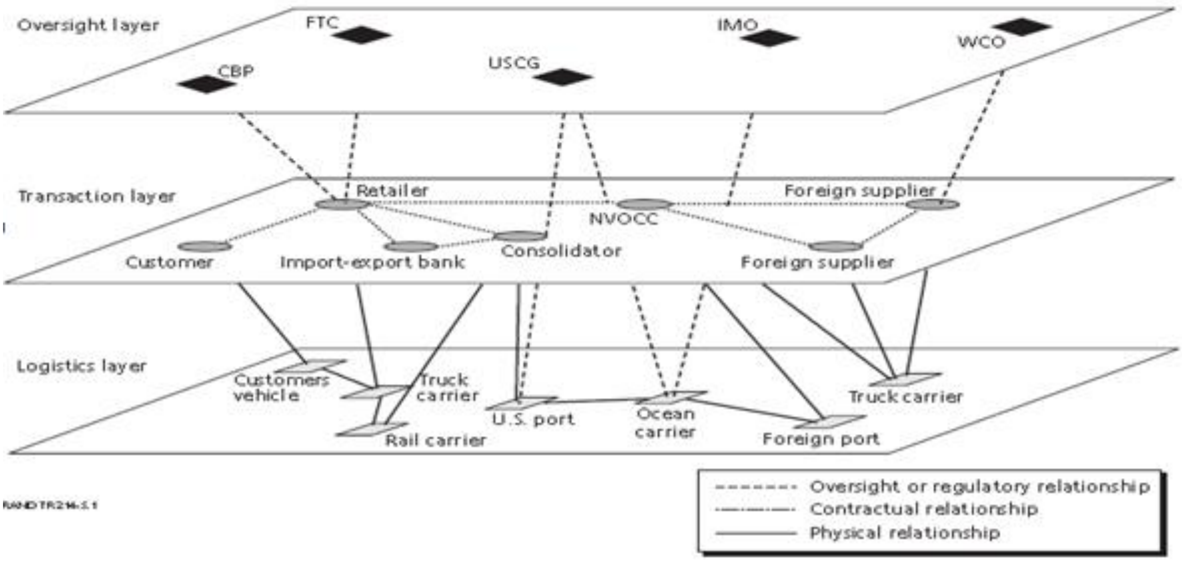


Figure 2-3: The Three Layers Model Concept of a Supply Chain
Source: (Willis and Ortiz 2004)

2.3.2 Review of Transport Related Supply Chain Disruptions

Within the literature, the role of transport has tended to be regarded as a passive or marginal activity within a SC network, with little attention being paid to the study of transport uncertainty and its impact on overall SC performance (Mason and Lalwani 2004). Modern-day managers however have recognized increasingly that transport is a key component of global SC networks and that effective transportation operations can improve overall SC performance. Any disruption to transport services can impact the delivery to customers. A more flexible and responsive transport operation, and an integration of transportation into the overall SC are needed to deliver customer value more effectively (Stank and Goldsby 2000; Mason and Lalwani 2004). Thus, more attention is required to study SCD explicitly in transportation.

Types of transportation disruptions can include port stoppages, high levels of handling or inspections whilst crossing borders, and interruptions or delays caused during changing transportation modes. The transportation system is the most vulnerable part of a SC (Stecke and Kumar 2009) due to the fact that is a complex system involving multiple transport modes and facilities. Transportation disruptions can lead to different magnitudes of loss to the SC network. Goods stopped in transit may result in increases to unfilled customer order rates, inventory fluctuations, and a greater level of inventory being carried in transit (Wilson 2007).

Many factors involving intra- and inter-organizational, and external environments can result in transportation disruptions. Rodrigues et al. (2008) developed a conceptual model that categorised the causes of SC uncertainty impacting on transport operations. Replicated in Figure 2-4, this study highlighted the root causes of uncertainties within the transportation sector of SCs and categorised these into five main uncertainty sources: 1) uncertainty related to suppliers, 2) customers, 3) carriers, 4) control systems, and 5) external uncertainty. The model rationalises uncertainties into various types and enables practitioners to diagnose where the greatest uncertainties are and how to mitigate them once identified.

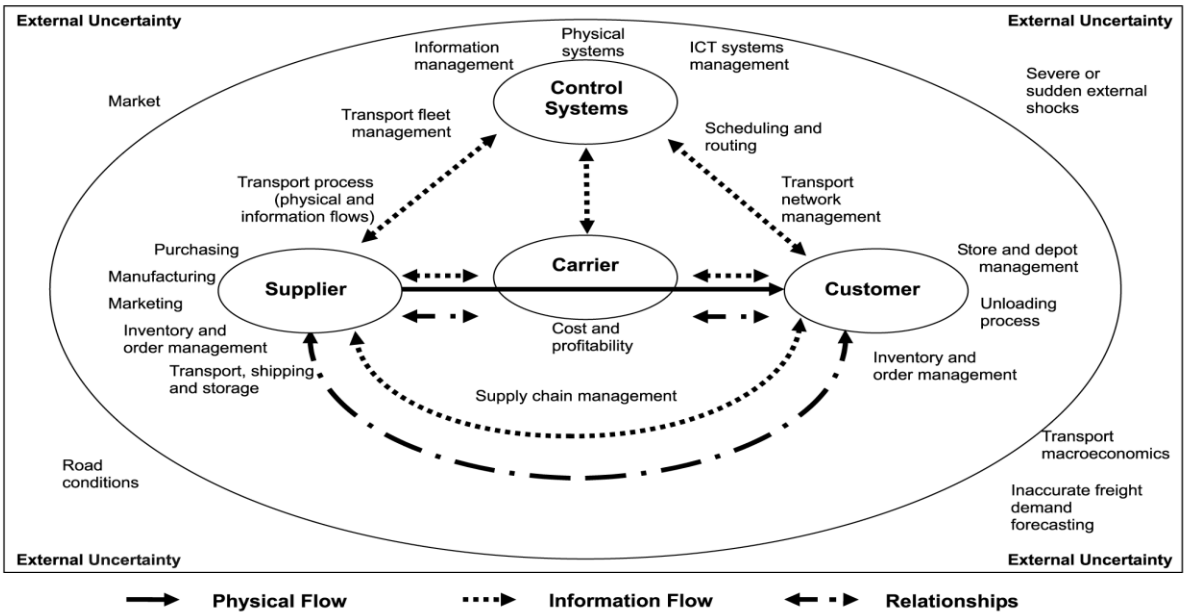


Figure 2-4: Logistics Triad Uncertainty Model-Location of Key Uncertainties
Source: Rodrigues et al. (2008)

Disruptions to transport operations can affect economic and environmental sustainability. Rodrigues, Potter and Naim (2010) refine the 2008 model to assess the different causes of SC uncertainty that might affect the sustainability of the United Kingdom (UK) road freight transport sector. Based on survey data collected using online questionnaires, the study investigated the link between uncertainty in transport operations and their impact on economic and environmental sustainability. The results of the study reveal that delays, variable demand and poor information provision, delivery constraints and insufficient SC integration are the main drivers affecting the sustainability of transport operations.

Zhang and Figliozzi (2010) conducted a survey in China which showed how Chinese importers and exporters perceive the performance of international and domestic transport and logistics systems. The empirical results from this study indicated that Chinese customs and regulations inhibit efficient transport operations. The main causes of delay were found to be derived from "other factors", including supply side, demand side and external uncertainties rather than from transportation issues. Transhipment was found to be the highest ranked reason for inefficient transportation operations followed by delays arising at the loading and discharge ports. Lost sales were a ubiquitous answer to questions related to the perceived costs of transport-related SC delays. Delays were associated with severe damage to a company's image, reputation, and customer relationships. Exporters were concerned more with increased transportation and administration costs, whilst importers were concerned more with increased administration costs, affected sales, impacts on promotion plans, increased transport costs, as well as increased inventory costs. Mitigation strategies were also stated by interviewees as being placed at an operations level within the firm rather than at a strategic level.

As discussed previously, the transportation system is complex and represents one of the most vulnerable parts of a SC since transportation and distribution systems involve multiple transport modes and facilities (Stecke and Kumar 2009). Use of an "inventory theoretic model" represents the traditional approach to investigate logistics or transport uncertainty and to highlight the impacts to inventory levels of transport-related uncertainty. The impact has been measured by the increased costs of holding more safety stock to prevent stock-outs due to transportation variability in transit times and reliability (Rodrigues et al. 2008). An investigation into rail stock delays within the chemical sector by Closs, Keller and Mollenkopf (2003) revealed small changes in rail transit time could reduce safety stock levels significantly for the shippers concerned. Saldanha, Russell and Tyworth (2006) analysed transit time variability on ocean liner shipping routes and suggested carriers should add more slack time into their published schedules to achieve better reliability. Vernimmen, Dullaert and Engelen (2007) conducted a case study to expose the impact of liner shipping schedule unreliability on the level of safety stock when the manufacturer is sourcing spare parts from overseas. Their results showed that the standard deviation of demand during lead time (DDLT) decreased by over 20 percent and the level of safety stock required drops at a similar level if transit time at sea is shorter and more reliable. Their findings indicate that an improvement in liner shipping schedule reliability can lead to significant cost savings ranging from EUR $240,780 to EUR $2 million annually for low and high value spare parts respectively.

2.3.3 Theoretical Framework Identifying Transport Related Supply Chain Disruptions

As one form of uncertainty might interact and influence other types of uncertainty, any risk management strategy may become suboptimal without a full recognition of the overall SC risk sources (Rao and Goldsby 2009). Thus, a formal comprehensive framework is required to manage risks in terms of identification, quantification, and mitigation (Frosdick 1997; Khan and Burnes 2007; Rao and Goldsby 2009).

Based on the above review of the literature on SC risk management, a conceptual framework to identify the sources of transportation related SCD is presented in Table 2-3. Transport related SCD sources are categorized into external, internal and network related causes (Jüttner, Peck and Christopher 2003). Internal SCD can be further categorised based on cargo type, actors, and information and financial. Operation and network-related SCDs are caused mainly by insufficient interaction and cooperation between organizations within the SC. External SCD sources can be classified into environment risks, security risks and catastrophes risks. Environment risks mean macro level risks (social and economic environment). Security risks refer to malicious acts or terrorisms. Catastrophic risks include natural hazards and non-terrorist intentional acts.

Table 2-3: Framework to Identify Sources of Transport-Related SCDs

<table>
<tr><td rowspan="8">Sources of Transportation Related SCD</td><td rowspan="3">Internal Vulnerability</td><td colspan="2">Cargo</td></tr>
<tr><td colspan="2">Actors</td></tr>
<tr><td colspan="2">Information and Financial flows</td></tr>
<tr><td rowspan="2">Operational and Network Related Vulnerability</td><td colspan="2">Operational Vulnerabilities (e.g., Schedule unreliability; empty containers reposition)</td></tr>
<tr><td colspan="2">Infrastructure Vulnerabilities (e.g., Ineffective infrastructures; congestions)</td></tr>
<tr><td rowspan="3">External Vulnerability</td><td>Environment Risks</td><td>Environment risks mean macro risks (social and economic environment, external infrastructures and environment surrounding the whole SC network).</td></tr>
<tr><td>Security Risks</td><td>Security risks refer to malicious acts or terrorisms.</td></tr>
<tr><td>Catastrophes Risks</td><td>Catastrophic risks include natural hazards and non-terrorist intentional acts.</td></tr>
</table>

2.4 International Containerised Maritime Transport Chains

2.4.1 The Concept of Maritime Logistics

Maritime logistics is a concept that has evolved from the traditional definition of maritime transportation and logistics. Maritime transportation has been defined as the transportation of goods and passengers between two or more seaports by sea. Primarily, maritime logistics is concerned with activities on the sea-leg (port-to-port) and operations related to the sea-leg of a journey. According to the Council of Logistics Management (CLM), logistics is an important element in global SCs, providing efficient services to effectively enable material, goods, and information flows through the entire SC channel, from original suppliers to ultimate customers, hence, ultimately satisfying the final customers' requirements. Benefiting from the development of globalization, consumers nowadays are able to purchase quality goods at relatively low cost, delivered at the right time and place. Thus, an all-inclusive door-to-door transportation concept has been derived as a result of intensive competition within transportation markets resulting in increased customer requirements. It requires the provision of low cost and highly efficient logistics services from origin supplier to final customer often via multi-modal transportation means. As part of this, ocean carriers are increasingly interested in the provision of total door-to-door logistics services, hence including inland transportation services, to satisfy their customers (Panayides 2006).

Maritime logistics is the integration and convergence of maritime transport and logistics. It is a systematic embodiment of integrated logistics systems, including the process of planning, implementing, and managing the movement of ocean carriage cargoes and information in an effective and efficient manner by multi-transport modes or via intermodal transportation from original supplier to ultimate customer. As a result, individual transport modes have to work together as partnerships instead of competitors to pursue faster, more efficient and more effective logistics services. Maritime logistics covers activities in maritime transportation areas and additional logistics services, such as contracting, shipping, sea voyage, moving cargo and loading/unloading, stripping/stuffing, storage, warehousing, inventory management, offering a distribution centre, quality control, testing, assembly, packaging, repacking, repairing, inland connection, and re-use (Lee and Song 2010) .

2.4.2 The Importance of Maritime Logistics

The importance and contribution of maritime logistics to the global economy is obvious since about three-quarters of the surface of the earth is covered by water. Historically, shipping first made intercontinental travel and trade possible. Maritime transport carries roughly 90 percent of world trade every year while air transportation is primarily confined to the movement of urgent and/or expensive cargo (International Maritime Organization (IMO) 2009). Thus, maritime logistics may be considered as the lifeblood of the global economy.

Maritime logistics is the first logical and efficient choice for most cargo movement. The growth of economic globalization suggests that the sourcing, manufacturing, distribution, and sales for any particular good may occur across different countries. As a result, rapidly increasing movements of raw materials, components, and finished products are occurring between nations. Many raw materials, characterised as heavy density, low unit value, or bulk need to be moved long distances. Maritime transport provides an efficient mode of transportation for these raw material movements at low cost, large volume, and high quality. The introduction of containers to the shipping sector has enabled global distribution systems to reconcile spatially diverse supply and demand relationships and interact more efficiently (Notteboom and Gue 2008). Innovations in technology have also enhanced maritime transportation competitiveness in terms of efficiency (low cost) and effectiveness (reliability, flexibility and responsiveness). Shippers of high value products nowadays have a more open attitude toward maritime transportation given its many advantages including inexpensive freight rates, unstinted shipment space, and acceptable delivery speeds (Kendall and Buckley 2001).

Maritime logistics therefore contributes significantly to world trade. The maritime industry has experienced a steady and healthy growth over the last two decades. Global container trade recorded an estimated 10 percent annual growth rate on average over the last two decades. The value of world maritime container trade increased from USD $2 trillion in 2001 to USD $4 trillion in 2008. A total of 7.9 billion tonnes of seaborne trade in 2009 where transported, 15.3 percent of which was containerised cargo (Clarkson Research Services 2009). The proportion of containerised trade in the world's total dry cargo sector increased from 5.1 percent to 25.4 percent from 1980 to 2008. The world containerised trade in total was 137 million TEUs (1.3 billion tons) in 2008 (United Nations Conference on Trade and Development (UNCTAD) 2009).

2.4.3 General Background on Containerised Maritime Transport Chain

The containerised maritime transport chain is a sub-component of the global SC and is concerned mainly with the movement of goods via shipping containers. It is a complex hybrid system involving complex interactions amongst a multitude of actors, industries, regulatory agencies, transport modes, operating systems, liability regimes, and legal frameworks during a container's transmission from the time it is packed, via loading and unloading at intermodal terminals and on maritime vessels, to the time it is delivered to the consignee (Organisation for Economic Co-operation and Development (OECD) 2005).

2.4.3.1 The Process of Containerised Maritime Logistics

Global SCs execute international trades involves multiple agents including suppliers, manufacturing centres, warehouses, distribution centres/consolidators, retailers, logistics service providers, and ultimate customers. The process of an international transaction trade encompasses physical flows, information flows, and financial flows.

The flow of international trade also illustrates the process of maritime logistics as consumers demand a comprehensive and all-inclusive door-to-door logistics service. The demand of the ultimate customers (including realistic and forecasted demand) triggers container movements of raw materials and components across borders to manufacturing centres (transforming raw materials and components into finished products). Finished products are then transported to warehouses, distribution centres/consolidators, retailers, and final customers via intermodal transport logistics system (including road, rail, sea, air transportations, and related logistics services) from the origin to destination worldwide. Containerised maritime logistics is therefore firstly a physical movement of cargo from place to place by different modes, and secondly involves information and financial flows, with the aim of ensuring the cargo's physical movement at the right time, the right place, and with the correct quantity and price (see Figure 2-5).

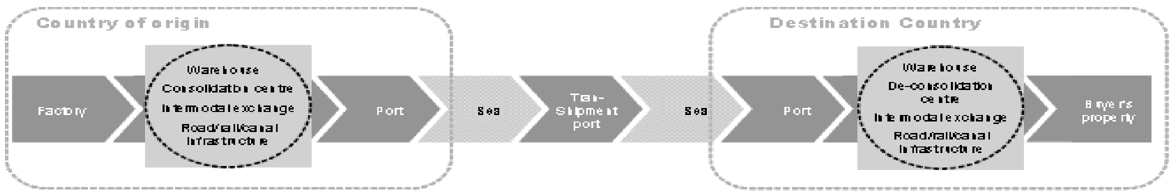


Figure 2-5: International Container Logistics Chain: Place in the Logistics Chain
Source: (Organisation for Economic Co-operation and Development (OECD) 2003)

2.4.3.2 Information and Financial Flow in Maritime logistics

Information and financial flows are vital to international trade. First, information transmission insures that every international transaction is carried out so that the right product in the desired quantity is delivered to the correct agent at an acceptable time and cost. To fulfil this purpose, each international transaction can involve up to 40 separate documents to transmit amongst different participants and government organizations (Organisation for Economic Co-operation and Development (OECD) 2003). These documents specify the details of each shipment, including the specification of products in a shipment, their quantity, how they are packed in a container, details of custody and liability, information about the shippers, receivers, freight forwarders/ transporters/brokers and other intermediaries, information regarding the timing and responsibility for payment, etc. Secondly, elaborate information flows support customs and security agents to make timely and efficient inspections or other security judgements as required. Third, information and documents related to financial flows ensures each transaction is implemented and completed correctly. Any interruption to information or financial flow can delay or otherwise impact negatively an international trade. Figure 2-6 illustrates a common example of information and financial flows in an international trade transaction.

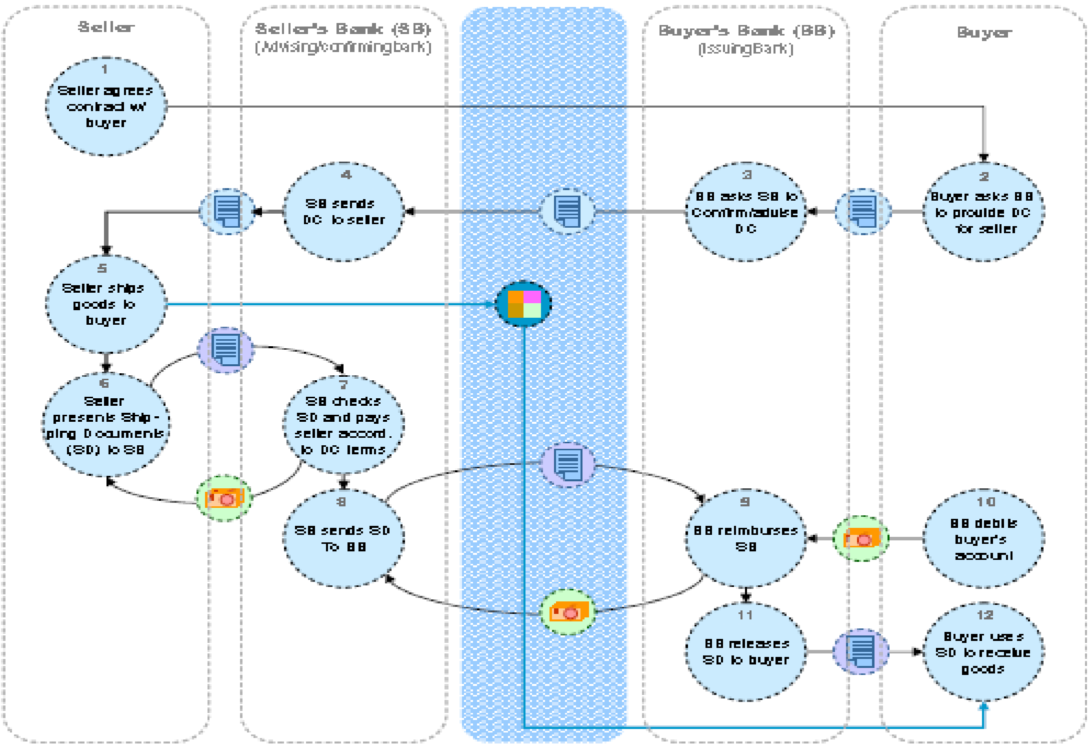


Figure 2-6: Information and Financial Flows in International Container Logistics Chain: Documentary Credit (DC)

Source: (Organisation for Economic Co-operation and Development (OECD) 2003)

2.4.3.3 The Stakeholders/Actors of Containerised Maritime Logistics

There exist a large number of stakeholders within the maritime logistics system as Willis and Ortiz's (2004) layered model indicates. Any organization involved in the physical movement of cargo, facilitating the movement of cargo, and supervising the physical, financial, and information flows related to cargo is considered a stakeholder of the containerised maritime transport chain (Willis and Ortiz 2004). Therefore, not only does this include all ocean carriers, rail freight providers, trucking companies, port operators and their vendors (shipyard, crane workers, etc.), but also suppliers, manufacturers, distribution centres, retailers, customers, and any supervisory organization (including customs, IMOs, etc.). Based on Willis and Ortiz's (2004) theory, maritime stakeholders can be categorized as jurisdictional (e.g., customs, navy, police and port authorities at a national, state or local government level), exporters (i.e., exporters, freight consolidators, inland transportation carriers, terminal operators, freight forwarders, ocean carriers, and customs), and importers (e.g., ocean carriers, customs brokers, custom inspectors, terminal operators, inland transportation carriers, and importers). In addition, the huge number of personnel required to service all these stakeholders can also be viewed as stakeholders within the maritime logistics industry (see Figure 2-7).

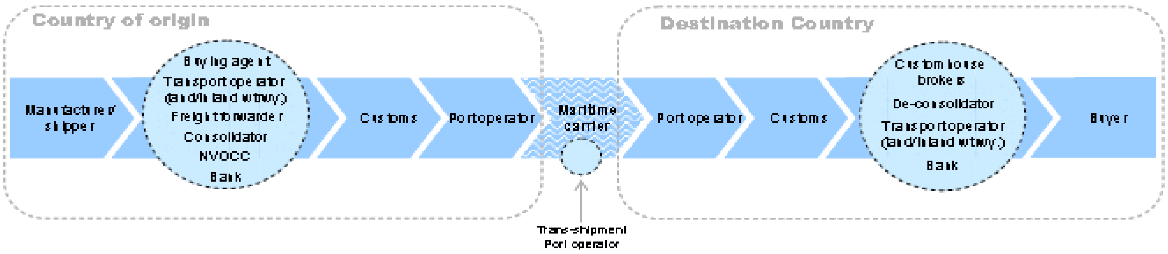


Figure 2-7: International Container Logistics Chain: People/Actors Involved
Source: (Organisation for Economic Co-operation and Development (OECD) 2003)

2.4.3.4 The Infrastructures and Assets in Maritime Logistics

In the process of international trade, importers and exporters may ship cargo via trucks on roads to intermodal terminals, tranship to trains on railroad or onto barges on coastal/inland waterways, and again tranship these to ships which travel on the sea from one port to another. This process involves the following transport infrastructure: Road/highway infrastructure, train tracks/railroad, inland container terminals and storage areas, inland navigation channels, and port facilities. In all of this, ports represent the crucial connecting point between transhipped land-based transport modes and maritime modes, with a large number of researchers emphasizing their importance (United States General Accounting Office (GAO) 2002; Organisation for Economic Co-operation and Development (OECD) 2003; Congressional Research Service (CRS) 2005; Sarathy 2006; Bichou 2008).

Port infrastructure is very expensive and once built not easy to expand. Port infrastructure can include the gate (the frontier between in-land and port), the port area (container yard, free trade zone, warehouse, containers and vessels maintenance), the berth (frontier between sea and port, berth length and depth are parameters affecting port efficiency, dock-side cranes to load and unload containers), the container cleansing and maintenance yard, the ship yard, and intermodal container transfer facilities (see Figure 2-8).

Assets in the containerised maritime logistics sector not only include expensive vessels and cranes, but also a high technology inspection equipment for the purposes of customs and security clearances, information sharing, and handling facilities within the marine system. The diverse set of cargo shipped within the containerised maritime logistics may also be considered assets as well.

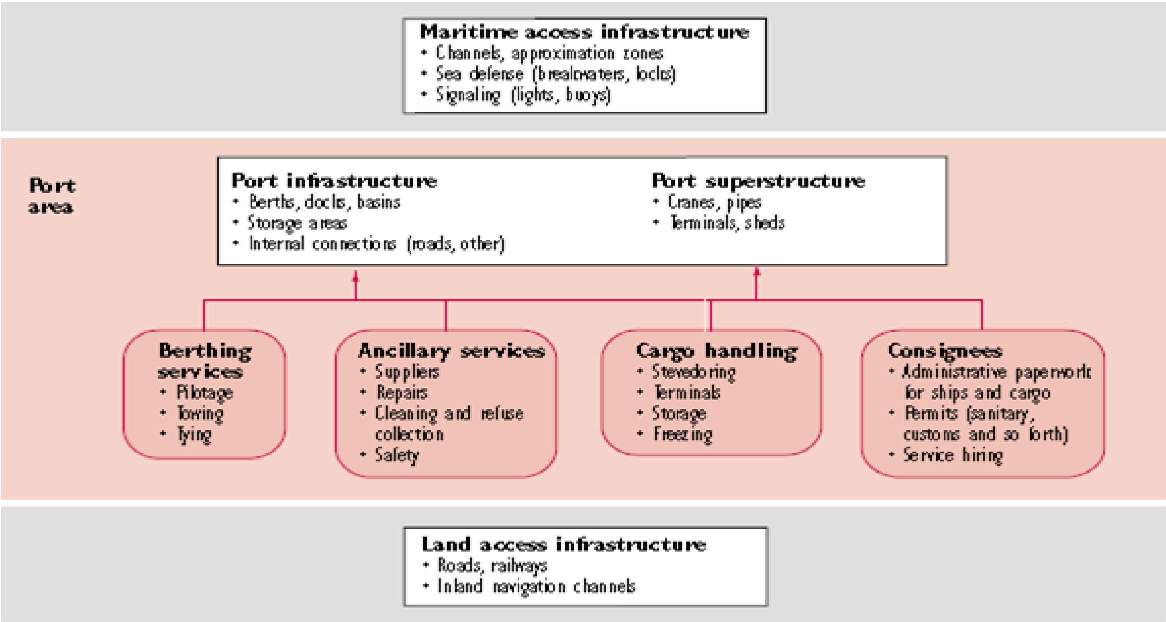


Figure 2-8: Port Activities and Infrastructures
Source: (Estache and Rus 2000)

2.4.4 Identifying the Vulnerabilities in the Containerised Maritime Transport Chain

According to research, the more exposure points that exist within a SC or the more dense, complex, or the greater the number of critical nodes in a SC, the higher the probability there exists in terms of experiencing a severe SCD (Craighead et al. 2007; Stecke and Kumar 2009). SCs involving containerised maritime transportation are more vulnerable than those without containerised maritime transportation for a number of reasons. Firstly, SCs with containerised maritime transportation are prone to vulnerability as they have more exposure points and critical nodes that are susceptible to SCD. Secondly, containerised maritime transport chains typically connect more/multi-modes to a greater variety of infrastructure and rely on more complex partnerships throughout the SC. Furthermore, distance and time between origin and destination are prolonged inevitably if SCs are involved in maritime transportation.

According to the framework for identifying SCDs discussed in section 2.3.3, the vulnerable nodes in containerised maritime transport chains are identified and summarized as the following sections.

2.4.4.1 Internal Vulnerabilities

As containerised maritime transport chains are concerned mainly with the movement of goods via shipping containers, the identification of internal vulnerabilities will tend to focus on activities related to the movement of containers and the contents of containers. This is discussed in more detail in the section that follows.

2.4.4.1.1 Cargo and Containers

The staggering volume and high velocity of container movements and its ubiquity worldwide should not only be viewed as the strength of the containerised maritime transportation system, but rather should be emphasised as a challenge or vulnerability from the perspective of security. Most of the world's non-bulk cargo travel via marine shipping containers. The tremendous amount of international container movements and the fact that these containers can be found virtually everywhere imply that the containerised maritime transport system could be easily subverted, or misused, or used in such a way to carry out a terrorist attack. In addition, there are numerous container types (including tank containers for gaseous or liquid cargo, open frame containers for transporting odd-sized consignments, soft-top containers, containers fitted with special garment racks, and refrigeration units ("reefers") for transporting chilled food) involved in international containerised maritime transport chains, and each of these container types pose unique security risks to an entire chain (Organisation for Economic Co-operation and Development (OECD) 2003; 2005).

Containers or cargo in containerised maritime transport chains have suffered several criminal and terrorist threats, including piracy throughout history. This includes the theft of goods, fraud, illegal immigration, drug and contraband smuggling, piracy, and the potential misuse for terrorist purposes. Losses due to cargo theft are estimated to be between USD $30 and $50 billion per year, mostly related to road transportation. Nevertheless, container loading locations potentially increase the vulnerability of containerised maritime transport chains. The container could be loaded anywhere, whether it be at a manufacturing plant, a warehouse, a consolidation centre, directly in an open courtyard or on the street. (Organisation for Economic Co-operation and Development (OECD) 2003).

Cargo carried in containers can also represent a potential source of vulnerability for containerised maritime transport chains. Although thousands of legitimate hazardous or danger goods containers are safely shipped every day, there remains a threat that such containers may be misused by terrorists or operated irregularly, resulting in significant accidents or other unsavoury incidences (Organisation for Economic Co-operation and Development (OECD) 2003).

2.4.4.1.2 People/Actors

As mentioned in Section 2.4.3.3, there exists a large number of actors within the containerised maritime transport chain system, including millions of importers and exporters who depend upon thousands of logistics service providers to coordinate and carry cargo to hundreds of ports where containers are shipped overseas, and dozens of different supervisory authorities governing the transmission processes and ensuring security. Thus, it is extremely difficult to cooperate and collaborate in order to achieve entire network optimisation among the numerous participants. As a result, contradiction and vulnerability inevitably exists along many SCs where there exist incompatible operations and information management systems, and un-harmonised and un-coordinated regulatory frameworks and security practices (Organisation for Economic Co-operation and Development (OECD) 2005).

A large portion of actors in a container shipping chain is represented by Small and Medium sized Enterprises (SME). Approximately 40 percent of exporters in the European Union (EU) and 97 percent of US exporters are SMEs; more than 99 percent of road transport operators are SMEs and less than 0.1 percent are large enterprises in the EU (Organisation for Economic Co-operation and Development (OECD) 2005). From this number, it is not difficult to infer that a high proportion of export/import firms, transportation operators, and other intermediaries in Asia are also SMEs. SMEs usually have insufficient resources and motivation to implement optimal SCM and security measures. This may result in the exploitation of regulatory loopholes existing inside organizations and among SC partners, and the concealing of potential vulnerabilities and security risks along the chain.

The labour force involved in container transport chains is also vast. Any mistake made by an officer or worker in the network, deliberately or unconsciously, can compromise the entire performance of a SC, or hide numerous implicit vulnerabilities that may disrupt an entire SC operation at a later time. Further, seafarers are under increasing risk of being kidnapped or hijacked. Further, it is not impossible to assume that that some within the labour force may be accomplices to criminal or terrorist groups (Organisation for Economic Co-operation and Development (OECD) 2003).

2.4.4.1.3 Information and Financial Flows

Information disruption refers to disruptions to the effective or otherwise inerrant information flows throughout a SC network. Under lean SCM practices, SC networks increasingly rely on IT infrastructure to ensure secure, accurate and reliable information sharing. Unfortunately, the more information sharing that occurs, the greater the risk of failure someone along the chain.

To dispatch containers quickly and accurately from the original shippers location to the final consignees, accurate information is required in terms of trade contracts, regulatory compliances, and operational details. However, since most participants operating in a containerised maritime transport chain are SMEs, many of them can only provide paper files, faxes, phones, and oral messages due to technological shortages. Some shippers even have to recourse intermediaries to facilitate their international trade. This means first hand information of container contents can be disharmonised, incompatible, and un-interoperable. As a result, re-transcription errors of data are often unavoidable, since data sent along the chain is often re-keyed or re-transcribed by intermediaries. Any unclear or inaccurate information may then slow down or interrupt container movements during customs or other authority clearances who rely on the processed data. In such cases, long delays and additional storage costs are inevitable as containers are withheld and stored until all documentary requirements are satisfied.

2.4.4.2 Operational or Network Related Vulnerabilities

2.4.4.2.1 Operational Vulnerabilities

The operational factors that might cause road transport delays in international containerised maritime transport chains are first, the large number of verification and identification documents regarding information related to the container, vehicle, and driver which have to be presented to different authorities (e.g., information about the container should include cargo type, quantity, origin and destination, taxes/duties, etc.; vehicle identification should include license, safety, and emissions standards, etc.; and driver identification should include passport/visa verifications, driver licence, etc.). Incomplete or unclear documentation can delay the container movements. The more detailed the document verification carried out by authorities, the longer any possible delays may be. Second, commercial vehicles are under increasing risk of theft and hijacking. Road transportation represents a vulnerable link in any containerised maritime transport chain given multiple stops, infrastructure openness, and extreme accessibility. For example, a 20 percent increase in commercial vehicle thefts was reported between 1995 and 1998 in a 1998 ECMT survey (Organisation for Economic Co-operation and Development (OECD) 2005). Finally, insufficient fleet capacity/fleet management, defective vehicles, lack of drivers, and fierce competition in freight transport industry may affect container delivery on the road and result in transportation delay and SCDs (Mason et al. 2003; Fowkes et al. 2004; McKinnon and Ge 2004).

Rail re-marshalling and the need for shunting are the major causes of rail transportation delays. Rail re-marshalling and shunting are very complicated and time-consuming processes. Consequently, long travel times and delays are not uncommon within the rail transportation sector. In addition, some freight trains might have to change locomotives and train crews for international rail services due to the technical incompatibility of signalling, electrical systems, or lack of personnel qualified for cross-border operations. Changing locomotives and crews is costly and complex and a time-consuming process which potentially may result in a higher risk of delays to scheduling (Organisation for Economic Co-operation and Development (OECD) 2005).

Scheduling unreliability is becoming a major challenge to container shipping. According to Drewry Shipping Consultants (2006b), 21 percent of the vessels deployed on worldwide liner services arrived one day late, eight percent two days late, and at least 14 percent of vessels calling their port of arrival where three or more days late. Only four percent of the vessels arrived two to three days before their scheduled estimated time of arrival (ETA) with on-time vessel calls about 52 percent. Less than 40 percent reliability levels were reported in liner routes through the Asia/East Coast, South America, Asia/West Coast South America, Europe/Med/Australia/New-Zealand/South Pacific, Europe/Med/West Coast South America, North America/Caribbean/Central America, and North America/East Coast South America trades. Transit time delays of three days or more are not uncommon on many trade routes (Drewry Shipping Consultants 2006b). The Maersk line recorded the highest schedule integrity of 70 percent, with MSC recording the lowest level with 41percent (Notteboom and Gue 2008).

Schedule unreliability is mainly caused by port congestion, which is a consequence of an insufficient match between demand for container services and supply of container handling capacity. An average 11 percent annual growth rate was reported for total throughput handled by the world's container ports between 2000 and 2006. That is, including empty container movements and transhipments, total container circulation increased from 236 million TEU to an estimated of 442 million TEU between 2000 and 2006 (Drewry Shipping Consultants 2006a). However, it is difficult to expand ports and increase terminal/container handling facility capacity. Thus, many container ports worldwide have experienced utilisation levels of no less than 90 percent. A shortage of terminal flexibility is obvious at 90 percent plus facility utilisation levels (Appleton 2005; Ocean Shipping Consultants 2006). Consequently, severe port congestion is a common maritime issue, particularly during peak seasons. In addition, port delay/congestion can generate knock-on effects at other ports due to the nature of closely integrated liner services. Further, terminal planning tools (e.g., COSMOS and NAVIS) were designed to work under optimal/normal circumstances, and hence do not work well in practice, particularly where serious congestion conditions exist. This has resulted in further deterioration of schedule reliability. Other factors that cause schedule unreliability can range from bad weather, labour strikes at ports, delays at the access to port, or security considerations (Notteboom and Gue 2008).

Empty container repositioning is increasingly becoming a key logistics challenge due to global trade imbalances. Taking the US as an example, a mismatch between export and import of containerised trade between Asia and Europe resulted in an 11.1million TEU container disequilibrium in the year 2005. Thus, about 70 percent of the slots of containerships leaving the US were empty in 2005 (Boile et al. 2006; Notteboom and Gue 2008). Inefficient empty container repositioning may also result in capacity shortage or transportation delays for the container shipping sector.

Slow steaming refers to transoceanic cargo ships, especially container ships operated at significantly less than their maximum speed to reduce the fuel oil costs and cut carbon dioxide emissions. Driven by the stubbornly high fuel prices, slow streaming has been one of the dominant trends in container shipping over the past five years (Wikipedia 2013). However, the impact of slow steaming on SCs performance, as well as the uncertainties and vulnerabilities that could potentially be increased by slow steaming in container shipping, have not yet been adequately studied (Maloni, Paul and Gligor 2013). Although carriers have identified slow steaming as having the potential to significantly reduce the fuel oil costs, lower greenhouse gas emissions and improve schedule reliability (Maloni, Paul and Gligor 2013), speed is the primary concern for ocean shipping (Saldanha et al. 2009), and longer transit times caused by vessel speed reduction will increase shippers' pipeline inventory costs. In addition, the longer transit time could also increase SC operation vulnerabilities, particularly, SCs handling of perishable and short life cycle products (such as clothing and electronics) (Page 2011) by extending the forecast horizon, decreasing forecast accuracy, increasing safety stock needs and risks of out of stocks, and making JIT shipment volumes more difficult to estimate (Bonney and Leach 2010). Furthermore, schedule optimisation in slow steaming is extremely important, considering the restrictions of the berthing window in most ports, and the range of ports that need to be served at both ends (Drewry Maritime Research 2013).

2.4.4.2.2 Network Related/Infrastructures Vulnerabilities

Containerised maritime transport chains operate via complex intermodal transportation systems comprising ocean routes, road, and rail networks in order to connect two places anywhere in the world. This transport system is vulnerable due to a number of factors.

In the intermodal transport system, each mode operates on its own infrastructure. Most roads, rail tracks, and waterways are open (i.e., unfenced). The openness of these transportation infrastructures means they are accessible and operationally flexible, however, at the same time potentially vulnerable to damage, or to a loss of integrity of the cargo. Most road and rail networks not only traverse dense urban landscapes but also vast rural stretches. This provides multiple access points and easy escape for any thief or other criminal or terrorist (Organisation for Economic Co-operation and Development (OECD) 2003). Moreover, highly ineffective freight transportation infrastructure (i.e., inadequate road networks, poor or badly maintained infrastructure) may affect SC operations, particularly in many developing countries (Gulyani 2001). When compared with already developed countries, the efficiency of China's logistics industry is still low in terms of the ratio of logistics expenditures to Gross Domestic Product (GDP). In 2000, China's logistics expenditures amounted to 20 percent of the GDP whereas logistics spending accounted for 10.3 percent of the US's GDP, 14 percent of Japan's GDP, and 10–13 percent of EU's GDP (Waters 2007). Consequently, additional unit freight costs, vehicle operation costs, damage costs, and inventory carrying costs are imposed on different participants along the SC and ultimately passed on to the customers. This may result in decreases to customer satisfaction and compromises the entire SC performance and competition.

Congestion is a severe transportation problem no matter whether it occurs inland or on a waterway. Congestion can cause a service reliable decreases due to variable and unpredictable travel times (McKinnon and Ge 2004; Rodrigues et al. 2008). Congestion of road transportation might cause small or serious delays for short-distance deliveries, and increase operating costs (labours, fuel, inventory, etc.), as well as decrease customers' satisfaction levels (Mckinnon 1999; Figliozzia 2010). Congestion occurring at ports however can result in longer delays, disruptions to containerised SC operations, and impact upon a nation's economy (Rodrigues et al. 2008). Disruption to road, rail, and water channels may also severely impact both freight transportation and passenger transportation. For example, a railcar that caught fire took five days to extinguish in a tunnel under downtown Baltimore in 2001. The incident interrupted rail movements throughout the Northeast Corridor, and light rail passenger trains in the downtown area as well as Amtrak passenger trains (Riley 2004).

Ports are considered to be one of the principal vulnerable chokepoints in the containerised maritime transport chain. First, many ports are located in or near major metropolitan areas and are extensive in size. They are also the switch point of a container between ocean and land transport. This means that most ports are accessible by water or land. The very accessibility of ports leaves potential loopholes that may be exploited due to lax security resulting in criminal activity which is hard to detect, and difficult to prevent. Second, the rapidly growing international container trade over past two decades has made seaports scarce commodities. Capacity shortages are becoming increasingly severe for most ports. However, ports are hard to expand due to restrictions of space and the unwillingness of various authorities to actually do so. Thus, ports are becoming major bottlenecks for most international containerised maritime transport chains. A port is comprised of a number of dedicated terminals and cargo handling facilities. The capacity limitation of container terminals and cargo handling facilities may result in port congestion. Further, delay at one port may have flow on effects to land transportation, as well as delays at other ports. Hence, delays may have an international dimension that needs to be considered in terms of the global economy (Organisation for Economic Co-operation and Development (OECD) 2005; Notteboom and Gue 2008).

2.4.4.3 External Vulnerabilities

Regardless of the inherent vulnerabilities associated with network or internal operations, containerised maritime transport chains are operating in an increasingly uncertain external environment which brings with it various challenges, such as energy security, cost issues, climate change, bad weather, financial crises, and economic recessions. As mentioned in section 2.3.3, external SCD sources may be categorize into environment risks (social and economic environment), security risks, and catastrophes risks (natural hazards and non-terrorist intentional acts). Over the last 10 years, the occurrence of natural and man-made catastrophes has risen dramatically, and its average cost has increased 10 times compared with the costs incurred in the 1960s (Tang 2006b; Stecke and Kumar 2009). As such, an increasing number of researchers are concern with vulnerabilities emanating from the external environment, such as variations in key transport macroeconomic indicators (fuel prices, HGV driver shortages, etc.), bad weather, and uncertainty from future government policies (Evenson 1999; Boughton 2003; Sheffi et al. 2003; Dawes 2004; Hale and Moberg 2005; Runhaar and van der Heijden 2005; Braathens 2010). A growing emphasis is also being placed on terrorism and piracy.

After the September 11 2001 attack, maritime security concerns switched from cargo damage, theft and smuggling to the misuse of shipping containers and the transport system for the purposes of terrorism. Container shipping is now considered the most attractive and accessible component of the transport sector for the illicit transport of conventional and unconventional terrorist weapons (Tzannatos 2003). The threat of terrorists using containers and the maritime transport sector to conduct activities includes the possibility of sinking or disabling one or more ships in a channel or at port, hijacking a ship and using it to destroy some form of infrastructure, using shipping containers to deliver a conventional bomb, a radiological dispersion device, or even a nuclear weapon. The consequences of a successful terrorist attack could result in catastrophic human injury and death, millions or billions of dollars in losses or damage to a nations economy or the global economy as a whole, and political instability and upheaval with ongoing consequences (Greenberg et al. 2006).

Mainly driven by the prospect of windfall profits, the scale and sophistication of piracy has also jumped markedly in recent years. Thus, it is necessary to set it apart from maritime terrorism which focuses more on causing damage or harm than profit. According to Chalk (2009), the number of registered piracy incidents was 1845 globally between 2003 and the end of 2008, with an average annual rate of around 352. Almost 900 crewmembers were abducted in 2008, representing a 207 percent increase compared to 2007. In 2009, 406 piracy and armed robbery incidents were reported (International Maritime Bureau's (IMB) Piracy Reporting Centre 2010). Factors contributing to the emergence of piracy in the contemporary era include the reduction of sailing crews, the widespread and openness of coastal and port-side infrastructure, the difficulty for maritime security related to and limited resourcing, the availability of weapons worldwide, and the anarchic situation in countries such as Somali, as well as official complicity in high-level pirate rings (Chalk 2009). The overall annual cost of piracy to the maritime industry was estimated at between USD $1 and $16 billion in 2009, more if the cost of implementing mitigation efforts are also counted (United Nations Conference on Trade and Development (UNCTAD) 2009).

2.4.5 The Impacts of Containerised Maritime Transportation Related Disruptions

A port closure can potentially cause a loss ranging from millions to trillions of dollars for shippers, carriers, and consignees, with possible damage to an entire nation's economy. As discussed previously, the October 2002 US West Coast longshoremen's lockout cost USD $1 billion per day for the first week, growing to USD $2 billion per day in the second week. The New United Motor Manufacturing Inc. (NUMMI) is an example of a company affected by this event. NUMMI was forced to shut down and idle 5500 workers in its California plant. To satisfy market demand, NUMMI had to use airfreight instead of sea freight to carry parts from Japan during that period. In turn, NUMMI suffered substantial costs due to added transport fees, storage, and overtime wages (Sheffi 2005).

Schedule unreliability in liner shipping has the potential to affect several actors within container maritime transport chains. First, shipping lines are increasingly confronted with longer total round-trip times, fixed daily ship and operational costs, and the need to reshuffle the order of, or even the omission of, certain port calls to ensure schedule integrity. Second, terminal operators are confronted with increased uncertainty of ETA of container vessels, decreased efficiency of berth and yard planning, the full or over utilization of facilities, and congestions at terminals. Third, inland transport operators are confronted with increased delays and reduced productivity levels. Finally, shippers and consignees are confronted with imposed congestion surcharges, increased lead times, and higher safety stock/inventory levels required to avoid disruptions of SC activities (Vernimmen, Dullaert and Engelen 2007).

The dangers of piracy are also multifaceted. First, piracy it is a threat to the lives of crews and may result in an increase of mental trauma. Second, it delays shipments, either when a ship is hijacked or has to re-route to avoid harm, resulting in abnormal operations of the maritime industry and global containerised maritime SCs. Third, it creates additional costs to all containerised maritime stakeholders. Authorities have to increase investment on military presence and operations in affected areas. Shipping lines/carriers have to re-route ships to bypass affected areas such as the Gulf of Aden and the Suez Canal at an estimated additional cost of USD $7.5 billion per annum resulting from the re-routing of 33 percent of cargo via the Cape (United Nations Conference on Trade and Development (UNCTAD) 2009). Besides the increased re-routing costs, shipping lines/carriers are confronted with increased costs related to the hiring and retention of greater numbers of security personnel and the installation of deterrents, as well as higher insurance premiums. A war risk insurance coverage of USD $20,000 per ship, per voyage (excluding injury, liability and ransom coverage) has been imposed on ships that transit via the Gulf of Aden and the Suez Canal for example. This compares to USD $500 previously required to purchase additional insurance coverage, representing an incremental cost of war risk insurance premiums for the 20,000 ships passing through the Gulf of Aden at an estimated USD $400 million (United Nations Conference on Trade and Development (UNCTAD) 2009). There is no doubt that these increased costs are or will be passed onto shippers and or consumers in the future. Finally, piracy can undermine the oceanic environment via the spilling of hazardous or danger goods containers. Environmental damage will also pose economic and political impacts on affected ocean areas, particularly if affected areas rely heavily on the oceans as a primary resource of food, and/or regional and international export (Chalk 2009).

Aside from piracy, the consequences of terrorist attacks on containerised maritime transport chains include human, economic, and intangible consequences. These impacts range from minimal to massive affects depending on the way any such attack is conducted. Depending on how an attack is conducted, either using conventional weapons or nuclear or radiological weapons, the consequences to human life may be limited to the number of people aboard the vessel and in the immediate vicinity, or range from hundreds to millions of deaths and injuries which may persist for decades, for example in the form of latent cancers. The economic consequences might range from tens or hundreds of millions of dollars to billions of dollars, and may have global consequences such as causing economic recessions. Other financial consequences may result from the need to repair or replace vessels, the loss of cargo, damage or destruction of private and public infrastructure, delays to shipments and the need for long-term adjustments to or the modification of freight transportation systems. The augmentation of security procedures and equipment, and global containerised SCDs are also possibilities that require consideration. Intangible consequences including the loss of human capital (experience/skills of workers), the loss of history and culture related to an affected area, and the implementation of stricter guidelines on the movement of container freight with subsequent impacts on containerised SCDs and governments may result in a worsening of the political landscape and social and political/economic instability and upheaval (Greenberg et al. 2006).

2.4.6 The Need for Studying Disruptions in Containerised Maritime Transport Chains

Containerised maritime transport logistics is a complex system. Numerous participants are involved in a wide variety of international containerised maritime trades. Diverse cargoes are packed and placed into various containers, delivered by different transport modes, travelling via all sorts of transportation infrastructure and facilities worldwide, and are loaded/unloaded at different intermodal terminals/depots. A mass, elaborate, accurate, and fast information flow is required to support the complex interactions that take place, and enable various governing authorities to carry out required security measures, collect taxes and dues, and protect the regional/national safety of transportation systems. A secure financial flow is also needed to guarantee transnational trades across numerous participants. In addition, immeasurable internal operational vulnerabilities and unavoidable external vulnerabilities potentially affect global containerised maritime transport chains incessantly. Considering the complexity and vulnerabilities inherent in containerised maritime transport chains, all actors along a chain have to cooperate and coordinate their actions to improve SC performance and customer satisfaction. Nevertheless, since most participants are SMEs, they often lack the resources and motivations to bolster SC operation optimization and security. Sub-optimality in any node of a chain compromises integrated optimization and provides vulnerabilities that may result in disruptions.

No existing framework or known measures address the security of a container transport chain in its entirety. This represents the biggest difficulty in addressing security of daily operations. There currently exists no single system governing international container movements. Especially lacking is an integrating framework for inland transport on the outer edges of the chain, which typically presents a degree of higher risk than anywhere else along the chain. Security leaks or localized conflicts potentially create disruptions and discontinuity of container movements. Thus, a comprehensive intermodal framework integrating measures across the entire container transport chain is required for addressing security in a holistic manner (Organisation for Economic Co-operation and Development (OECD) 2005).

Vulnerabilities related to containerised maritime transportation are ever present. Any vulnerability may result in the cessation of container movements and halt ordinary operations across the entire SC in a multifaceted manner. The consequences of containerised maritime transportation related disruptions are diverse ranging from tangible to intangible, and economical to political to varying degrees. Thus, different stakeholders in container transport chains require an evaluable cost benchmark for analysing their risk mitigation strategies. Hence, a quantitative measure is needed to quantify containerised transportation related disruption costs.

The main consequences of transportation disruptions are reflected in lengthened transit time, increased travel time, unpredictability and scheduled unreliability, increased damage and loss in transit, added additional carrying costs in pipeline inventory and safety stocks, and knock-on effects on different sequential ports of calling, delay shipments, decrease customers' satisfaction levels. These consequences are difficult to estimate in terms of value. Inventory theory, unit freight costs, and vehicle operating costs are traditional approaches to investigate the impacts of transport related uncertainty. However, it is difficult to quantify the value of unreliability/unpredictability, as well as the possible delay and damage through traditional methods. Hence, a precise value of different containerised maritime transportation attributes, as well as its interaction value of different SC characteristics is required. The provision of such a valuation is one of the main aims of this current thesis.

2.5 Containerised Maritime Security-Related Initiatives

2.5.1 The Needs to Improve Maritime Security

The need to improve maritime security is multi faceted. First, as identified in section 2.4.4, the vulnerabilities of containerised maritime transport chains are inherent and omnipresent, whether they relate to internal operations, network related infrastructure/facilities, or external disasters. Second, not only regional and national economies may be affected when something goes wrong, but there may be a global economic impact. Huge volumes of goods and raw materials are shipped by sea worldwide to satisfy the different needs of resource redistribution and globalization. A disruption to the maritime transportation system could not only compromise a SCs performance but also halt or endanger a nation's economy. Third, awareness of the importance of maritime security has greatly increased since September 11, 2001. Coupled with fears of terrorism, rampant piracy attacks continue to occur raising further concerns about maritime security issues. It is anticipated that improving maritime security may help ensure the performance SCs worldwide. In conjunction with the above, it is clear that there is a need for comprehensive maritime security measures that cover entire maritime transport chains beyond measures that are currently in place. Nevertheless, the next section outlines current initiatives so as help understand what limitations exist.

2.5.2 The Extant Maritime Security Initiatives/Regulations

This section outlines the extant international maritime security initiatives/regulations post-September 11, 2001. The list of security programs is not exhaustive but designed to highlight the major security initiatives that have been implemented.

2.5.2.1 Customs-Trade Partnership against Terrorism (C-TPAT)

The US Customs and Border Protection (CBP) agency initiated the Customs-Trade Partnership against Terrorism (C-TPAT) initiative in April 2002. C-TPAT is a voluntary program which seeks to build public-private relationships with the aim of increasing SC and border security. C-TPAT shifts the responsibility of cargo security to all stakeholders in an SC. Participants are expected to conduct a comprehensive self-assessment of their SC security practices. Members in the program are required to comply with the CBP guidelines. In return, CBP offers members a reduction in the number of inspections, priority processing, security validation, and involvement with a network of security conscious businesses (United States Customs and Border Protection (CBP) 2007). There were 7737 certified members in C-TPAT at the end of 2007 (U.S. Department of Homeland Security (DHS) 2007).

2.5.2.2 Container Security Initiative (CSI)

The CBP announced the Container Security Initiative (CSI) in January 2002. The CSI is a series of bilateral, reciprocal agreements that enable CBP personnel at selected foreign ports to pre-screen U.S.-bound containers. The objective of CSI is to prevent illegal shipments to be transported to the U.S. by moving the process of container screening to ports of origin. Thus, containerised cargo is inspected and cleared before a shipment leaves a foreign port bound for the U.S. One positive externality of the CSI is that it has the potential to reduce overall delays by reducing the processing time at U.S. domestic ports of entry, and also reduce the U.S. to exposure of losses from fraud and damage (Willis and Ortiz 2004). The CSI comprises four fundamental elements. 1) using intelligence and automated information to identify and target high-risk containers, 2) pre-screening containers identified as high risk at the port of departure, 3) employing detection technology to rapidly pre-screen high-risk containers, and 4) the use of smarter tamper-proof containers (Dahlman et al. 2005).

2.5.2.3 Ninety-Six and Twenty-Four-Hour Rules

The ninety-six-hour rule is designed to reduce the possibility of terrorists controlling a vessel and sailing it to a selected port. It further concentrates U.S. government efforts towards specific vessels that warrant particular scrutiny. The initiative requires a four-day (96 hour) advance notice of arrival of any vessel be submitted to the U.S. government (Thibault, Brooks and Button 2006).

The twenty-four-hour rule (the advance manifest rule) became effective in December 2002. This rule requires that maritime carriers and non-vessel operating common carriers (NVOCCs) provide a cargo declaration 24 hours before cargo is laden aboard a vessel at a foreign port outside the U.S. The advance manifest information must be submitted for all containers including U.S.-bound or transiting through the U.S. Using the advance manifest information, U.S. customs officials are able to assess potential terrorist threats before a vessel sails from a foreign port. Only containers that are deemed to meet acceptable security thresholds are allowed to be shipped to the U.S. ports. This minimizes delays or disruptions to container lines and ports. The benefits of the twenty-four-hour rule include paperless processing, the elimination of repetitive trips to the local customs houses, a reduction of cargo dwell time, and an increase in customs compliance. However, if participants do not have suitable documentation, the rule can blunt the effectiveness of SCs and impart significant negative impacts on industry. This is because the CBP may issue “do not load” container messages for violators and deny access to U.S. ports for those disregarding the instructions. About 100 containers worldwide were held before loading during the first year of operation due to incomplete documentation (Dahlman et al. 2005; Thibault, Brooks and Button 2006).

2.5.2.4 The International Ship and Port Security Code (ISPS)

The IMO established the International Ship and Port Security Code (ISPS) in December 2002. It entered into force on July 1, 2004, and requires all 167 IMO member-states to certify compliance. Any non-compliant port or vessel will be precluded from participating in international trade. The ISPS code sets out detailed standards for security, roles and responsibilities, and methodologies for assessing security. It establishes an international framework for co-operation among governments and their agencies, local administrations, shipping companies, and port authorities to detect security threats and to design plans to prevent security incidents affecting ships or port facilities. Contracting governments must set security levels (normal, medium, and high threat situations), conduct port facility security assessments, and approve elaborate security plans that can be implemented for each of the security levels for both ships and port facilities (Organisation for Economic Co-operation and Development (OECD) 2005). Security officers are required at the company, port, and ship levels and are responsible for complying with the ISPS code security requirements. The U.S. implemented the ISPS code by signing the Maritime Transportation Security Act of 2002 (MTSA).

2.5.2.5 Operation Safe Commerce (OSC)

Operation Safe Commerce (OSC) is a public-private partnership program with 18 projects designed to monitor and improve the security of containers in transit using off-the-shelf and emerging technologies. The objective of OSC is to remove or eliminate the possible utilization of containers and the containerised transport system as a tool for terrorism by identifying and addressing security risks in an operational environment. In the OSC program, existing containerised SC practices and security solutions are analysed through container tracking and tracing technology, non-intrusive detection strategies, and improved seal concepts. Security techniques and solutions that have proved successful under the program are recommended for implementation system-wide (Dahlman et al. 2005; Organisation for Economic Co-operation and Development (OECD) 2005).

2.5.3 The Implementation Costs of New Security Measures

New maritime security measures are costly. The implementation of new security regimes and initiatives requires continuous investment in terms of equipment, procedures, and the recruitment and training of security personnel. Additional costs are also needed to carry out the new security measures, including detailed reporting, further inspections, and other operational requirements (Bichou 2008). For example, the costs of applying RFID tags will include system installation, monitoring, responding to system and information changes, maintenance, as well as technology upgrades, software development, and database maintenance (Sarathy 2006).

The extra costs related to the implementation of new maritime security measures have been widely studied. The burden placed on global shipping operators was estimated to be at least USD $1279 million for the initial ISPS code compliance costs and USD $730 million for annual operation/maintenance (Organisation for Economic Co-operation and Development (OECD) 2003). The compliance costs on ports worldwide were revealed to be USD $287,000 for the initial investment and $105,000 per port annually for the ISPS code initiative; for each ton or TEU handled, it is estimated to be USD $0.08 and $3.6 respectively (United Nations Conference on Trade and Development (UNCTAD) 2007). The implementation and annual operating costs of C-TPAT for a multinational firm are reported to be approximately USD $38,471 and $69,000, respectively (Diop, Hartman and Rexrode 2007). The additional costs to comply with the twenty-four-hour rule are estimated up to be USD $6 per shipped container and USD $40 per bill of loading. If missing or inaccurate data is submitted to CBP, a fine of USD $5000 for the first time and $10,000 thereafter is imposed to ocean carriers and NVOCCs (Bichou 2008).

2.5.4 The Impacts of Implementing New Security Measures on the Maritime Industry

The implementation of new maritime security measures has both positive and negative impacts on different stakeholders. The negative impacts on shipping companies, port operators, and freight forwarders are adding extra workload requirements, spending more resources in monetary and labour terms for service providers to comply with the new initiatives, the creation of difficulties in carrying out operations and management and affecting service quality, and the requirement for large investment costs. Other impacts include delays of shipments. In addition, excess security efforts for a perceived security threat, or ineffective management of security improvements can potentially cause waste, reduce maritime transport operation efficiency and reliability, and result in further possible delays (Thibault, Brooks and Button 2006; Thai 2007).

The benefits of the new security requirements are investment on IT and EDI and its wide application in the maritime industry which potentially may increase the reliability of information and improve the outcome of service performance, application of the ISPS Code assisting in preventing terrorism, piracy, and other traditional security threats and assuring the safety and security of equipment and facilities, as well as cargo, and in return decreasing insurance premiums charges, and new security requirements enhancing firm reputation for reliability in the market. Other benefits include shipment tracing capability, increased environmentally safe operations, enhanced socially responsible behaviour and concerns for human safety, and the facilitation of sustainable business development (Thai 2007; Prentice 2008). Thibault, Brooks and Button (2006) noted the implementation of new maritime security initiatives have fostered a co-operative security relationship between industry and government. Business procedures and processes in the maritime industry have been re-examined and amended to manage operations better from a security perspective. The negative impacts on maritime participants are outweighed by its benefits. Undeniably, new maritime security measures have imposed different magnitudes of costs on all stakeholders within the maritime industry, and will require further investment into the long run. This raises several important issues. How should maritime security be funded for the long term? Who should provide funding for improving maritime security? Who should bear the huge security costs and annual running/maintenance costs, and should these costs be passed on to the ultimate users? Finally, what procedures and measures should be introduced to best facilitate recovery of port and containerised SC operations in the event of a terrorist attack (Thibault, Brooks and Button 2006).

2.6 The Important Roles of China and Australia in the Global Economy

There is an intrinsic connection between maritime transportation, international trade, and globalization trends. Globalization promotes the relocation of resources and goods to the regions or populations with the greatest levels of demand, and facilitates a steady growth in international trade. Maritime transportation is an integral part of the global economy to ensure uninterrupted and smooth cargo flows. In particular, the containerised maritime transportation system has enabled the integration of freight transportation across all modes. Asia is a dominant area for global seaborne trade with a share of 40 percent of total goods loaded (United Nations Conference on Trade and Development (UNCTAD) 2009). This thesis studies Chinese and Australian containerised maritime transport chains and conducts a comparison between them. The sections that follow discuss the importance of both countries to maritime logistics.

2.6.1 China, an Increasing Important Role in the Global Economy

China's is not only the world's manufacturing centre, but is also an engine for the world's economic growth. China's GDP experienced an average 10 percent annual growth rate between 1980 and 2005. According to the National Bureau of Statistics of China, China's GDP has risen from RMB ¥362.4 billion in 1978 to RMB ¥20, 941 billion in 2006 (equivalent to 2006 USD $2800 billion). Further, in 2010, China's economy surpassed that of Japan's and that it became the world's second largest economy in terms of nominal GDP, while the United States is still the world's dominant economy (China Second in Line 2010).

Within this context, China plays a pivotal role in a growing number of global SCs. China's main export destinations are the US, the EU, Hong Kong and Japan, which represents 68 percent of China's exports by value. Almost 50 percent of total imports come from Japan, Korea, Taiwan and the EU. China's foreign trade has grown at an even faster pace. According to the WTO, during the decade 1995–2005, China experienced an annual growth rate of 18 percent in merchandise exports and 17 percent in merchandise imports. China's exports tripled from USD $63 billion in 1990 to USD $184 billion in 1998 and again tripled to USD $593 billion by 2004. China's imports also achieved a quadruple increase from USD $140 billion in 1998 to USD $561 billion in 2004 (Johnson 2007).

Given the increasing significance of China as a major trading partner, the importance of China's logistics industry cannot be ignored. In 1999, China's logistics industry reported an annual growth rate of 31 percent, 35 percent in 2000, and 55 percent in 2001 (Bolton and Wei 2003). Between 1992 and 2004, the average annual growth rate of the China's logistics industry was 22.2 percent, and logistics expenditures accounted for an average of 21.8 percent of GDP (Wang et al. 2006). Nevertheless, the international trade surge has also imposed an increasing burden on the international and domestic transportation networks supporting China. As a result, congestion, delays, and environmental problems in ports and coastal regions are becoming increasingly severe in China.

With the acceleration of world economic integration, global seaborne trade rose to 8.17 billion tons of goods loaded in 2008. Of this, dry cargo accounted for the largest share of 66.3 percent. China has contributed significantly to these figures with growing demand for raw materials and the exporting of manufactured goods. China has become one of the most important and dynamic shipping markets in the world with a continuous, rapidly developing economy heavily invested in foreign trade. In addition, China's 110,000 km of navigable distances provides the world's largest in-land waterway network. Maritime transportation has become the most important mode for transporting domestic and international trade, which accounts for 2,373 bntkm, or 53.4 percent of the national total freight transport (Business Monitor International (BMI) 2011). In 2003, container throughput of mainland Chinese ports reached 48 million TEUs and ranked No 1 in the world (Zhang 2004b). China's largest ports and harbours are located in Shanghai and Shenzhen. Other important ports include Dalian, Fuzhou, Guangzhou, Haikou, Huangpu, Lianyungang and Nanjing; Nantong, Ningbo, Qingdao, Qinhuangdao, Shantou, Tianjin, Wenzhou, Xiamen, Xingang, Yantai and Zhanjiang. Shanghai international port is the largest commercial port in China. In August 2010, Shanghai port alone handled 2.64mn TEUs and took Singapore's title as the world's busiest port (Singapore handled 2.43mn TEUs) (Business Monitor International (BMI) 2011).

2.6.2 Australia, an Important Role in the Global Economy

Australia lies between the South Pacific and Indian Oceans and is a significant maritime nation. There are approximately 72 commercial and semi-commercial ports located around the Australian coastline and surrounding islands, of which approximately 30 handle containers (Bureau of Transport and Regional Economics 2002). Australia's global and regional economies rely heavily upon merchant shipping. Australia's economy is also profoundly dependent upon seaborne trade comprising 99.9 percent of trade by volume and more than 75 percent by value (Cordner 2008).

The Australian economy is heavily interconnected with the global economy. Australian exports by volume comprise more than 10 percent of the world's total. In 2006, dry bulk cargoes comprised more than 60 percent of global shipments with Australia providing 13.3 percent of the total goods loaded (Cordner 2008). Australia's international trade is a vital component of the country's economic prosperity measured at USD $507 billion in 2009. Australia's merchandise exports rose at an average annual rate of 12.1 percent and reached USD $196.2 billion in 2009. China is its largest export-trading partner accounted for 21.6 percent (USD $42.4 billion) of its total merchandise exports in 2009, followed by Japan, the Republic of Korea, India, and the U.S. Australia's average annual import growth rate has been 8.7 percent over the past five years. Australia's merchandise import was USD $200.6 billion in 2009. In 2009, China was also the largest import trading partner to Australia, accounting for 17.8 percent of its import trade, followed by the US, Japan, Thailand, Singapore, and Germany (Australian Government Department of Foreign Affairs and Trade 2009). Similarly, Australia is also one of the major import and export partners of China, ranked seventh in 2009 (Wikipedia 2009).

2.7 Research Questions and Conclusions

The Global economy relies highly on SCs to facilitate national and international trade. Indeed, domestic and international trade is not possible without transportation and transportation systems. A containerised maritime transportation system is an integrated transport system ensuring uninterrupted and smooth flows of cargo from a plethora of origins to multiple destinations. Nevertheless, containerised maritime transportation chains are vulnerable and can be easily disrupted due to their complex natures. A disruption anywhere within a containerised maritime transport chain can have a significant economic impact on individual companies, personnel, nations, and even the global economy. It may also cause political instability which may cause further issues. Thus, improving maritime security is crucial to reducing the vulnerabilities inherent in containerised maritime transport chains and to prevent them from experiencing possible disruptions. However, the implementation of maritime security initiatives is costly and requires continuous investment for maintenance and improvement. This raises concerns over who should fund security improvements, how much is worth investing, and where or what kind of transport services should be invested in to improve or facilitate any post disruption recovery. It is therefore necessary to quantify containerised maritime transport related disruption costs and the value of different maritime transport attributes.

SC risks have been studied widely in conceptual and empirical terms. Studies on valuing SCD costs are rare however, especially in quantifying disruption costs in containerised maritime SCs. This thesis proposes the use of the discrete choice models based on stated preference data to estimate the value of maritime transportation service attributes, including travel time, reliability, damage rate, and sailing frequency, and to examine the interaction effects of these with product category, shipment type, and SC and company characteristics. This thesis also examines which maritime transport attributes are most important during a transport related disruptions and which SC characteristics affect the value of these attributes. It is hoped that the results of this research will help explore where and how much is worth investing to facilitate recovery from a disruption event from the point of view of maritime participants.

Asia is a dominant loading area for global seaborne trade with a share of 40 percent of total goods loaded (United Nations Conference on Trade and Development (UNCTAD) 2009). China and Australia are important trading partners in the area for most countries. The containerised maritime transport chains in both countries are pivotal elements to most global SCs. Applying industrial data by interviewing importers/exporters in both countries to quantify the SCD costs in a containerised maritime transportation system has practical meanings to the maritime industry worldwide.

Chapter 3 focuses on describing discrete choice techniques and reviews the applications of these methods to the freight transportation literature. A theoretical framework is established in which the econometric modelling undertaken to fulfil the thesis's analytical requirements is also presented.

CHAPTER THREE

3 METHODOLOGY

3.1 Introduction

Market and non-market valuation is a characteristic of the main consequences caused by maritime transportation disruptions. For instance, it is hard to measure or quantify realistic or possible transport disruption impacts, such as lengthened transit time; increased travel time unpredictability and schedule unreliability; increased possible damage and loss in transit; possibly added additional carrying costs in pipeline inventory and safety stocks; knock-on effects on different sequential ports of calling; delayed shipments; decreased customers' satisfaction level, and so on. These non-market value consequences create unreliability and unpredictability to all stakeholders in containerised maritime transport chains without exception, in turn, creating difficulty for their managerial, strategic and political decision-making. However, it is extremely important to quantify those non-market value consequences and provide a measurable costs benchmark to all containerised maritime transport chain stakeholders for their strategic purpose.

First developed by Louviere and Hensher (1983) and Louviere and Woodworth (1983), stated choice methods have been utilised widely for the purposes of non-market valuation over last two decades. Their application covers a wide range of fields, including transportation, environmental science, health economics, entertainment, marketing, political science, and econometrics. Thus, the stated choice method is used in this research to explore SCD costs in containerised maritime transportation, particularly, to reveal how transport related disruptions influence the value changes of maritime transportation service attributes, such as travel time, reliability, damage, and frequency.

This chapter first reviews the application of Stated Preference (SP) choice techniques in SC and freight transportation to identify the reality of applying SP techniques in containerised maritime transportation. Second, a review of key variables in freight transport studies is conducted to select the applicable studying attributes in maritime transport. Third, to examine the research questions of this study, hypotheses are listed. Further, the fundamentals of stated choice modelling techniques and its advance models are reviewed, and followed with an introduction of seemingly unrelated regression equations (SURE) model techniques. A detailed description of the Latent Class Model (LCM) and seemingly unrelated regression equations (SURE) model techniques are stated, as they are the most appropriate statistical analysis tool for the research purposes of this thesis. Finally, conclusions are drawn.

3.2 Discrete Choice Techniques in Freight Transportation

Within the transportation literature, the study of the value of travel time savings (VTTS) has become increasingly popular since the pioneering contribution of Becker (1965). To date, the vast majority of studies addressing the issue of VTTS have focused on private vehicle usage. In contrast, the evaluation of the value of travel time saving within the freight transport sector (VFTTS) has received scant attention.

A number of theoretical and practical issues complicate the evaluation of VFTTS that don't exist when dealing with passenger VTTS (see e.g., Fridstrom and Madslien (1994), Jong (2000), Massiani (2003) and Zamprini and Reggiani (2007)). First, freight transportation arrangements are typically such that decisions are made by multiple agents, including the sender, consignee, haulier, carrier, liner, etc. This makes it difficult from a research perspective as it is necessary to identify the economic agents whose profit function has to be maximized. Secondly, there often exist extreme levels of heterogeneity in terms of what is being shipped which makes it difficult to obtain data, and even more difficult to estimate robust econometric models. Third, typical sample sizes are very small, particularly if one wishes to concentrate on one part of the freight sector. Fourth, survey costs within the transportation sector are usually prohibitive when compared to passenger samples. Finally, it is often difficult to obtain real market freight information due to issues such as confidentiality.

Despite these difficulties, there exist some studies examining the VFTTS. The quantification of the value of freight time, as well as the value of freight time reliability has been undertaken successfully using discrete choice methods. The majority of empirical studies on the freight transport value of time and reliability (VOT, VOR) or valuing other transport related attributes relate to land based transport such as trucking and or rail (Kawamura 2000; Kurri, Sirkiä and Mikola 2000; Wigan et al. 2000; Shinghal and Fowkes 2002; Bolis and Maggi 2003; Danielis, Marcucci and Rotaris 2005).

An even smaller number of studies have looked at identifying the freight transport service attributes within the maritime transportation sector that drive the decision processes of those acting within the industry, and of these studies, most have concentrated on the issue of port selection behaviour. Tiwari, Itoh and Doi (2003) establish a model of port and shipping line choice behaviour in China and estimate the factors influencing containerised cargo shippers' decisions on port or carrier selection behaviour. Magala and Sammons (2008) argue port choice should be modelled within the paradigm of a port as an element in a value-driven SC, and suggest that discrete choice modelling is an effective approach to understanding port choice and shipper choice decisions.

Only a relatively few studies have been conducted that attempt to identify the determinants of choice empirically in maritime or maritime related intermodal transport sector. Bergantino and Bolis (2005) used an adapted stated preference technique to estimate operator's preferences for maritime RO-RO transport services. Their results indicate freight rates, reliability, and frequency are important determinants of modal choice; in their study, freight forwarders ranked frequency higher than reliability and were willing to pay approximately three Euros per ton for a one percent improvement in reliability and seven Euros per ton for a variation in frequency. Beuthe and Bouffioux (2008) estimated the relative importance and value for service frequency, transport time, reliability of delivery, carrier's flexibility and safety for various modes of transport including road, rail, inland waterway, short-sea shipping, and their inter- and multi-modal combinations. Their results identify that these qualitative factors play a significant role in the modal choice/or possible modal shifts, however the relative importance of these attributes varies according to different subsamples of actors within the sampled population. Feo-Valero et al. (2011) applied a mixed logit model based on data collected from a stated preference survey to estimate a modal choice model between road and rail transport on the inland leg of a containerised maritime freight shipment in Spain. Their results confirm that rail transport has a comparative advantage over road haulage in terms of cost, and frequency plays a vital role in the relative competitiveness of rail transport. They also estimated a willingness to pay (WTP) for a one-hour decrease in rail transit time per shipment of 17 Euros, three Euros for a one percent reduction in delays, and 70 Euros to increase rail frequency by one extra service per week.

Based on the research conducted to date in this area, discrete choice modelling has been shown to provide an effective analytical framework in which to better understand shipper decision processes (Magala and Sammons 2008). Further, most empirical studies in this area have been based on stated preference (SP) methods as SP experiments have been shown to offer greater flexibility and control over the data collection process than other methods. This current study therefore uses both these methods.

3.3 Selection of Key Variables in this Research and the Research Objectives

A large number of researchers have investigated and identified the important factors that influence freight transportation or modal choice decisions in different transportation sectors. McGinnis (1990) reviewed the literature and found that freight transportation choices are typically influenced largely by freight rate, reliability, transit time, loss/damage/claims processing/tracing, and market considerations as viewed by shipping and carrier agents. Service attributes were more important than freight rates, on average, but freight rates remain an important attribute and in some segments, rank higher than service. Lambert, Lewis and Stock (1993) summarized 166 attributes in the carrier selection process and identify that respondents placed greater import on high-quality customer service and accurate billing but were less concerned with price as long as the rates they paid were competitive. Tiwari, Itoh and Doi (2003) summarized several decision factors related to transportation mode choice. These included *route factors*, including frequency, capacity, convenience, directness, flexibility and transit time; *cost factors*, including freight rate, and other costs; and *service factors*, including delays, reliability, damage and loss, quick response, documentation, tracing capability and cooperation between shipper and carrier. Brooks (1984; 1985) identified the determinants of shippers' choice of a container carrier. She found that smaller shippers mostly base their choice on cost; whilst, frequency of sailings, reputation, transit time and directness of sailing, as well as other service factors were more important than cost for large shippers and forwarders. The importance of various freight liner shipping service attributes have also been examined within the literature, with two notable studies contrasting shipper and carrier decision processes (Jamaluddin and Shah 1995; Chiu 1996). In the current research, based on the above studies, the key containerised maritime transport attributes influencing shippers' choice are investigated, including freight rate, transit time, reliability, damage rate and frequency.

Transportation service factors or quality attributes have been found to take precedence over other factors (Brooks 1984; Tiwari, Itoh and Doi 2003), and including costs (Lambert, Lewis and Stock 1993; Chiu 1996; Danielis, Marcucci and Rotaris 2005). This suggests that shippers are willing to trade off price for improvements in quality and reliability in transportation services. However, since freight transport is a derived demand originating from shippers' propensity to trade, a firm's freight transport decisions can be expected to be influenced by organisational and SCM characteristics. Therefore, investigation of the importance/value of transport service attributes in freight choices decisions should not be isolated but integrated with other SC decisions or wider SCM strategies.

For example, Magala and Sammons (2008) suggest that port choice modelling should be conducted within the paradigm of a port being an element in a wider value-driven SC. The importance of transport service attributes will be expected to vary with each company's own management strategy, such as a JIT policy, and will affect shippers' transport decisions. For example, firms applying JIT in American Manufacturing plants give significantly higher emphasis to rate, customer service, claims handling/follow-up, and equipment availability/service flexibility in the ranking of carrier selection attributes relative to firms operating under different strategies (Bagchi, Raghunathan and Bardi 1987). Transit time and reliability were dominant factors for companies using JIT principles or serving the consumer market directly, service frequency was also significant, and cost was important particularly for low value commodities for shippers in Italy and Switzerland (Bolis and Maggi 2003). Shippers' freight transport decisions are also expected to be affected by company size, production, and transport distance, etc. Danielis, Marcucci and Rotaris (2005) reveal that the type of goods shipped also influence shippers' preferences; the company size was related negatively to the intensity of preference for quality attributes; the shorter the travel time the more important time and reliability become relative to cost; the adoption of JIT strategy increases the preference for reliability while outsourcing strategies have no influence on shippers preferences. Beuthe and Bouffioux (2008) indicate that freight transport qualitative factors: service frequency, transport time, reliability of delivery, carrier's flexibility and safety, are important in shippers' modal choice decisions, and their relative importance varies according to transport distance, cargo value, cargo categories, as well as transport mode.

Their results reveal that 1) for short distances (less than 300 km) deliveries, shippers focus on minimising trucking costs, and transport quality factors are less important whilst transport time appears negligible; for intermediate distances (between 300 and 700 km), time and reliability gain more attention than cost factors; cost plays a dominant role in longer distance (more than 700 km) deliveries. 2) Cost becomes more important and becomes the greatest concern for low-value goods; time and reliability are relatively important for middle-value goods, while service flexibility and safety are more important if cargo is of high-value. 3) Shippers' preference profiles vary with the categories of goods they shipped. For example, time, reliability, and flexibility are much more important than cost for shippers shipping minerals, fertilisers, and agricultural products, whereas, cost is the determinant attribute for the shipments of metal products. 4) Transport time and reliability are important factors for rail shippers, while shippers operating on waterways are more concerned about time and the flexibility of response to unexpected service demands. 5) Transport time and reliability are the two critical qualitative transport attributes, whilst adopting certain pricing policies may also be an effective way to induce better balanced modal shifts. The regulation/de-regulation of transportation industries or government policies particularly new security measures also influences shippers' transportation choices. McGinnis (1990) reviews the carrier attribute literature before and after deregulation, and found that shippers' freight choice was affected by freight rates, reliability, transit time, loss/damage/claims processing/tracing, and market considerations from the shipping and carrier agents' point of view.

The key variables used in studies employing choice modelling to determine SC transport choices have tended to focus on factors influencing shippers' choice behaviour in their transportation decision process. The key containerised maritime transport attributes influencing shippers' choice investigated in this research are freight rate, transit time, reliability, damage rate, and frequency. The current research attempts to model shippers' maritime transportation choices within the SC perspective. Therefore, the impacts of different product, shipment, company, and SC characteristics on shippers' transportation decision will be examined herein.

The first research objective of this study is to identify and quantify the key transport attributes influencing shippers' containerised maritime transport decisions, as well as any interaction impacts these have with various SC and organisational differences, including geographical location, product, company/SC characteristics, and industry regulation or policy.

The second objective is to quantify the transport related SCD costs through exploring the trade-offs amongst identified maritime transport service attributes under a scenario of a SCD event, and to identify the discrepancy and variation of shippers' preferences for maritime transport service attributes with a SCD for different shipments, in different industries and companies, as well as SCs. To the best of the author's knowledge, no scholarly work has collected data regarding how companies perceive transport related SCDs and what they do to respond and address them. Further, no attempts to quantify the costs of disruptions using measures applicable and useful from a transportation planning perspective have been made. Meanwhile, this research is the first time modelling containerised maritime transport service attributes based on an integrated SC perspective.

The next section states the hypotheses that would be examined through discrete choice modelling and SURE modelling in this study.

3.4 Hypotheses

Containerised maritime transportation involves complex decision making processes involving multiple agents faced with significant amount of uncertainty making decisions about multi-mode of transportation. As such, shippers' containerised maritime transportation choices have to be integrated into an integrated SC rather than be made in isolation. To complicate matters, SC and firm heterogeneity, including differences in production processes, organisational structures and shipment characteristics are all likely to influence shippers' choice behaviour. Further, the importance and perceived value of factors influencing key decisions may vary over time, or in the event of a SCD. It is effect of the later which is the focus of this thesis.

This thesis makes use of discrete choice models applied to stated choice data to address a number of hypotheses. According to theory, population heterogeneity may result in significantly different estimations of values in non-market valuation studies. Therefore, the identification of key transport attributes and different heterogeneity sources affecting shippers' choice from a SC perspective are the subjects of the hypotheses tested in the context of discrete choice modelling in this thesis. In light of this, the hypotheses to be tested herein are now detailed.

The first hypothesis (H_1) relates to the identification of the key maritime transport service attributes influencing shippers' containers transport decisions under normal operations. Based on a review of the literature, the null hypothesis is:

H_0: Compared with other selection criteria (such as capacity, directness, reputation, communication, tracking system and market consideration), freight rate, transit time, reliability, damage rate, and sailing frequency are not taking precedence over other factors, with these factors having equivalent importance when shippers make choice decisions in containerised maritime transport under normal operations.

The alternative hypothesis therefore is stated as:

H_1: Compared with other selection criteria (such as capacity, directness, reputation, communication, tracking system and market consideration), freight rate, transit time, reliability, damage rate, and sailing frequency take precedence over other factors, and these factors have different values to shippers' choice decisions in containerised maritime transport under normal operations.

Hypothesis two (H_2), examines the influences of a SCD on shippers' preferences and the value placed on key maritime transport service attributes. This hypothesis aims to identify the salient maritime transport service attributes influencing shippers' transport decisions when experiencing a disruption event, and to investigate how these preferences vary in terms of attribute importance from normal operating conditions. The null hypothesis is:

H_0: Surcharge or rebate, delay time, reliability, and damage rate are the same as other potential affected factors (such as communication, documentation, and tracking system), and contribute equivalent value to shippers' containerised maritime transportation decisions given a disruption, and shippers' preference and WTP for these attributes under a disruption do not differ as they do under normal operating conditions.

The alternative hypothesis two therefore is stated as:

H_2: Surcharge or rebate, delay time, reliability, and damage rate are found to take precedence over other potential affected factors (such as communication, documentation, and tracking system), and contribute different value to shippers' choice behaviour in containerised maritime transportation decisions given a disruption, and shippers' preference and WTP for these attributes under a disruption do differ as they do under normal operating conditions.

If H_1 and H_2 are not rejected, then the following hypotheses can be tested.

The third hypothesis (H_3) attempts to verify the influence of company geographic location on shippers' WTP for transport service attributes with and without a disruption event. The null hypothesis can be presented as:

H_0: Shippers in different geographic locations have equivalent logistics preferences and WTPs for containerised maritime transport service attributes independent of whether they are operating under normal or disrupted service conditions.

The alternative hypothesis is therefore:

H_3: Shippers in different geographic locations have different logistics preferences and WTPs for containerised maritime transport service attributes under normal operating conditions as they do under a disruption event.

The fourth hypotheses (H_4) examines whether product characteristics, such as product category and value of goods transported affect shippers' transportation choices, and whether differences in product characteristics influence shippers' transportation preferences given a SCD. The null hypothesis for H_4 is:

H_0: Shippers shipping different industrial products of differing value have the same WTPs for containerised maritime transport service attributes under normal operating conditions as they do when facing a SCD.

The alternative hypothesis is:

H_4: Shippers shipping different industrial products of differing value significantly have different WTPs for containerised maritime transport service attributes under normal operating conditions as they do when facing a SCD.

The fifth hypothesis (H_5) investigates how company characteristics (including a role of importer/exporter and organization sales) impact on shippers' transport decisions and WTPs for key transport attributes with or without a SCD. The null hypothesis is:

H_0: All shippers have equal WTPs for containerised maritime transport service attributes under all operating conditions, independent of their company characteristics, such as their nature of business (importers and exporters) and firm size.

The alternative hypothesis five therefore is stated as:

H_5: All shippers have unequal WTPs for containerised maritime transport service attributes under all operating conditions, depending on their company characteristics, such as nature of business (importers and exporters) and firm size.

The sixth hypothesis (H_6) explores whether different SCM strategies (such as contingency planning, the assessment of carrier reputation and the application of JIT inventory principles) affect shippers' WTPs for maritime transport service attributes, and how these vary during a SCD. Thus, the null hypothesis is:

H_0: The WTPs for containerised maritime transport service attributes do not vary by alternate SCM strategies under both normal and disrupted operating conditions.

The alternative hypothesis six therefore is stated as:

H_6: The WTPs for containerised maritime transport service attributes do vary by alternate SCM strategies under both normal and disrupted operating conditions.

The seventh hypothesis (H_7) seeks to assess what shipping/transport characteristics (including shipment contract terms (FOB/CIF), whether shipment reconsolidation is used, the shipment involves a transhipments, and the length of travel time) influence shippers' WTPs for the marine transport service attributes, and whether these differ from normal and SC disrupted operations. The null hypothesis is:

H_0: Shippers, independent of shipment and trip characteristics, have the same WTPs for containerised maritime transport service attributes both under normal and disrupted operating conditions.

The alternative hypothesis seven therefore is stated as:

H_7: Shippers, independent of shipment and trip characteristics, have different WTPs for containerised maritime transport service attributes both under normal and disrupted operating conditions.

The last hypothesis (H_8) assesses whether concerns about security (e.g., terrorist attacks) or other risks (such as delays) affect shippers' WTPs for maritime service attributes under normal and disrupted operations. The null hypothesis is:

H_0: Shippers, whether or not they consider and prepare for security and risks issues when making their transport decision, would have exactly equivalent WTPs for containerised maritime transport service attributes under all operating conditions.

The alternative hypothesis eight therefore is stated as:

H_8: Shippers, whether or not they consider and prepare for security and risks issues when making their transport decision, would have entirely different WTPs for containerised maritime transport service attributes under all operating conditions.

Table 3-1 lists the summaries of the hypotheses in this thesis.

Table 3-1: Summary of Thesis Hypotheses

	Hypotheses
	Important Transportation Attributes Affecting Shippers' Maritime Choice
H_0:	Compared with other selection criteria (such as capacity, directness, reputation, communication, tracking system and market consideration), freight rate, transit time, reliability, damage rate, and sailing frequency do not take precedence over other factors, and these factors are having equivalent importance when shippers make choice decisions in containerised maritime transport under normal operations.
H_1:	Compared with other selection criteria (such as capacity, directness, reputation, communication, tracking system and market consideration), freight rate, transit time, reliability, damage rate, and sailing frequency take precedence over other factors, and these factors have different values to shippers' choice decisions in containerised maritime transport under normal operations.
H_0:	Surcharge or rebate, delay time, reliability, and damage rate are the same as other potential affected factors (such as communication, documentation, and tracking system), and contribute equivalent value to shippers' containerised maritime transportation decisions given a disruption, and shippers' preference and WTP for these attributes under a disruption do not differ as they do under normal operating conditions.
H_2:	Surcharge or rebate, delay time, reliability, and damage rate are found to take precedence over other potential affected factors (such as communication, documentation, and tracking system), and contribute different value to shippers' choice behaviour in containerised maritime transportation decisions given a disruption, and shippers' preference and WTP for these attributes under a disruption do differ as they do under normal operating conditions.
	Company Geography Location Impacting on Shippers' Transport Choice
H_0:	Shippers in different geographical locations have equivalent logistics preferences and WTPs for containerised maritime transport service attributes independent of whether they are operating under normal or disrupted service conditions.
H_3:	Shippers in different geographical locations have different logistics preferences and WTPs for containerised maritime transport service attributes under normal operating conditions as they do under a disruption event.
	Production Characteristics Affecting Shippers' Transport Choice
H_0:	Shippers shipping different industrial products of differing value have the same WTPs for containerised maritime transport service attributes under normal operating conditions as they do when facing a SCD.
H_4:	Shippers shipping different industrial products of differing value significantly have different WTPs for containerised maritime transport service attributes under normal operating conditions as they do when facing a SCD.

	Company Characteristics Affecting Shippers' Transport Choice
H_0:	All shippers have equal WTPs for containerised maritime transport service attributes under all operating conditions, independent of their company characteristics, such as nature of business (importers and exporters) and firm size.
H_5:	All shippers have unequal WTPs for containerised maritime transport service attributes under all operating conditions, depending on their company characteristics, such as nature of business (importers and exporters) and firm size.
	Supply Chain Management Strategies Affecting Shippers' Transport Choice
H_0:	The WTPs for containerised maritime transport service attributes do not vary by alternate SCM strategies under both normal and disrupted operating conditions.
H_6:	The WTPs for containerised maritime transport service attributes do vary by alternate SCM strategies under both normal and disrupted operating conditions.
	Shipping Characteristics Affecting Shippers' Transport Choice
H_0:	Shippers, independent of shipment and trip characteristics, have the same WTPs for containerised maritime transport service attributes both under normal and disrupted operating conditions.
H_7:	Shippers, independent of shipment and trip characteristics, have different WTPs for containerised maritime transport service attributes both under normal and disrupted operating conditions.
	Security Issues and Risks Concerns
H_0:	Shippers, whether or not they consider and prepare for security and risks issues when making their transport decision would have exactly equivalent WTPs for containerised maritime transport service attributes under all operating conditions.
H_8:	Shippers, whether or not they consider and prepare for security and risks issues when making their transport decision would have entirely different WTPs for containerised maritime transport service attributes under all operating conditions.

3.5 Fundamentals of Discrete Choice Modelling

3.5.1 Introduction of Choice Modelling

Individuals are constantly making choices, consciously or sub-consciously. According to Lancaster (1966), goods and services are perceived by consumers as being composed of bundles of attributes described by different attribute levels rather than being viewed as a whole composite product. For example, individuals deciding how to travel to work will under this view look at alternative transport options as being made up of attributes such as costs, travel time, reliability, comfort level, and so on, rather than as cars, buses and trains.

Consumers view the attributes and attribute levels of competing alternatives, weigh the relative importance of each attribute based on the levels of the attributes, make their decision. As such, consumer satisfaction is derived from different combinations of characteristics instead of the commodities themselves, as well as the weights that consumers place on each of the characteristics. Under this framework, shippers would be expected to choose carriers based on the service attributes on offer, including freight rates, travel times, service frequency, damage rates, and reliability.

Micro-economic theory suggests that it is important to understand individual preferences in order to understand their choices. Theory suggests that individuals select their most preferred alternative out of a set of possible alternatives (where the set of alternatives is referred to as a choice set) subject to a number of constraints, such as their budget, any time windows they face, and documentation or regulatory limitations, etc. In behavioural economics, preference or satisfaction is referred to as utility. Utility is an important notion in choice modelling (CM). Bentham (1781) defined utility as "property in any object, whereby it tends to produce benefit, advantage, pleasure, good, or happiness" or "to prevent the happening of mischief, pain, evil, or unhappiness to the party whose interest is considered." Theory underlying CM methods therefore suggest that individual's choose alternatives which maximize their level of utility (or minimise their level of disutility) subject to whatever constraints they face when making the decision, in a process known as "utility maximizing behaviour" (Hensher, Rose and Greene 2005). Thus, the key assumption is that decision makers act rationally in selecting alternatives that will generate the maximum utility or satisfaction for them.

CM is not a single technique but a series of quantitative methods designed to model individual or group choice outcomes in a manner that allows the analyst to understand how individual's trade-off attributes when making choices between discrete outcomes. In the sections that follow, we discuss the theory of CMs alongside several specific models. Before we do so, however, a short discussion on the data necessary to under choice modelling is presented.

3.5.2 Comparing Stated Preference and Real Preference Data

In CM, stated preference (SP) and revealed preference (RP) data represent the two primary sources of data used. RP data is data based on choices observed in real markets. As such, RP data represents the preferences of individuals made in an actual choice environment. In contrast, SP data is based on observed choices made in hypothetical markets, and hence represents stated intentions behaviour (Hensher, Rose and Greene 2005).

SP and RP data both offer advantages and disadvantages (Danielis and Rotaris 1999; Hensher, Louviere and Swait 1999; Bhat and Castelar 2002). According to Danielis and Rotaris (1999) and Bhat and Castelar (2002), RP data reflects existing products or services and actual choices and hence preferences in real markets. These choices also reflect all possible constraints faced by those operating in the market. Therefore, the advantage of RP data is that it reflects information about real actual markets. Nevertheless, RP data have known limitations. Firstly, the analyst has little to no control over RP data; that is, RP data simply is what is observed within real markets. This may and often does result in data quality issues, such as high levels of correlation, limitations in terms of the availability of alternatives, an inability to model outside of the range of attribute levels, and the need to capture information not just about the alternative that was chosen, but also about the alternatives that were not chosen. This last point is critical. In order to understand why an alternative is chosen over other alternatives present in the market, one needs to know about all alternatives that could potentially be chosen. In many instances, understanding or capturing data on non-chosen alternatives may prove problematic, particularly if such data is captured by surveying respondents. Typically, RP data will also be limited by sample size restrictions, particularly when what is being modelled is organisational rather than individual choices. Finally, RP data may have difficulty forecasting to products or attributes that do not currently exist in real markets, or which are not traded in real market.

SP data on the other hand allows researchers to study individual choices and preferences for a wide range of markets. SP questionnaires are designed by the analyst, and hence are limited only by the information that can be provided by the analyst in a survey. The analyst may include in SP data any alternative, attribute or range of attribute levels as desired, including alternatives or attributes that don't currently exist in real markets, and attribute level ranges that are outside those currently offered in real markets. Researchers may also ask multiple questions from single respondents, hence capturing a larger number of observations for the purposes of modelling. This may result in reduced data collection costs and potentially smaller sample size requirements relative to RP data. One major limitation of SP data is the hypothetical nature of the markets. Respondents simply stating preferences for alternatives in hypothetical markets, typically do so without having to consider any outside constraints, such as budgetary or time constraints which are automatically built into their choices made in similar real market decision making. Whilst methods and techniques to mitigate any hypothetical bias have been examined extensively in the literature, the risk of hypothetical bias remains in any study relying on SP data. Danielis and Rotaris (1999) summarize the advantages and disadvantages of the RP and SP, as shown in Table 3-2.

Table 3-2: RP versus SP data
Source: (Danielis and Rotaris 1999)

Pros	*Cons*
Revealed preference method • Actually made, observed, "real" choices	• Only some attributes are measurable • Needs many costly data • Data hard to be collected (e.g. prices are confidential and of commercial nature), scarce availability of data • Correlation among attributes • Insufficient variability to allow robust estimate • Measurement errors • Unspecified choice set
Stated preference method • Hypothetical, "stated" choices in controlled experiments • Ability to analyse reaction to future, not existing options • Low cost • Precisely specified choice set • Multiple answers from each respondent • Multiple choice formats (choice, ranking or rating) • Capability of analysing trade-offs among qualitative attributes	• Hypothetical bias

For the current study, the possibility of capturing RP data from real markets was not feasible. As noted by others working on modelling freight transport choices, significant difficulties arise in capturing RP data within this application area (Bolis and Maggi 1998; Danielis and Rotaris 1999; Bolis and Maggi 2003; Bergantino and Bolis 2005). Firstly, it is often impossible to obtain actual market freight rates due to commercial sensitivities with companies often reluctant to share such information, even if for research purposes. Secondly, the freight sector is very heterogeneous in terms of organisations involved, cargoes carried, and contractual terms commercially negotiated. Thirdly, freight transport decisions are complex. Decisions within the freight sector do not simply depend on the freight transport service, but also on multiple logistics strategies spread over a variety of firms, as well as any overall SCM strategy that may be in place. Finally, more than one actor is usually involved in the decision making process, making asymmetric information a likely occurrence leading to uneven decision power across actors.

Given the above, the use of SP techniques is already well established within the freight sector and has been commonly applied to study shippers' choices in freight transportation sector (Bates 1988; Fowkes and Tweddle 1997; Kawamura 2000; Kurri, Sirkiä and Mikola 2000; Bolis and Maggi 2003; Bergantino and Bolis 2005; Danielis, Marcucci and Rotaris 2005; Danielis and Marcucci 2007; Beuthe and Bouffioux 2008; Marcucci and Danielis 2008). Thus, for this thesis, SP data is utilised to study shippers' preferences for containerised maritime transportation service attributes with and without a SCD event. To make the survey more relevant to individual freight decision makers, and hence in an effort to minimise hypothetical bias, a pivot SP experiment is used to create scenarios related to each individual firms circumstances in terms of commodity type carried, origin/destination port, travel time, freight rate, and so on.

3.5.3 Discrete Choice Model Theoretical Framework

The conceptual foundation underlying the modelling of discrete choices is random utility theory. The Random Utility Maximization (RUM) model was first introduced into economics by Marschak (1960) based on the earlier work on psychophysical discrimination undertaken by Thurstone (1927). RUM assumes that decision makers make choices based on full information and maximise their own utility based on that information. RUM on the other hand assumes that analysts and researchers have limited access to the decision making processes undertaken by decision makers and hence, there exists a stochastic or random component when modelling choice behaviour (McFadden 2001). Nevertheless, as Louviere

(2001) points out, in carefully constructed experiments, only a fraction of choice behaviour need remain unobserved by the researcher.

To understand RUM more fully, let overall utility for the i^{th} alternative be depicted as U_i. The utility function of the i^{th} alternative is composed of an observed component (V_i) called 'representative utility' and an unobserved component (ε_i) representing 'error' or white noise. The utility expression of i^{th} alternative for decision maker q can therefore be written as:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{3.1}$$

An individual q is assumed to choose alternative i over j in a set of alternatives A, only if alternative i generates a greater amount of utility than for all other alternatives j, such that

$$U_{iq} > U_{jq} \text{ for all } j \neq i \; \forall \text{ S} \tag{3.2}$$

Based on equations 3.1 and 3.2 it can be shown that

$$V_{iq} - V_{jq} > \varepsilon_{jq} - \varepsilon_{iq} \tag{3.3}$$

Given that ε_{iq} is not observed, or modelled by the researcher, the researcher has no information about what value it takes for any individual q. As such, the researcher is required to make assumptions about the distribution of ε_{iq} over the sampled population. The most common assumption is that ε_{iq} are distributed extreme value type 1 (EV1) and are independently and identically distributed (IID) over alternatives. IID is further discussed in the next section. The EV1 distribution in the main appears Normally distributed with deviations in the tails (hence the name, extreme values, as it is in the extreme values of the tails that the distribution becomes importantly different to the Normal distribution).

Given that the researcher has no information as to where any particular individual q sits within the distribution of ε_{iq}, it is not possible for the analyst to determine the exact value of utility individual q has for alternative i. Given knowledge of the EV1 distribution, it is however possible to work out up to a probability that the utility of one alternative will exceed that of another. The probability of an individual q choosing alternative i over j in a choice set S is given as

$$P_{iq} = P(i|i, j \in S) = P\big[(V_{iq} - V_{jq}) > (\varepsilon_{jq} - \varepsilon_{iq})\big] \text{ for all } j \neq i \; \forall \text{ S} \tag{3.4}$$

This probability represents the logit probability and is at foundation of the multinomial logit (MNL) model. The probability P_{qjs} that respondent *q* choices alternative *j* in choice situation *s* is given as

$$P_{qjs} = \frac{\exp(V_{qjs})}{\sum_{i \in J_{qs}} \exp(V_{qis})} \tag{3.5}$$

Within the model, the representative or modelled component of utility V_{iq} can be decomposed further into *k* attributes, X_{ikq} and associated weights, which reflect the preferences of the sample population for each attribute. The preference weights are unknown to the analyst and must be estimated. Estimated weights are referred to as parameters or coefficients within the literature, represented as β, and represent the marginal utility of each attribute to overall utility (Hensher, Rose and Greene 2005). The utility expression can be written as:

$$V_{iq} = \beta_{0iq} + \beta_{1iq} f(X_{1iq}) + \beta_{2iq} f(X_{2iq}) + \beta_{3iq} f(X_{3iq}) + \cdots + \beta_{kiq} f(X_{kiq})$$

or alternatively as:

$$V_{iq} = \sum_{k=1}^{k} \beta_{ik} X_{ikq} \tag{3.6}$$

In the MNL model, the parameters β_{ik} in equation 3.6 are unknown, and must be estimated. The estimation of the parameters is done by maximizing the likelihood function, L, for the model (Rose 2011):

$$L = \prod_{q=1}^{Q} \prod_{s \in S_q} \prod_{i \in J_{qs}} (P_{qsj})^{y_{qsi}} \tag{3.7}$$

where *Q* indicates the total number of respondents and S_q represents the set of choice situations faced by respondent *q*. P_{qsj} is the choice probability given in Equation (3.5), and Y_{qsi} an index equal to one if alternative *i* was chosen, and zero otherwise.

Mathematically, Equation (3.7) will result in extremely small values which can be difficult for many programs to handle. As a result, it is more common to take the Log of the likelihood function when estimating the model parameters. This is given in Equation (3.8).

$$LL = \ln\left[\prod_{q=1}^{Q}\prod_{s\in S_q}\prod_{j\in J_{qs}}(P_{qsj})^{y_{qsj}}\right] = \sum_{q=1}^{Q}\sum_{s\in S_Q}\sum_{j\in J_{QS}} y_{qsj}\ln(P_{qsj}) \tag{3.8}$$

The MNL model is derived under the assumption that the error terms are EV1 IID. In the next section, we discuss the IID assumption and behavioural equivalent, the assumption of independence of irrelevant alternatives (IIA) assumption.

3.5.4 Limitations of the MNL Model

Although the MNL model remains the most widely used choice model to date, it is derived under very strict assumptions. One of the most restrictive assumptions relates to the error terms of the model. The main assumptions related to the error terms of the model are the independently and identically distributed (IID) assumption and its behaviourally equivalent independence from irrelevant alternatives (IIA) assumption. Other assumptions about the independence of observed choices, and homogeneity of preferences also are required to derive the model. These assumptions are discussed later in Section 3.6.1 on latent class models. This section however discusses the potential for IIA/IID violations.

The IIA assumption infers that the presence or absence of any other alternative will not change the ratio of the probabilities for two alternatives. The IIA assumption is related to the IID assumption which indicates that the random error component of the model is distributed independently and identically over alternatives and individuals (Louviere, Hensher and Swait 2000; McFadden 2001; Train 2003; Hensher, Rose and Greene 2005). Firstly, according to Louviere, Hensher, and Swait (2000), the variance of the unobserved effects is defined as: $var(\varepsilon_{iq}) = \pi^2 / 6\lambda^2$

and re-arranging $\lambda^2 = \pi^2/6var(\varepsilon_{iq})$ (3.9) where λ represents a scale parameter.

The IID assumption restricts all variances to be constant (identically distributed) in the MNL model, such that normalising the scale to one implies that over the sampled population, the variance of the error term is assumed to be 1.283 (Hensher, Rose and Greene 2005). If the error variance for one or more alternatives is empirically different to the error variance of other alternatives, then a violation of IID and IIA will have occurred.

Within the model, the scale is intrinsically related to the utility function. In reality the scale parameter is multiplicative of utility such that utility is

$$V_{iq} = \lambda_{iq}\beta_{0iq} + \lambda_{iq}\beta_{1iq}f(X_{1iq}) + \lambda_{iq}\beta_{2iq}f(X_{2iq}) + \cdots + \lambda_{iq}\beta_{kiq}f(X_{kiq}) \tag{3.10}$$

That is, λ scales each coefficient of a utility function to reflect the variance of the unobserved portion of utility. As such the larger the variance of the unobserved effects in a sampled population, the lower the value of λ and the smaller the value of V_{iq}. (Train 2003). In the presence of preference heterogeneity, the IIA/IID condition will be violated, since population/preference heterogeneity if not allowed for in the betas, will manifest itself within the error term of the model which can lead to the error variance varying across alternatives and sampled respondents. Further, both observed and unobserved attributes are not independent of each other, error can arise in the parameter estimates if the error terms (ε_j) are correlated amongst alternatives (Louviere, Hensher and Swait 2000). Thus, more advance choice models may be required if IID exists within a data set required.

A second issue with the MNL model is that it assumes homogeneity of preferences. In the MNL model, a single parameter estimate is used to represent the entire sample population. For example, the parameter for price is assumed to reflect the preference or influence of price for all sampled respondents. Whilst it is possible to include interaction effects to establish sources of segment specific heterogeneity, these sources must be known in advance by the analyst and included within the model. More advanced models relax the assumption of preference heterogeneity by allowing the parameter estimates to vary over respondents.

A final issue related to the MNL model is the assumption that each choice observation is made by a different respondent. This assumption arises in the way the log-likelihood function is specified for the model. In cases where respondents provide multiple choice observations, the model ignores this fact and treats the data as if it were cross-sectional rather than a pseudo form of panel. This may impact upon the standard errors of the model at a minimum, or affect the parameter estimates themselves.

Given the above, although MNL models are estimated and reported, a more advanced econometric is used to provide more substantive results as part of this research. To this end, we rely on a latent class model, which either implicitly or explicitly deals with the issues raised above. The Latent class model is discussed in the section that follows.

3.6 The Advance Discrete Choice Models

3.6.1 The Latent Class Model

Initially introduced by Lazarsfeld and Henry (1968), the latent class model (LCM) has been widely used in the social and behavioural sciences, and biostatistics for over two decades (Greene and Hensher 2003; Harel and Miglioretti 2007; Wen and Lai 2010; Grisolía and Willis 2012). The LCM is derived under the behavioural assumption that individual behaviour depends on observable attributes but that preference heterogeneity is a latent unobservable (Greene and Hensher 2003).

A LCM consists of an unobserved class variable (or called latent variable, C classes or segments) and a number of observed attributes variables (or called manifest variables) (Zhang 2004a). A latent relationship can be described as Figure 3-1. A LCM can identify the size of segments and segment membership of respondents. Thus, LCM can be used to explain relationships among multiple categorical variables (Harel and Miglioretti 2007). Sampled respondents are modelled probabilistically and allocated to classes. That is, each respondent is allocated to a class up to a probability in a LCM.

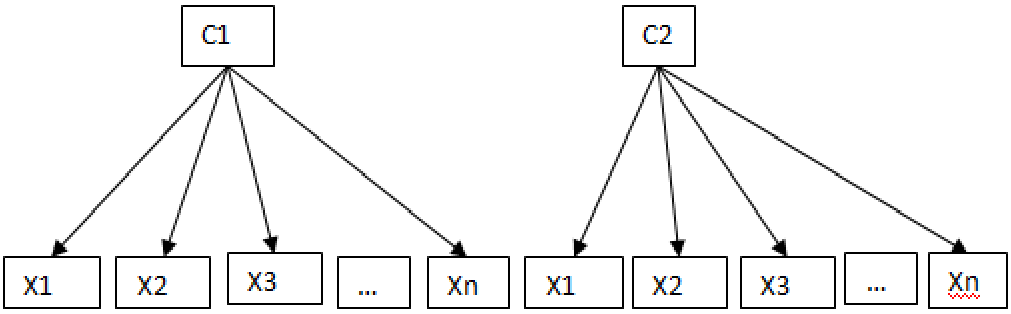


Figure 3-1: Structure of LCMs

The basic LCM was built based on three assumptions (Davier 2009): response probabilities depend on membership to class C; local independence given class membership C (i.e., the manifest variables are independent within each latent class): $P(x_1, \cdots\cdots, x_I|c) = \prod_{i=1}^{I} P_i\ (x_i|c)$; and each respondent *n* belongs to all latent classes up to a probability.

Assuming the existence of C classes/segments among the sampled respondents, *q*, in the population, a LCM tries to allocate respondents to different classes using a probabilistic modelling method based on the samples' latent preference heterogeneity. As such, each class in a LCM will have a unique utility function (Rose 2011). It can be expressed as:

$$U_{qsj|c} = V_{qsj|c} + \varepsilon_{qsj|c} \tag{3.11}$$

The probability that respondent *q* belongs to a particular latent class *c* via class assignment model can be presented as:

$$P_{qc} = \frac{\exp(V_{qc})}{\sum_{c\in C}\exp(V_{qc})} = \frac{\exp(\delta_c h_q)}{\sum_{c\in C}\exp(\delta_c h_q)} \tag{3.12}$$

The probability that respondent *q* chosen alternative *j* in choice situation *s* in a particular class *c* can be also calculated:

1) If it is modelled under cross sectional formulation, the probability is presented as:

$$p_{qsj|c} = \frac{\exp(V_{qsj|c})}{\sum_i \exp(V_{qsi|c})} = \frac{\exp(\sum_{k=1}^{K} \beta_{qsk} x_{qsjk})}{\sum_i \exp(\sum_{k=1}^{K} \beta_{qsk} x_{qsik})} \quad , \tag{3.13}$$

where $V_{qsj|c}$ represents the observed component of utility under cross sectional formulation ($V_{qsj} = \sum_{k=1}^{K} \beta_{qsk} x_{qsjk}$).

2) If it is modelled under panel version, the probability can be presented as:

$$p_{qj|c} = \prod_s \frac{\exp(V_{qsj|c})}{\sum_i \exp(V_{qsi|c})} = \frac{\exp(\sum_{k=1}^{K} \beta_{qk} x_{qsjk})}{\sum_i \exp(\sum_{k=1}^{K} \beta_{qk} x_{qsik})} , \tag{3.14}$$

where $V_{qsj|c}$ represents the observed component of utility under panel formulations ($V_{qsj} = \sum_{k=1}^{K} \beta_{qk} x_{qsjk}$).

Finally, the alternative conditioned class probabilities can be calculated based on the class assignment probabilities and the choice probabilities within choice situation. According to Equations (3.13) and (3.14), the alternative conditioned class probabilities can be presented as:

1) for the cross sectional

$$P_{qs|c} = \frac{y_{qsi} P_{qsj|c} \cdot P_{qc}}{\sum_{c \in C} y_{qsi} P_{qsi|c} \cdot P_{qc}} , \forall_C \in C. \tag{3.15}$$

2) for the cross panel formulations

$$P_{qs|c} = \frac{\prod_s y_{qsi} P_{qsj|c} \cdot P_{qc}}{\sum_{c \in C} \prod_s y_{qsi} P_{qsj|c} \cdot P_{qc}} , \forall_C \in C . \tag{3.16}$$

Correspondingly, there will be two different equations for the log-likelihood function of the LCM depending on whether the model is estimating the cross sectional or panel formulations:

1) for the cross sectional formulations:

$$LL = \sum_{q=1}^{Q} \sum_{s \in S_q} \sum_{j \in J_{qs}} \ln \left(\sum\nolimits_{c \in C} y_{qsj} \, P_{qsj|c} \cdot P_{qsc} \right), \forall_C \in C \, .$$

(3.17)

2) for the cross panel formulations

$$LL = \sum_{q=1}^{Q} \ln \left(\sum\nolimits_{c \in C} \prod\nolimits_{s} y_{qsi} P_{qsj|c} \cdot P_{qsc} \right), \forall_C \in C \, .$$

(3.18)

The number of *C* classes in a LCM is unknown and hard to test directly. A ‘testing down’ method is recommended for estimating the number of classes ‘C’ in a LCM. However, it is difficult to determine a best model fit neither comparing the log likelihoods of sequentially smaller models or setting the parameters to zero (Greene and Hensher 2003). Roeder, Lynch and Nagin (1999) suggest using the Bayesian information criterion (BIC) (Equation 3.19 or 3.20), but Louviere, Hensher and Swait (2000) suggest using the Akaike Information Criterion (AIC) (Equation 3.21) and Consistent Akaike Information Criterion (CAIC) (Equation 3.22) as the statistic measures to assess the LCM fit. Bhatnagar and Ghose (2004) indicate that the model achieves the most optimum fit to the data when the BIC is minimized, however, CAIC is also recommended for additional support since CAIC outperforms BIC at the penalization of overparameterization.

$$BIC(model) = \ln LL + \frac{(model\ size) \ln N}{N}$$

(3.19)

Or a more general definition of BIC can be presented as

$$BIC = -2LL + K \ln(N) \qquad (3.20)$$

$$AIC = -2LL + 2K \qquad (3.21)$$

where LL is the Log likelihood, K is the number of parameters, and N is the number of observations.

In this study, we agree with Bhatnagar and Ghose (2004) and argue that there is a contradiction if we use only BIC or AIC as the estimated index in LCMs. It is hard to tell whether the Log likelihood decreased in BIC or AIC formulas is better than the number of parameters (K) increased, as the number of classes increase in LCM would also increase the number of parameters. Therefore, in this research, we also apply CAIC (Equation 3.22) as the statistic measure to guide the best fit LCM selection.

$$CAIC = -2LL - (CK - (C-1)H - 1)(\ln(2N) + 1) \qquad (3.22)$$

where LL is the Log likelihood, C is the number of classes, K is the number of parameters, H is the number of parameters in classes assignment model, and N is the number of observations.

To determine the number of classes C in the LCMs, it also suggests that a model with a lower BIC, AIC, or CAIC value is preferred over a model with a higher BIC, AIC, or CAIC value (Roeder, Lynch and Nagin 1999; Louviere, Hensher and Swait 2000; Bhatnagar and Ghose 2004).

3.6.2 The Mixed Logit Model

The Mixed Logit (ML) Model is considered the most promising state of the art discrete choice model currently available. It is increasingly applied to estimate various degree of sophistication with mixture of revealed preference and stated choice data (Hensher and Greene 2003). The ML model is also called “random parameter logit”, “mixed multinomial logit” or “hybrid logit” model (Hensher, Rose and Greene 2005). Its utility function can be expressed as Equation (3.23), where it still assumes that Q indicates the total number of respondents, S_q represents the set of choice situations faced by respondent q, and J stands for alternative in each of S choice situation.

$$\mathrm{U_{jsq}} = \mathrm{V_{jsq}} + \varepsilon_{\mathrm{jsq}} = \sum_{k=1}^{K} \beta_{\mathrm{qk}} x_{jsqk} + \varepsilon_{\mathrm{jsq}} \quad (3.23)$$

x_{jsqk} is a vector of explanatory variables observed by analysts. The components β_{q} and $\varepsilon_{\mathrm{jsq}}$ are unobserved by analysts, and are treated as stochastic influences. β_{q} is assumed to be continuously distributed across individuals and correlated across alternatives, that is:

$$\beta_q = \beta + \Delta z_q + \eta_q \quad (3.24)$$

where η_q is a random term with zero mean whose distribution over individuals depends on underlying parameters, and Δz_q is observed data. Each random parameter β_{q} associated with an attribute of an alternative has a distribution with both a mean and a standard deviation (Hensher, Rose and Greene 2005). Therefore, it is critical to select the random parameters and their distribution function in a ML model.

The choice probability in ML model is a mixture of logit with a mixing distribution *f*. The conditional probability can be represented as Equation (3.25) (Hensher, Rose and Greene 2005).

$$p_{jqs} = \frac{\exp(\beta_q x_{jqs})}{\sum_{j=1}^{J_q} (\beta_q x_{jqs})} \quad (3.25)$$

3.6.3 The Merits of Latent Class Models

Both LCM and ML model are advanced interpretation of discrete choice models. They help analysts to reveal unobserved heterogeneities in their data and capture a rich variety of respondents' behaviour preferences. The primary difference between LCM and ML models is that parameter heterogeneity is assumed to be continuous distribution in the ML models, on the contrary, it is modelled with discrete distribution in the LCMs (Greene and Hensher 2003; Rose 2011).

Each model has its own merits conditioned on different data set performance or on different occasion. Specific assumptions about the distributions of parameters across individuals are needed in the ML models. It makes the ML models fully parametric and provides sufficient flexibilities for analysts to explore unobserved/individual heterogeneities over a wide range. However, the LCM is semi-parametric. It relaxes the requirement of specific distributional assumptions of parameters in ML models. As such, the LCM is less reliant on the random parameter distributions assumptions (Naik-Panvelkar et al. 2012). Thus, LCM is relatively simple, reasonably plausible, and statistically testable but less flexible comparing with the ML models (Shen, Sakata and Hashimoto 2009).

However, empirical studies provide evidence that the LCM often performs statistically better than the ML model does. The possible advantages of LCM have been highlighted through comparisons between LCM and ML models in some papers, such as Greene and Hensher (2003), Hole (2008), Shen, Sakata and Hashimoto (2009), Hess et al. (2011), and Dekker (2012). Hess et al. (2011), following the study of Greene and Hensher (2003), apply log-likelihood value, choice elasticities, willingness to pay valuations, and choice probability profiles as the useful statistics tools to determine which model is more appropriate for its analysis. Their empirical analysis results not only provide evidence for LCM improved statistical fit, easier interpretation, and greater policy relevance, but also illustrate that the LCM could retrieve richer patterns of heterogeneity through linking the class allocation to socio-demographic indicators, could easily link the heterogeneity in VTTS measures and the correlation between taste coefficients to socio-demographic characteristics, and allow for additional variation in the correlation across respondents. Grisolía and Willis (2012) indicate that LCMs have greater practicality because LCMs can identify different segments in terms of sizes and preferences and calculate WTP on the part of their constituents.

3.7 Willingness to Pay (WTP) and Discrete Choice Models

To measure non-market environmental values, one attribute in CM applications has to be a monetary cost. With that value attribute, CM can be used to quantify individuals' willingness to bear a financial expense to acquire some non-financial potential environmental improvement, or to prevent some potential environmental loss, and to measure the WTP for a unit improvement of an environmental attribute, as well as each non-monetary attribute in the choice sets (Bennett and Adamowicz 2001). This process of identifying the contribution of a specific attribute to overall utility of an alternative is called a "part-worth" estimation

(Hensher, Rose and Greene 2005). The monetary value of an attribute at the margin is estimated through the ratio of that service attribute coefficient to the cost/dollar coefficient. It shows how changes in attributes are traded off against a monetary attribute change. To estimate the marginal change or 'part-worth' of the k^{th} attribute (β_k), a WTP equation is described as Equation (3.26). Hence, the CM technique is a quantitative method to observe and capture how individuals trade-off between different attributes corresponding to the changes in the levels of the attributes. Further, decisions making by a population of individuals contain an amount of variability due to the heterogeneity nature of a population. Thus, variability exists in an individual's preferences across alternatives, as well as across individuals in a population. The aim of CM analysis is to reveal and explain these preferences across a sample of individuals give the choice set (Hensher, Rose and Greene 2005).

$$WTP = \frac{\beta_k}{\beta_u} \qquad (3.26)$$

Survey respondents in CM applications are asked to make a sequence of six to eight choices to a choice question. Correspondently, a 'status quo' ('no action') option and several 'proposed' ('changed') alternatives are provided to each choice question. Each 'proposed' alternative is different in its variations of assigning attributes' levels. Survey respondents are asked to choose a preferred option maximizing their satisfaction. By modelling that selected options (choices), analysts are able to explore and explain how respondents react to the changes of each attribute levels, and to estimate how much individuals are willing to abandon a certain level of an attribute in exchange for a higher level of another attribute (Bennett and Adamowicz 2001).

3.8 Seemingly Unrelated Regressions Model (SURE)

Zellner (1962) proposes the seemingly unrelated regression equations (SURE) model. It is a generalization of a linear regression model containing several regression equations. Each equation allows having its own dependent variable and potentially different sets of exogenous explanatory variables. In a SURE model, coefficients in all equations are estimated simultaneously applied feasible generalized least squares with a specific form of the variance-covariance matrix, and the error terms are assumed to be correlated across the equations (Zellner 1962).

According to Zellner (1962), the SURE model consists m regression equations can be presented as

$$y_{it} = x'_{it}\beta_i + \varepsilon_{it} \qquad (3.27)$$

where *i* represents the equation number, $i = 1, \ldots\ldots, m$. *t* is the observation index, $t = 1, \ldots\ldots, T$. Disturbances are uncorrelated across observations. y_{it} is a single "dependent" variable on the left hand side of each equation. ε_{it} is random error terms, which is normally distributed and each with mean zero and σ variance. x'_{it} are "independent" non-stochastic variables with k_i dimensional vectors. β_{it} are regression coefficients.

The SURE model can be presented in a vector form through stacking observations corresponding to the *i*-th equation into T-dimensional vectors and matrices:

$$y_i = X_i\beta_i + \varepsilon_i \qquad (3.28)$$

where y_i and ε_i are $T \times 1$ vectors, X_i is a $T \times k_I$ matrix, and β_i is a $k_i \times 1$ vector.

In addition, the system of Equation (3.27) can be presented as following, if the m vector equations were stacked on top of each other:

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{pmatrix} = \begin{pmatrix} X_1 0 & \cdots 0 \\ 0 \; X_2 & \cdots 0 \\ \vdots \; \vdots & \ddots \; \vdots \\ 0 \; 0 & \cdots X_M \end{pmatrix} \begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_m \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_m \end{pmatrix} = X\beta + \varepsilon \qquad (3.29)$$

The error terms ε_{it} is assumed independent across time, but may have cross-equation contemporaneous correlations: $\mathrm{E}[\varepsilon_{it}\varepsilon_{js}|X] = 0$, where $t \neq s$; whereas $\mathrm{E}[\varepsilon_{it}\varepsilon_{jt}|X] = \sigma_{ij}$. Thus, the covariance matrix of the error terms ε in formula (3.29) can be presented as:

$$\Omega \equiv \mathrm{E}[\varepsilon\varepsilon'|X] = \Sigma \otimes I_T \qquad (3.30)$$

where $\Sigma = \|\sigma_{ij}\|$ the $m \times m$ skedasticity matrix of each observation, I_T is the T-dimensional identity matrix, and $\otimes$ is the matrix Kronecker product.

The feasible generalized least squares (FGLS) method is a best linear unbiased and efficient estimator in the SURE models (Kmenta and Gilbert 1968). It takes two steps for the estimation procedure in the SURE models applying FGLS. First, ordinary least squares regression is run to estimate the elements of matrix Σ : $\hat{\sigma}_{ij} = \frac{1}{T} \check{\varepsilon}_i \hat{\varepsilon}_j$. Second, coefficients are estimated using the FGLS regression with the variance matrix $\hat{\Omega} = \hat{\Sigma} \otimes \mathrm{I}_{\mathrm{T}}$: $\hat{\beta} = \left(X' \left(\hat{\Sigma}^{-1} \otimes \mathrm{I}_{\mathrm{T}} \right) X \right)^{-1} X' \left(\hat{\sum}^{-1} \otimes \mathrm{I}_{\mathrm{T}} \right) y$ (Mentzer, Stank and Esper 2008; Wikipedia 2012).

Except FGLS, other estimation techniques recommended for SURE models include: the maximum likelihood (ML) method assuming the errors are normally distributed; the iterative generalized least squares (IGLS) are used to recalculate the matrix $\hat{\Sigma}$ and estimate $\hat{\beta}$ again using GLS, until model converges; and the iterative ordinary lease squares (IOLS) scheme iteratively estimates on equation-by-equation basis with the residuals from the previously estimated equations as additional regressors to account for the cross-equation correlations until convergence is achieved.

The SURE model is an efficient estimation procedure. The greater the correlation of the disturbances and the less correlation there is between the X matrices, the greater the efficiency gain accruing generalized least squares (Judge et al. 1985; Srivastava and Giles 1987; Lado, Martinez-Ros and Valenzuela 2004). The SURE model is generally applicable, and it has been successfully applied to estimate cross-industry correlation and variation (Zellner 1962), to estimate individual's dynamic behaviour (Karemera and Koo 1994) during choice decisions, to estimate a certain economic activity in different geographical locations (Donnelly 1982; White and Hewings 1982; Giles and Hampton 1984; Giles and Hampton 1987), and other areas. Since the error terms in this study for the WTP of transit time, reliability, damage rate and frequency, which generated by the same data set, can be correlated, the SURE model could help to identify systematic sources of variations in these WTP. Therefore, this study will also utilise SUREs models to examine the interaction effects of production characteristics, trip characteristics, and company/SC characteristics on shippers' value of maritime transportation preferences.

3.9 Conclusion

This chapter reviews the application of discrete choice technique in the estimation of value of time or other qualitative transport service attributes in freight transportation area, particularly, in maritime transportation. Key maritime transport service attributes are identified as the key variables for the purpose of this research. Eight hypotheses are developed to explore the influence of the population heterogeneity (such as production, company, and SCM characteristics) on the WTP for maritime transport attributes and shippers' choice. Furthermore, the impacts of a transport related SCD on the value of maritime transport attributes are also discussed to investigate in each hypothesis. Meanwhile, the fundamentals and theoretical framework of discrete choice and stated preference technique are presented, and three advanced discrete choice models tested in this study are introduced. The SURE model technique is also reviewed in this chapter to utilize and identify the sources cause sample heterogeneities for the study. Experiment design is presented in the next chapter.

CHAPTER FOUR

4 SURVEY DESIGN

4.1 Introduction

This chapter first focuses on issues of stated choice experiment design, and describes the steps of generating an efficient experiment designs. After that, a detailed explanation of the survey used for this research is provided.

4.2 Stated Choice Experiment Designs

Design of stated choice experiments is an increasingly important and complex component of studies involving discrete choice models. A number of different classes of experiment designs are available for the analyst to choose from. These include but are not limited to the use of full and fractional factorial designs, orthogonal designs, and efficient designs. We now describe each of these in turn. Before doing so, however, it is necessary to provide some nomenclature.

Using the same notation employed in Chapter 3, assume that each alternative j, $J=1,\ldots i, J,$ contains K_j associate attributes. A stated choice experiment will consist of a series of questions whereby individual respondents $q=1,\ldots Q$, answer all S choice questions, commonly referred to as choice situations. Each attribute in each choice situation s, $s=1,\ldots,S$ may take different attribute levels X_{jks} ($k=1,\ldots,K$) over the course of the experiment. These may also vary across each of the J alternatives. The theory of experiment design is aimed at generating a matrix $X_q = [X_{jksq}]$ for each respondent q with $X_{jksq} \in \Lambda_{jkq}$, where Λ_{jkq} is the set of possible attributes levels for each attribute for respondent q, and $\ell_{jk} = |\Lambda_{jkq}|$ represents the numbers of levels for an attribute (Bliemer and Rose 2009). Choice observations y, where $y_{jsq} = 1$ if respondent q chooses alternative j in choice situation s, otherwise $y_{jsq} = 0$. β denotes parameters to be estimated, and $P_{jsq}(X, \beta)$ is the probability of respondent q choosing alternative j in choice situation s.

4.2.1 Full and Fractional Factorial Designs

Full factorial design consist of all possible treatment combinations/choice situations where all possible combinations of the attribute levels are enumerated (Hensher, Rose and Greene 2005). The total number of choice situations in a full factorial design can be calculated as:

$$S^{ff} = \prod_{j=1}^{J} \prod_{k=1}^{K_j} \ell_{jk} = L^{JK} \tag{4.1}$$

where L is the number of attribute levels, J the number of alternatives, and K the number of attributes. L^{JK} is the full enumeration of possible choice sets for labelled choice experiments (Hensher, Rose and Greene 2005; Bliemer and Rose 2009).

Fractional factorial designs use only a fraction rather than the full enumeration of the total number of choice situations. Although full factorial designs will always be orthogonal and balanced (i.e., the attribute level balance property, that is each attribute level appears an equal number of times for each attribute (Bliemer and Rose 2009)), for all but a small number of problems they will typically contain too many choice situations to either handle in a choice survey, or give to a single respondent. Fractional factorial designs on the other hand are typically more practical than full factorial designs as it reduces the number of choice situations to a more practical number. A number of methods exist to generate fractional factorial designs, including a random selection process without replacement from the total number of choice situations, the generation of orthogonal fractional factorials, and the generation of efficient designs (Bliemer and Rose 2009). Section 4.2.2 discusses orthogonal designs whilst Section 4.2.3 discusses efficient design methods.

4.2.2 Orthogonal Designs

Orthogonality is a mathematical constraint requiring all attributes be statistically independent of one another, or in other words, the correlation between each two attributes is zero (Hensher, Rose and Greene 2005). Orthogonal designs or fractional factorial orthogonal designs are designs that satisfy this orthogonality criterion. That is, it is designs that attribute levels are balanced and all parameters are independently estimable. One property of an orthogonal design using orthogonal coding is that the sum of the inner product of any two columns is zero (Hensher, Rose and Greene 2005).

Independence of the attributes is paramount in orthogonal designs, but it is not easy to preserve in practice. Orthogonality can be lost due to the coding employed by the researcher, such as dummy or effects coding of the attributes (discussed in detail in Section 6.4), non-evenly spaced attribute levels (e.g., price takes levels \$100, \$200, \$250 in the experiment), non-response/missing data (i.e., data is orthogonal if and only if all choice situations in the design are replicated an equal number of times within the data), or poor transition between the design codes and the attribute level labels (e.g., in generating the experiment, the levels used are 0,1, 2 however in the data, these are transformed to \$100, \$200 and \$250 respectively). An examination of the literature suggests that by and large, most studies employing an orthogonal design do not actually have orthogonal data. Thus, whilst orthogonal designs have been used widely, but optimal/efficient designs are becoming increasingly popular because they provide improved statistical efficiencies in the design (Rose and Bliemer 2006; Bliemer and Rose 2009). We now discuss efficient design theory.

4.2.3 Efficient Designs

An efficient design is an experimental design that aims to maximise the robustness of the parameter estimates, meaning that the design will produce standard errors for each of the parameter estimates that are as small as possible. In effect, by minimizing the standard errors of the estimates, efficient designs seek to maximise the statistical significance of the estimates at a given sample size, or in turn, obtain statistically significant estimates in small samples. Unlike orthogonal designs, efficient designs do not impose a zero correlations constraint on the attributes, and hence correlations may exist within the data when using an efficient design (Bliemer and Rose 2009).

The standard errors of a model are derived from the asymptotic variance-covariance (AVC) matrix (see Equation (4.2)).

$$\text{variance}-\text{covariance matrix} = \begin{pmatrix} se(\beta_1)^2 & \dots & \\ & \dots & \\ & \dots & se(\beta_k)^2 \end{pmatrix} \tag{4.2}$$

where $se(\beta_k)$ is the standard error of parameter β_k .

When generating a design, prior to obtaining data it is necessary to approximate the likely AVC matrix. This may be done by two means; use of Monte Carlo simulation or via analytical derivation. Monte Carlo simulation requires the generation of a large sample of virtual respondents to compute utilities for all alternatives after which each virtual respondent is assumed to choose the alternative with the highest utility. The AVC matrix and the variance-covariance matrix are then estimated. This process requires that the researcher assume *a priori* the parameter estimates to generate the choices of the simulated respondents.

A second approach is to derive the AVC matrix analytically without the need to conduct surveys or simulate respondents. Beginning with the models log-likelihood function

$$L_Q(\beta|X,y) = \sum_{q=1}^{Q}\sum_{s=1}^{S}\sum_{j=1}^{J} y_{jsq} \log P_{jsq}(X|\beta), \tag{4.3}$$

taking the second derivatives will provide what is called the Fisher information matrix

$$I_Q(\beta|X,y) = \frac{\partial^2 L_Q(\beta|X,y)}{\partial\beta\partial\beta'}. \tag{4.4}$$

The AVC matrix for the design is the negative inverse of the Fisher information matrix (Bliemer and Rose 2009). Let Ω_Q denote the AVC matrix, then

$$\Omega_Q(\beta|X,y) = -\left[E(I_Q(\beta|X,y))\right]^{-1} = -\left[\frac{\partial^2 L_Q(\beta|X,y)}{\partial\beta\partial\beta'}\right]^{-1}. \tag{4.5}$$

From equation (4.5), it can be seen that the AVC matrix is a function of the design *X*, the choice observations *y*, the parameters *β*, and the number of respondents *Q*. Although both *y* and *β* are unknown when generating a design, it turns out that *y* drops out or can be mathematically dealt with in other ways when taking the second derivatives of the log-likelihood functions of the MNL, NL, and ML models (Sándor and Wedel 2002; Rose and Bliemer 2005; Bliemer, Rose and Hensher 2007). Thus, the AVC matrix Ω_Q can be estimated without knowing in advance the outcomes *y*, whilst the AVC matrix remains scalable by the sample size *Q*, meaning that if the AVC matrix is known for a single respondent, it can be analytically determined for *Q* respondents. As such, the only requirement in calculating the design X is that the analyst assumes prior parameter estimations β' which represents their belief as to what the true population parameters β will be in practice.

The objective therefore is to locate a design X, given a set of prior parameters, β' which will provide the smallest possible values for each of the elements in the AVC matrix Ω_Q, the leading diagonal of which are the parameter standard errors. Rather than work with the entire AVC matrix, it is customary to work with a single summary measure. The D-error represents the most widely used efficiency measure and is based on the determinant of the AVC matrix. As such, a D-optimal design is the design that provides the best precision in parameter estimations, that is have lowest standard errors, and lowest D-error value. To determine if a design is D-optimal, all possible designs must be constructed and evaluated. This may not always be possible however. Take for example a simple experiment involving two alternatives, each described by three attributes defined by three levels. The full factorial will have 729 choice situations (i.e., $3^{(3\times2)}$, see Section 4.2.1). Assuming one wanted a design with only nine choice tasks, there exist 1.53×10^{20} possible designs that require examination. Given such large numbers, it is commonly feasible to only examine a subset of this number. Hence, in contrast to the D-optimal designs, a D-efficient design seeks to minimise the efficiency by locating the design with the lowest D-error, but does so by searching only a subset of all possible designs.

The literature distinguishes different types of D-errors based on the priors assumed by the analyst. These include designs generated under the assumption that:

1) $\beta' = 0$ results in what the literature terms the D_z-error:

$$D_z\text{-error} = \det(\Omega_1(X,0))^{1/K} \tag{4.6}$$

where, where K is the number of parameters to be estimated.

2) $\beta^{'} \neq 0$ resulting in a measure referred to as the D_P-error:

$$\text{D}_\text{p}\text{-error} = \det(\Omega_1(X, \beta'))^{1/K} \tag{4.7}$$

3) $\beta^{'} \neq 0$ but rather than take a fixed value, is drawn from a probability distribution function around the true value of β, in such case, resulting in what is termed a Bayesian D_b-error:

$$\text{D}_\text{b}\text{-error} = \int_{\beta'} \det(\Omega_1(X, \beta'))^{1/K} \phi(\beta'|\theta)\, d\beta' \tag{4.8}$$

where $\phi(\beta'|\theta)$ stands for a joint probability density function with given parameters θ (Bliemer and Rose 2009).

The D_z-error is typically used when no information is known about the parameter values, not even the sign. Such a design is optimal when the parameters are zero, and hence, as is hoped will be the case, not very efficient in practice given that the parameter estimates of the study will not be zero. The D_p-error is used when one is certain about the likely parameter estimates that will be obtained from the study, whilst the D_b-error is used if one is less certain about the parameter values, but believes them not to be equal to zero.

In the current study, we employ a specific type of efficient design, known as a pivot design. Pivot designs are discussed in the next Section.

4.2.4 Pivot Designs

Pivot designs are experiments whereby the attribute levels of the experiment are not determined by the analyst a priori but rather are based on the levels provided by each respondent based on some real life experience. That is, rather than the analyst define a cost attribute as taking the levels \$200, \$300 and \$400, the respondent provides the real price to the researcher early in the survey. Based on the respondents input, the design then generates levels that are pivoted of the reference level. As such, the design will reflect individual specific realities rather than some researcher imposed reality. Two ways to construct pivot designs have been discussed within the literature. As the attribute levels are pivoted from reference alternatives of each respondent, a pivot design can be generated using relative differences from the reference level or absolute deviations (Bliemer and Rose 2009).

Unfortunately, as the reference levels are not known in advance, it is necessary for the researcher to make assumptions about these when generating the design. According to Rose et al. (2008), four approaches are available to create an efficient pivot design. These are 1) the generation of a single design whose reference levels is based on some population average; 2) the generation of multiple designs based on segment average reference levels; 3) the generation of separate designs for each respondent, which requires a survey mechanism that captures the levels and optimises the design simultaneously; or 4) an experiment design approach separated into two stages, first capturing the respondent specific references levels after which a single design is generated and applied to all respondents. The first approach is easy to generate but provides the lowest efficiency. The second and last approaches take more time and effort, but perform the best and produce the highest levels of efficiency.

The pivoting design technique has been used increasingly for shipping/logistics decisions discrete choice surveys (Hensher and Puckett 2004). This is because such designs attempt to make the hypothetical choice tasks as realistic to each respondent and hence minimise any hypothetical bias that may exist. Given that the current study also has practical implications for the industry, it was felt that the use of an efficient pivot experiment design would be most suitable for the purpose of this research. Further, given heterogeneity within the industry in terms of actual market freight prices, the complexity of freight transport decision processes, and differences in shipments, designing an experiment that reflected all surveyed participants was not possible without reverting to a pivot design. To obtain the prior information of the parameters, a questionnaire based on industrial average levels and historical records of different carriers and routes was first obtained and an extensive pilot study was carried out. After capturing the references from the pilot studies, an amended efficient pivot design was created for this research, using the second approach outlined in Rose et al. (2008).

4.3 Study Survey Construction

4.3.1 Stimuli Specification

According to Rose, Scarpa and Bliemer (2009), the steps in generating an efficient design is as per Figure 4-1. After refining the specific problem, the researcher is required to define the stimuli to be manipulated in the experiment (including the alternatives, attributes, attribute levels, and the number of choice situations).

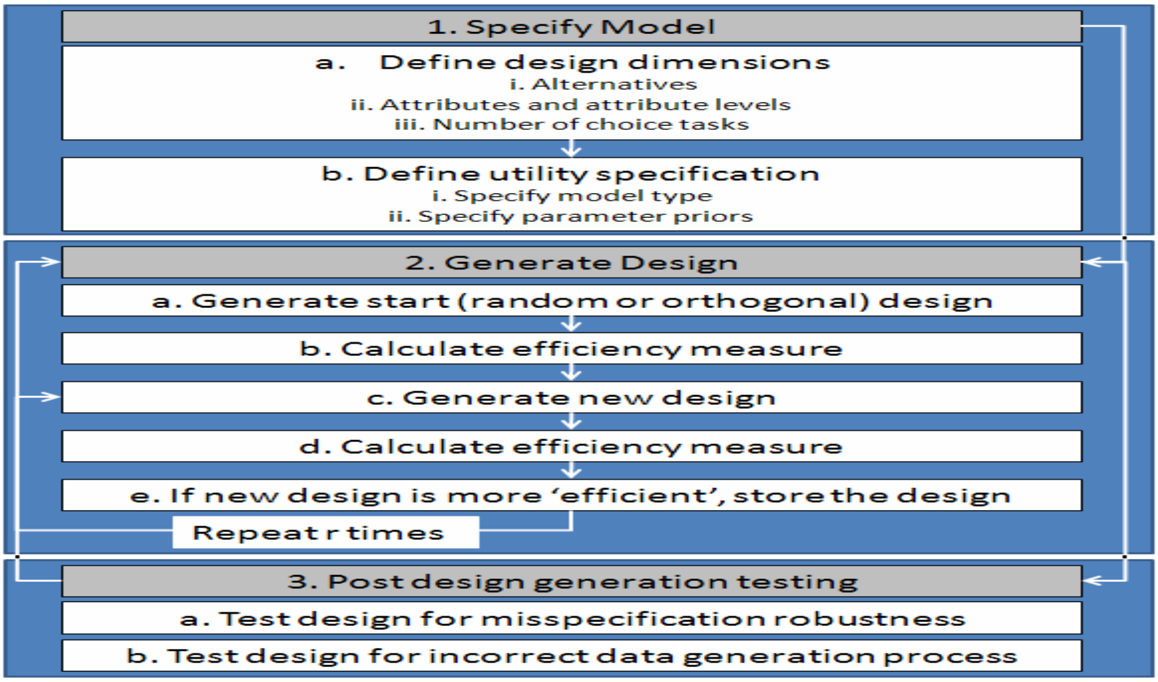


Figure 4-1: Design Generation Process
Source: (Rose, Scarpa and Bliemer 2009)

After an extensive literature review, it was felt that the current study should make use of an unlabeled experiment. An unlabeled experiment is one whereby the alternatives in each choice task provide no information to the respondent other than the order in which they are shown. For example, the alternatives may be Option A, Option B, Option C, etc. This contrasts to labelled experiments where the alternative names have substantive meaning to the respondents beyond the order in which they are shown. For example, a labelled experiment might consist of alternatives titled Train, Bus and Truck. For the current experiment, labels were inappropriate as the objective of the survey was to determine the influence of the attributes without confounded aligning these influences to a specific alternative type. For example, we were interested in determining the influence of damage or loss rates on maritime shipping decisions, not the influence of damage or loss rates related to specific contract types or specific shipping routes.

Attributes and attribute levels were selected and defined carefully based on previous literature, from consultation through pre-interview telephone calls, and an extensive pilot study. In order to define realistic and meaningful attributes, before conducting a pilot study, a substantial number of pre-interview telephone calls were carried out and industrial data were collected, however the response rate is very low (around 10 to 15 percent in all three cities) due to confidential and time constrain issues. As such, only 32 respondents participated in the pilot study, including 15 respondents from Shenzhen, 12 respondents from Sydney, and five respondents from Shanghai. The information gained from the pre-interview telephone calls and the pilot study helps to ensure the robustness of definitions of the attributes and attribute levels in the current study.

In generating the design, in order to link the levels of the experiment to the actual transport costs and value of the company's typical shipment, the freight rate, transit time, and frequency are expressed in absolute terms, while reliability and damage rate are expressed in percentage terms when shown to the respondent (see Figure 4.5).

The experiment involved respondents answering 16 choice questions. Eight of the 16 questions represented decisions made under normal operating conditions, whilst the remaining eight represented decisions made under abnormal conditions assuming some form of disruption event had occurred.

A summary of the attributes, attribute levels, and variable names used in the experiment are given in Table 4-1.

Table 4-1: Attributes and Attribute Levels for Normal and Disruption Circumstances

Operation	Attribute	Attribute levels in alternatives	Expected sign	Variable name
Normal	Freight Rate	-100,-300,+100,+300 (four design levels) design level × real freight rate from CAPI	-	FR
Disruption	Surcharge/ Rebate	-1,-3,1,3 (four design levels) design level × freight rate from CAPI×1(Sur) or × -1(Reb)	-	SUR
Normal	Transit Time	-1,-3,+1,+3 (four design levels) design level × coefficient +real transit time from CAPI	-	TT
Disruption	Delay	-1,-3,+1,+3 (four design levels) 14 + (design level × coefficient)	-	DEL
Both	Reliability	0.78,0.84,0.9,0.96 (four design levels) design level × 100 × coefficient	+	REL
Both	Damage	0.5,1,1.5,2 (four design levels) design level × coefficient	-	DAM
Normal	Frequency	0.5,1,1.5,2 (four design levels) design level × coefficient	+	FRQ

Freight rates were all converted into corresponding US dollars, and were defined as the freight rate per TEU. This was pivoted in the experiment around the real rate stated by respondents earlier in the survey. Surcharge and rebate are the costs under a disruption event; surcharge was defined as the expediting cost and rebate as the compensation required given a longer delay.

Transit time in the experiment was expressed as the door-to-door time in days under normal operating conditions. Delay is any additional transit time under the disruption scenario. Negative design levels indicated that shippers are willing to pay expediting costs to reduce the shipment delay days/delay time saving. Positive design levels indicated shippers prefer to receive compensation and tolerate a higher risk of delays occurring.

Reliability under normal operational conditions is expressed as a percentage of on-time arrival. It corresponds to the historical records of the different carriers and routes which were collected in questions asked prior to the choice experiment in the survey. Reliability under a disruption scenario can be interpreted as reliability of delay mitigation/extension after a disruption event (eg., strike). Reliability of delay mitigation/extension after a disruption is also expressed as a percentage of on-time arrival. For example, a shipment is expected to delay about 15 days due to bad weather, the logistics service provider can provide a hypothetical solution to reduce the delay to 11 days under an expediting cost of USD $300 per TEU, and this 11 days delay on-time arrival reliability is about 88%. On the other hand, if a shipper can tolerate a longer delay from 15 days to 17 days, the service provider can pay back USD $100 per TEU for compensation, and this 17 days delay on-time arrival reliability is 70%.

Damage is expressed as a percentage of the declared cargo value damaged during in transit. It corresponds to the historical records of the different carriers and routes.

Frequency is the number ship departures per week. For example, a frequency equal to 0.5 in the questionnaire indicates one service every two weeks.

Given the above definitions, freight rate, transit time, and frequency are attributes corresponding to a specific ship/route. Reliability and damage on the other hand are attributes associated with the long-term reputation or service level of a carrier.

Once the attributes are defined, it is possible to write out the expected utility functions of the surveyed respondents. Given that the attributes differ under the two operational conditions, there exists two sets of utilities. A shipper's utility function under normal and disrupted operational scenarios for the current study may be expressed as (4.9) and (4.10), respectively.

$$U_{qjs} = \beta_{FR}FR_{qjs} + \beta_{TT}TT_{qjs} + \beta_{RL}RL_{qjs} + \beta_{DM}DM_{qjs} + \beta_{FQ}FQ_{qjs} + \varepsilon_{qjs} \quad (4.9)$$

$$U_{qjs} = \beta_{SR}SR_{qjs} + \beta_{DL}DL_{qjs} + \beta_{RL}RL_{qjs} + \beta_{DM}DM_{qjs} + \varepsilon_{qjs} \quad (4.10)$$

The utility for company q choosing alternative j in choice situation s is expressed as $U_{qjs.}$ FR_{qjs} and SR_{qjs}, and TT_{qjs} and DL_{qjs} represent transportation attribute freight rate, transit time under normal operations, and expediting costs, delay days under the disruption scenario, respectively. The levels of these attributes vary in the experiment over company q, alternative

j and choice situation s. The remaining transport service attributes are denoted as RL_{ajs}, DM_{qjs}, and FQ_{qjs} for reliability, damage, and frequency respectively. ε_{qjs} denotes the error term of the model which is assumed to be extreme value type 1 distributed. The error term is assumed to represent the unobserved effects related to the utility for company q choosing alternative j in choice situation s.

The use of an unlabeled experiment requires that the model use generic parameter estimates. A generic parameter estimate is a parameter that is constrained to be the same for all alternatives in the model. The requirement for the use of generic parameters exists for unlabeled experiments as there is no behavioural reason for the estimates to differ over the alternatives (i.e., in a labelled experiment, the marginal utility for time for example may be expected to vary by two modes, such as car or bus, however in an unlabeled experiment, a parameter would not be expected to vary over what are in effect meaningless alternatives). As such, the parameters in the utility functions, β_{FR}, β_{TT}, β_{RL}, β_{DM}, and β_{FQ} are constrained to be same across all alternative j.

Finally, it was decided that each respondent be shown four alternatives in each choice situation and select their most preferred option. Hence, in this experiment J is assumed to equal four.

Using priors obtained from the pilot study, the experimental design was generated using Ngene V1.0.

Once the design was generated, the questionnaire instrument was developed. In this case, a computer-aided personal interview (CAPI) program was programmed. The next section discusses the survey questionnaire.

4.4 Survey Design

A questionnaire was designed to cover all essential information for the purpose of this study. Specific tailored CAPI software (see Figure 4-2) was utilized for a meaningful, systematic and integrated data collection process. This section outlines the survey and specific questions that were asked. The survey itself was divided into several sections which are detailed below.

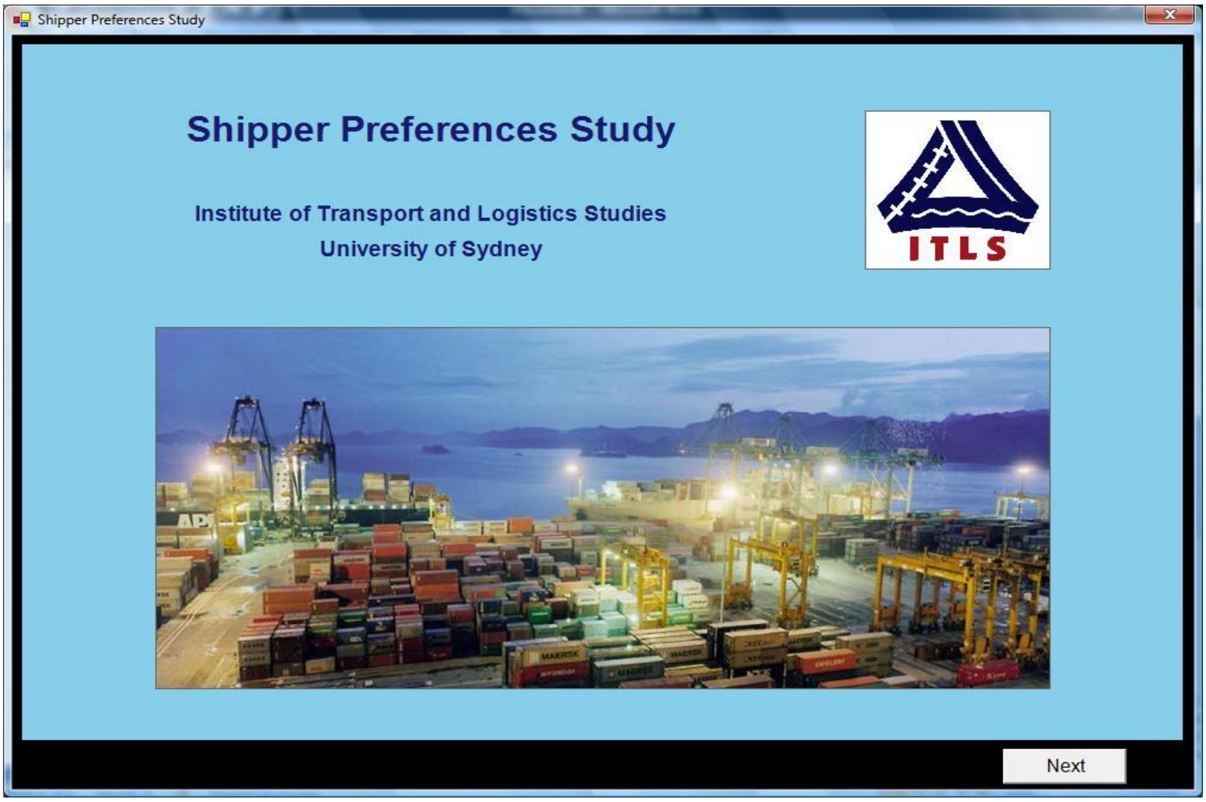


Figure 4-2: Survey CAPI

4.4.1 Survey Introductory

The first part of the survey was design to gather background information of firm-specific details including company size, commodity type, annual volume transported, how shipments are booked, general information on shipment delays, and any SCM and risk handling strategies that exist (see Figure 4-3 for some of the background questions asked). Respondents were sampled from small to medium sized companies in such a way as to ensure that they had adequate knowledge of the company's operations and were capable of answering all aspects of the questionnaire. Further information on the sampling plan is provided in Chapter 5.

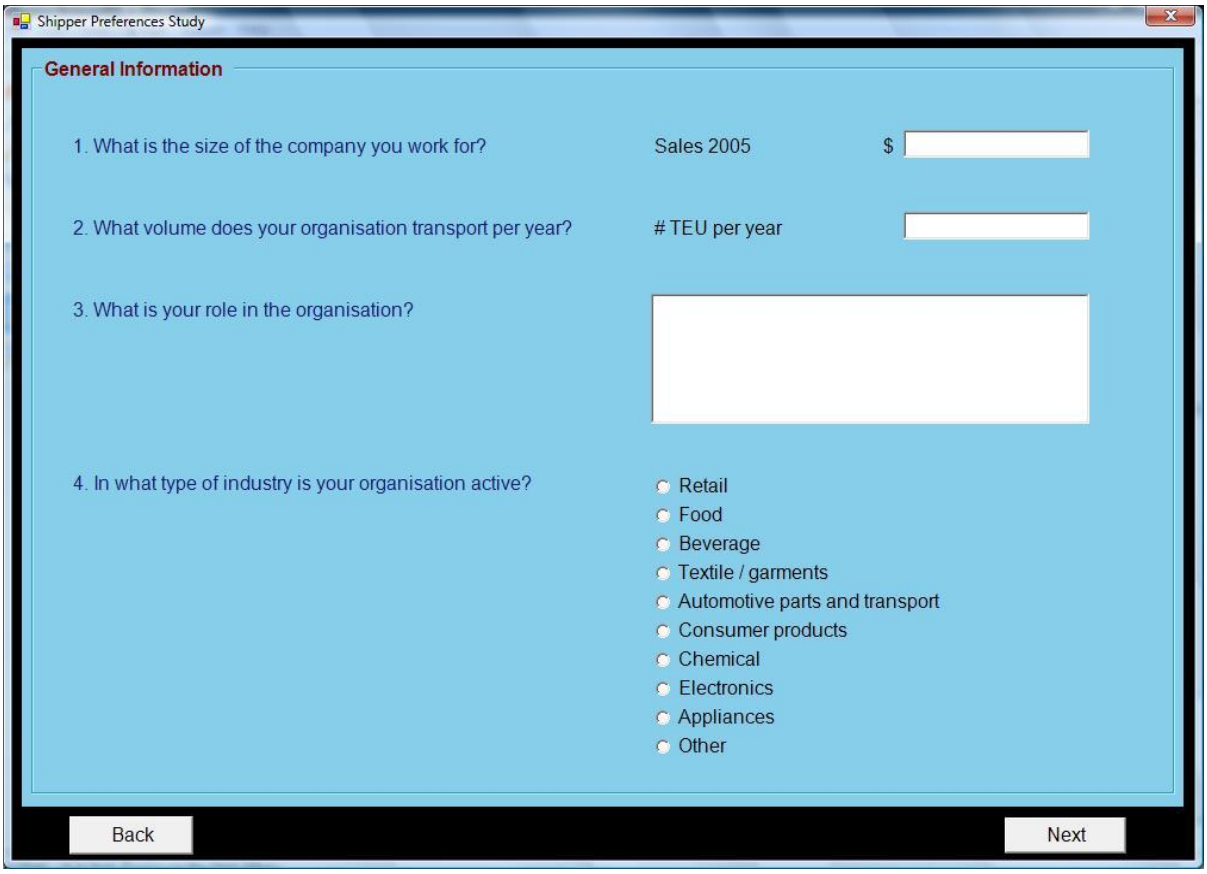


Figure 4-3: Survey Screen- General Information

4.4.2 A Specific Shipment Information and Normal Operation Choice Scenarios

The second section of the questionnaire also involved asking questions of surveyed logistics managers about specific information related to a recent containerised import or export shipment that they had knowledge of. Questions asked sought data on the origin and destination city of the shipment, the time in-transit, the transhipment port, the freight rate, the shipment size, the commodity type and value, and any delays that were experienced (see Figure 4-4 as an example screen). In cases where a respondent was unable to provide the details of a recent shipment, a representative shipment of the organization was sought.

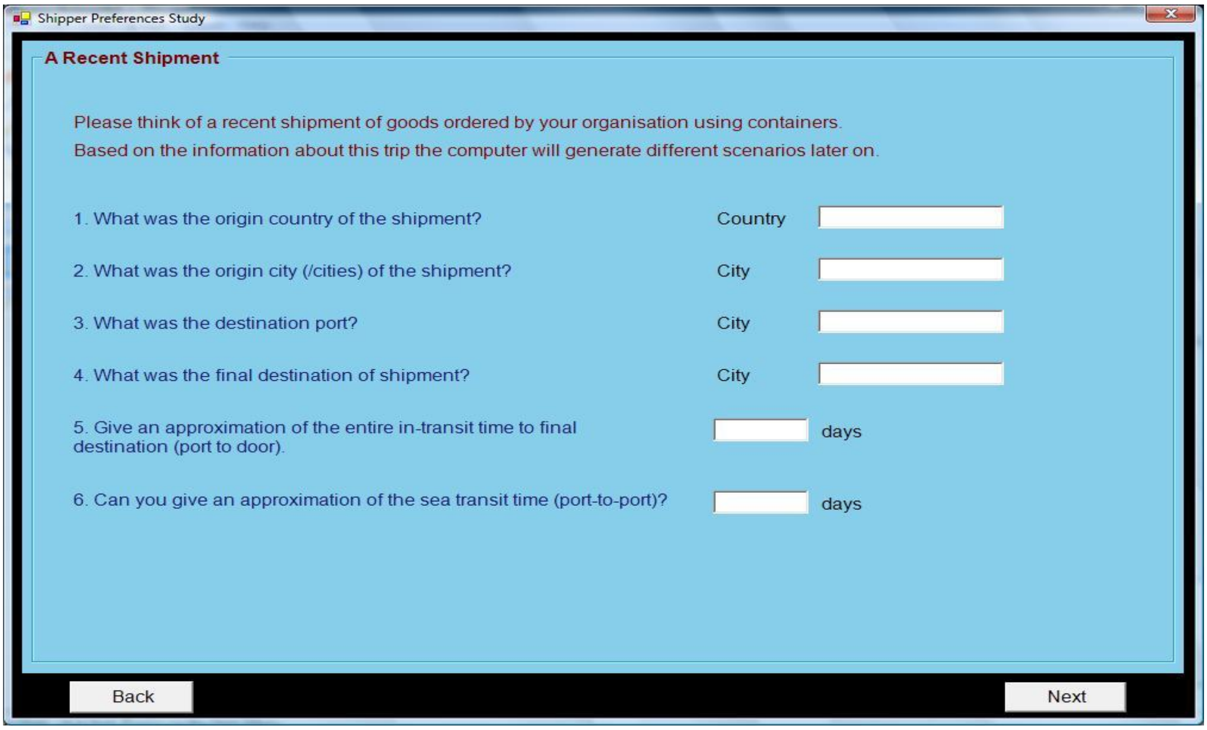


Figure 4-4: Survey Screen Involving a Recent Shipment

The third section of the survey consisted of the eight choice scenarios based on the experimental design, related to scenarios reflecting normal operating conditions. The shipment specific information captured in the second section of the survey represented the reference information required to generate the pivot design. For all respondents, the eight choice situations consisted of questions related to normal operating conditions. The tasks themselves involved the choice from four unlabelled alternative shipping options described by five attributes, these being the door-to-door freight rate, door-to-door transit time, reliability, damage, and service frequency. An itemised explanation of each attribute was provided at the top of each screen. A sample question is provided in Figures 4-5, and 4-6.

Respondents were asked to assume that four different service options/alternatives were available to arrange the transportation of his/her containers discussed earlier in the survey. The unlabelled service options were described as “option1” to “option 4”. Respondents had to choose one alternative that best suited individual personal preferences based on the given attributes for each of the choice sets given. Eight choice sets were provided following the practice game (see Figure 4-5). Prior to doing the experiment, respondents were asked to complete a practice game (see Figure 4-5). The practice game enabled the interviewer to explain the choice tasks and each attribute in detail.

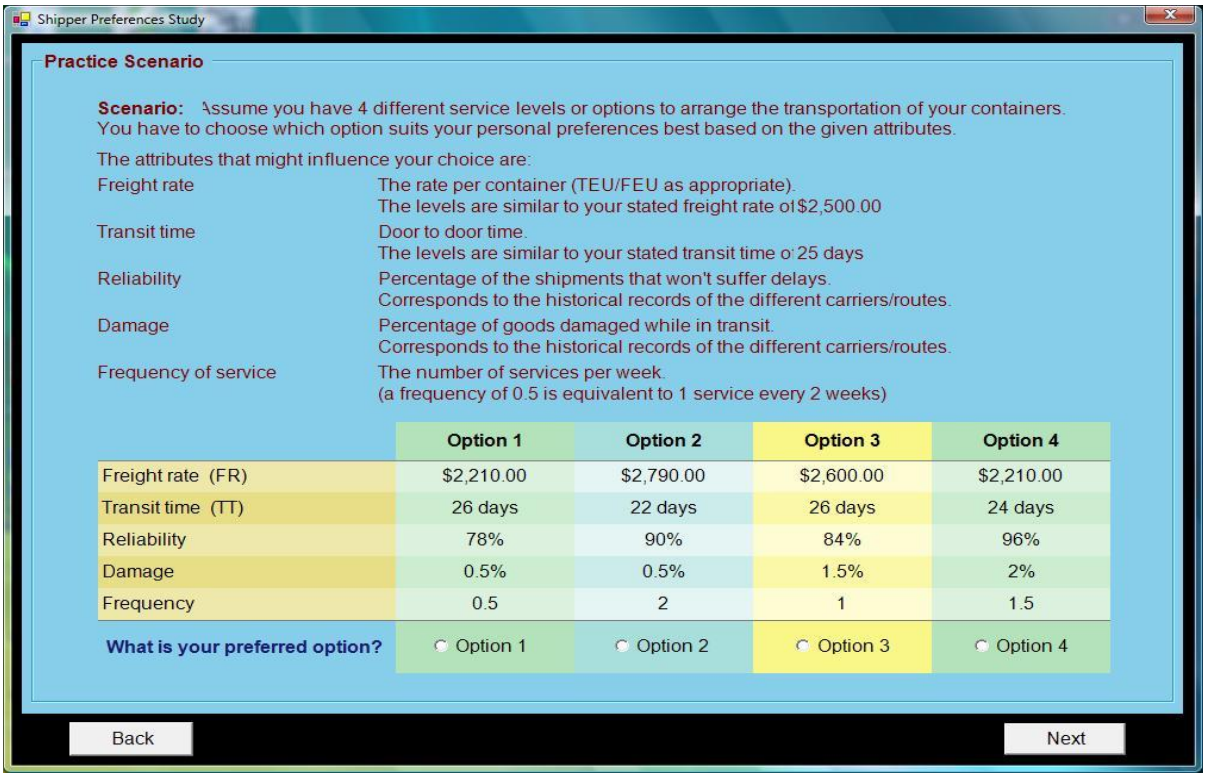


Figure 4-5: Survey Screen – Practice Scenario

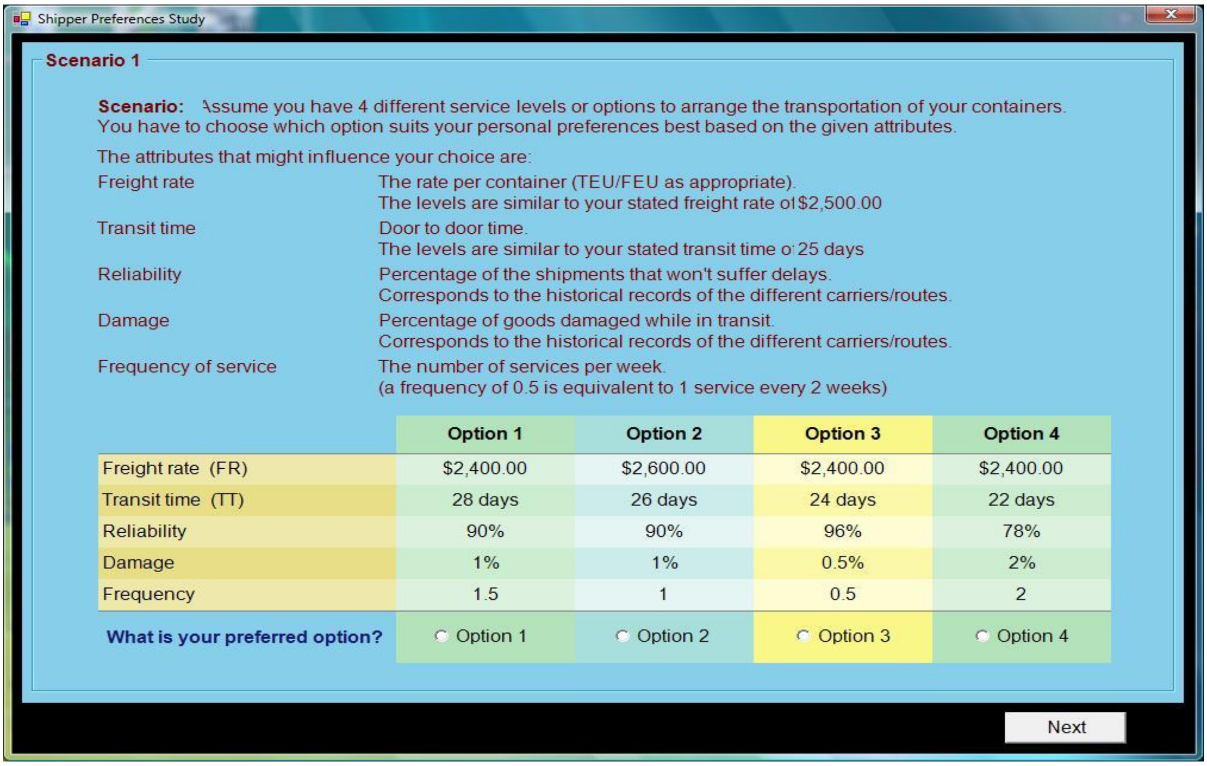


Figure 4-6: Survey Screen – Choice Scenarios under Normal Operations

At the end of the eight choice tasks, respondents were required to rank the service attributes from 'most important" to "less important", and to assess which if any of the attributes were deemed as being "not relevant" (see Figure 4-7). This supplementary information can be used to contribute to revealing and understanding shippers' rankings of importance for each maritime transport service attributes, although this is not part of this thesis.

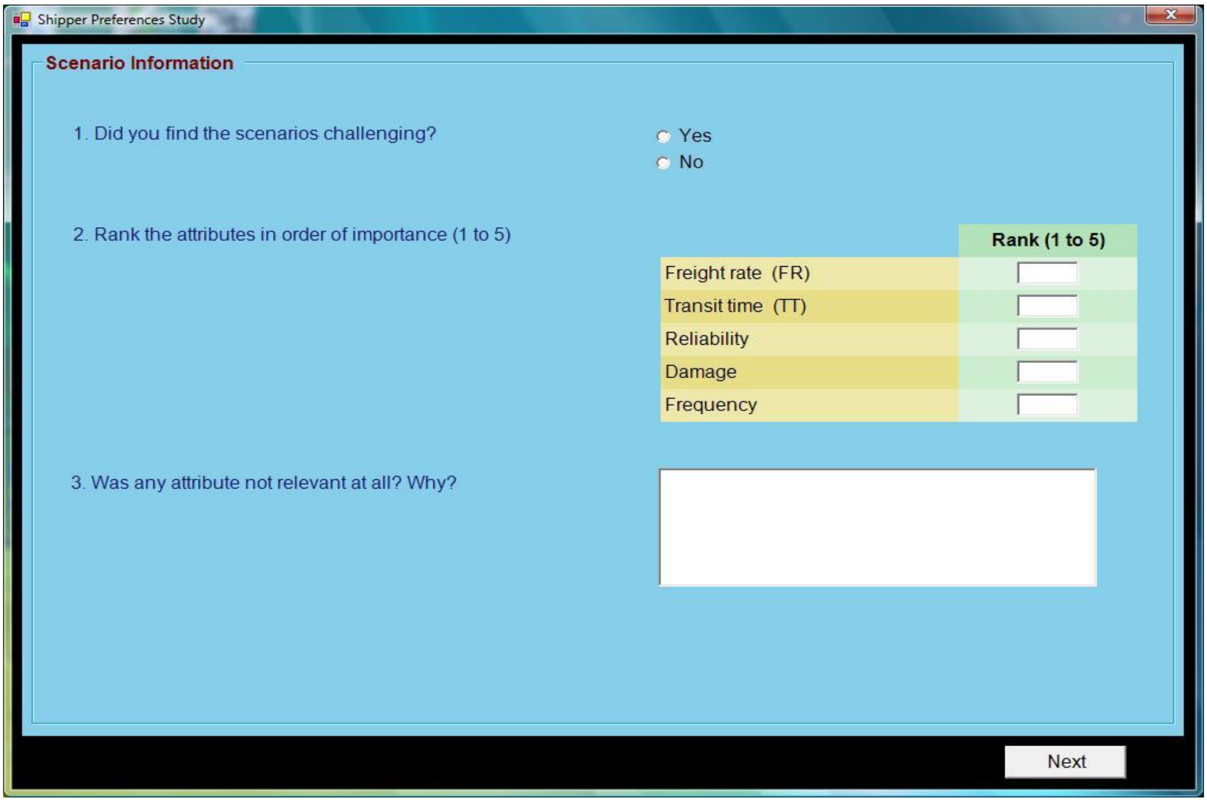


Figure 4-7: Survey Screen – Maritime Transport Service Attributes Importance Evaluation

4.4.3 Supply Chain Disruptions Scenarios

In the fourth section of the survey, surveyed logistics managers were asked to analyse a series of scenarios assuming that some disruption event had occurred. Before viewing the scenarios, the interviewer provided an explanation of possible SCDs through the use of some examples. Figure 4-8 illustrates the explanation given.

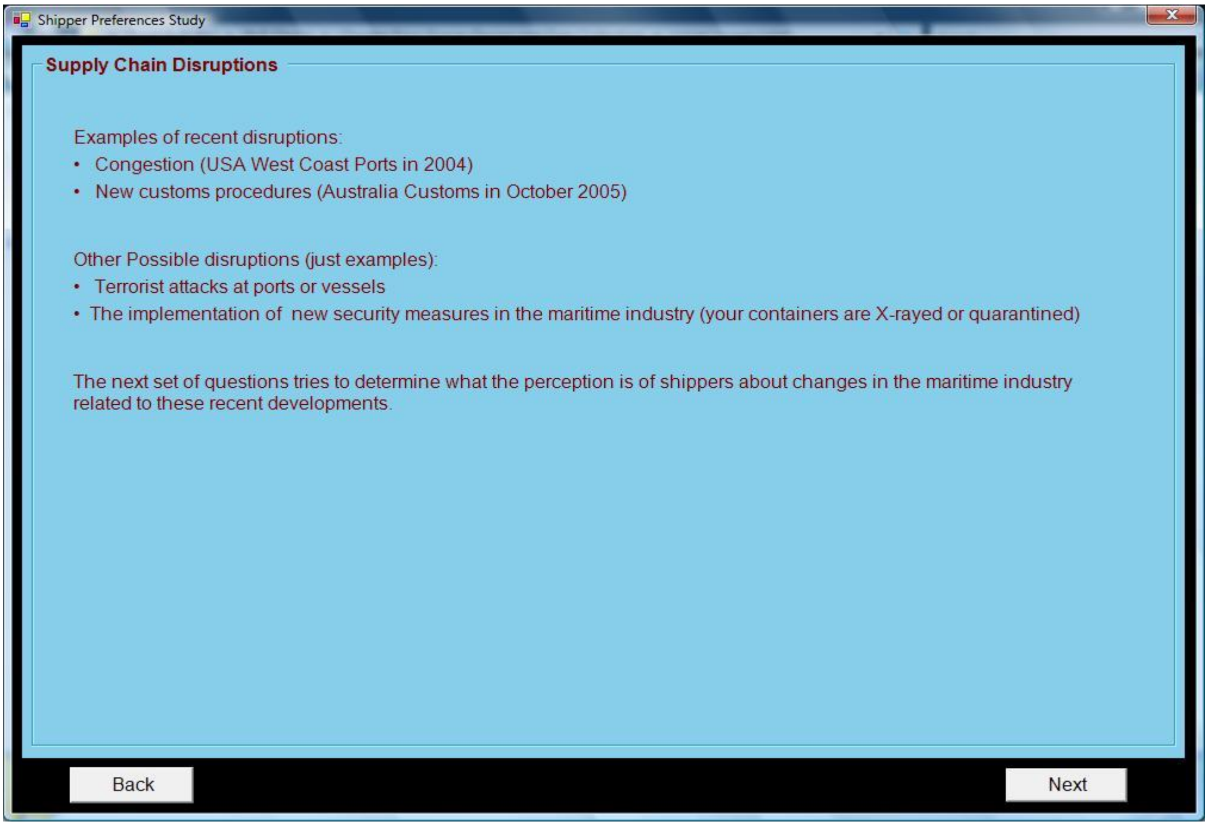


Figure 4-8: Survey Screen – Examples of Disruptions

Next, respondents were asked to relate the levels of a situation previously experienced where a transportation disruption occurred resulting in a delay of seven days or longer. Also asked were details of the company's contingency plans to tackle SCDs, and the impacts of increased security regulation or quarantine regulations on the companies' business operations. Also asked were questions about the possible effects a terrorist attack might have on transport decisions being made (see Figure 4-9).

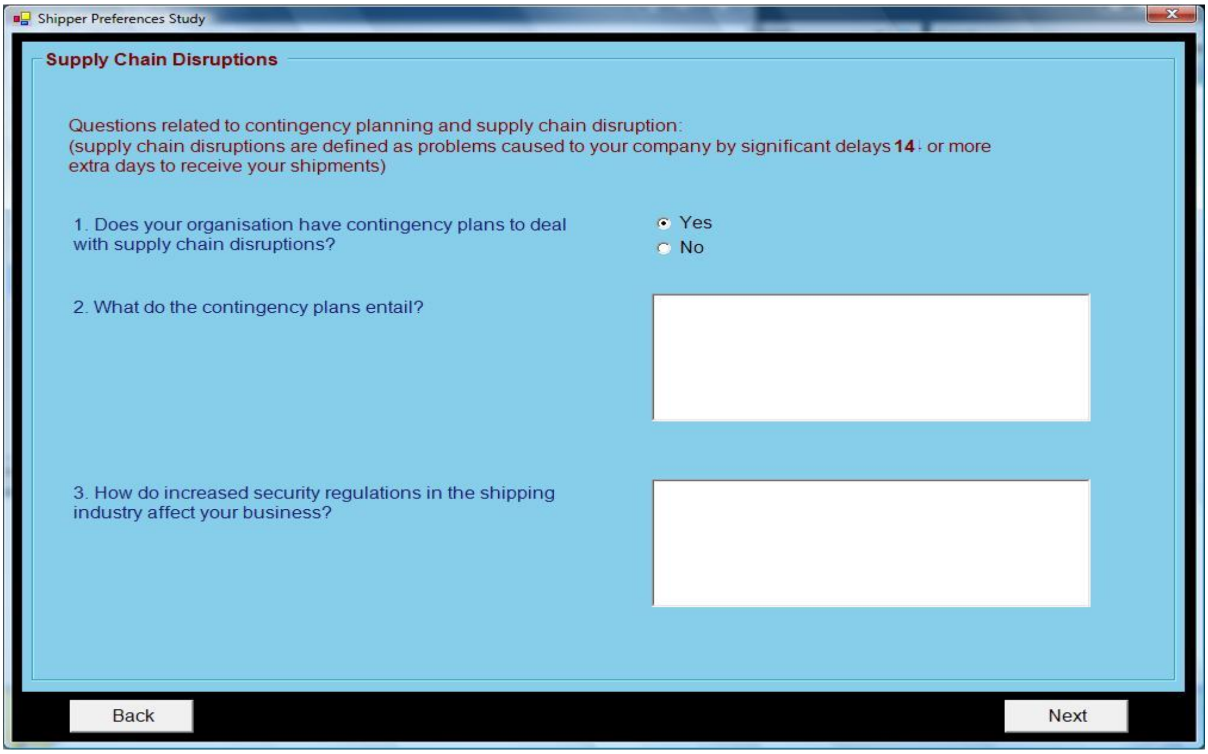
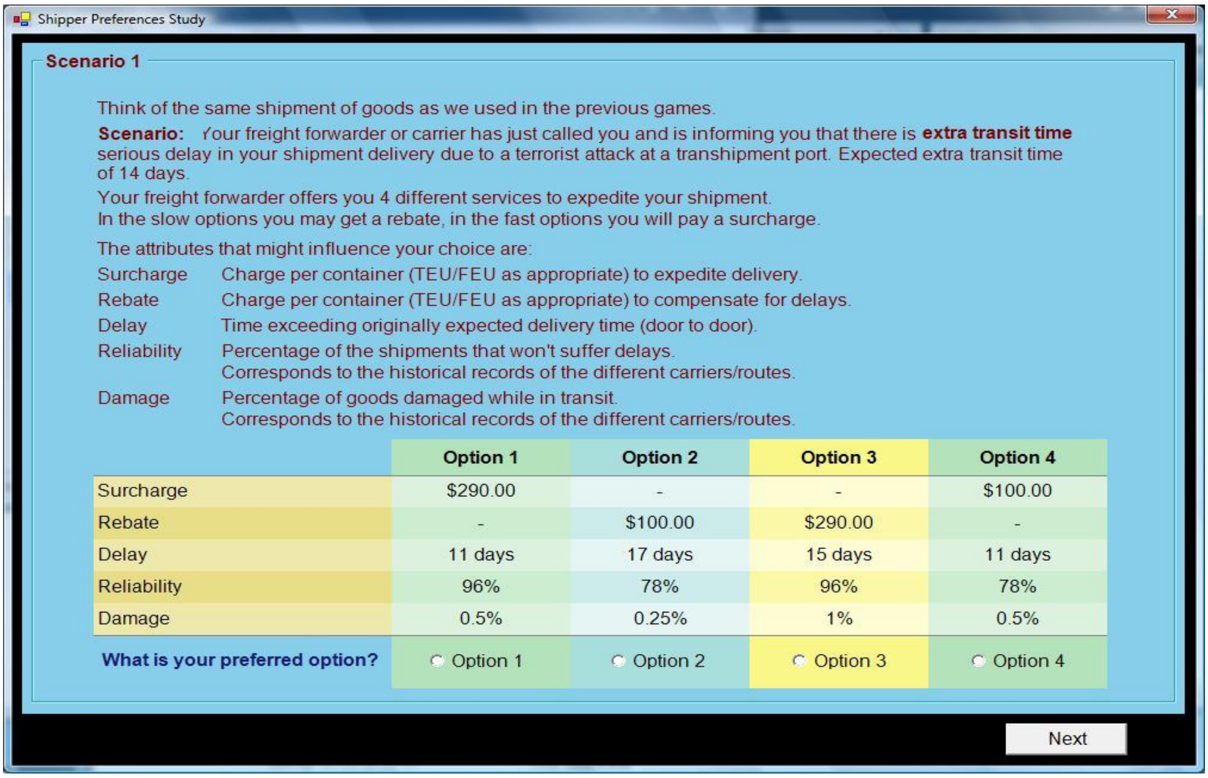


Figure 4-9: Survey Screen – Handling Supply Chain Disruptions

Next, choice scenarios under a hypothetical disruption circumstance were shown to respondents. These questions were constructed so as to be related to the data on the previous experienced disruption event captured earlier in the interview. The choice situations presented respondents with alternative options to expedite the shipment. The attributes for these scenarios included expediting cost (surcharge), time savings (delay), reliability, and damage. Expediting cost was expressed in dollars; time saving in days; reliability was expressed as a percentage of on-time arrivals; and damage was expressed as a percentage of the declared cargo value. Expediting cost and time savings were explained as attributes of an alternative mode/route. Reliability and damage were associated with the long-term reputation or service level of the carrier. Figure 4-10 illustrates an example question. A practice scenario was also provided ahead of the choice questions in this section. As before, the practice game enabled the interviewer to explain the hypothetical disruption scenario and each alternative, as well as each attribute in detail before the respondent started the following eight choice questions.

Finally, service attributes were also ranked in terms of their importance and irrelevance during respondents' decision-making whilst completing the questions (see Figure 4-11).



Shipper Preferences Study

Scenario 1

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

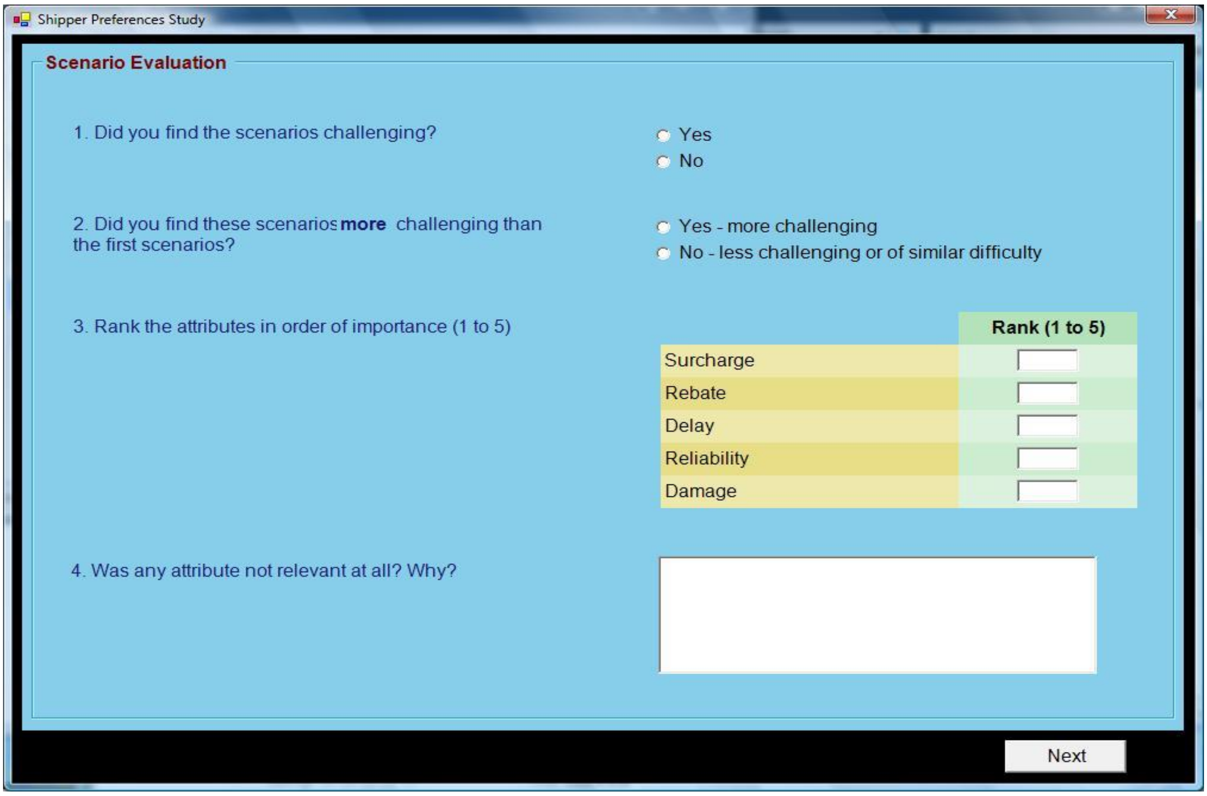
The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	$290.00	-	-	$100.00
Rebate	-	$100.00	$290.00	-
Delay	11 days	17 days	15 days	11 days
Reliability	96%	78%	96%	78%
Damage	0.5%	0.25%	1%	0.5%
What is your preferred option?	Option 1	Option 2	Option 3	Option 4

Next

Figure 4-10: Survey Screen – Supply Chain Disruption Choice Scenarios



Shipper Preferences Study

Scenario Evaluation

1. Did you find the scenarios challenging? — Yes / No

2. Did you find these scenarios **more** challenging than the first scenarios? — Yes - more challenging / No - less challenging or of similar difficulty

3. Rank the attributes in order of importance (1 to 5)

	Rank (1 to 5)
Surcharge	
Rebate	
Delay	
Reliability	
Damage	

4. Was any attribute not relevant at all? Why?

Next

Figure 4-11: Survey Screen – Service Attributes Evaluation under a Disruption Event

4.5 Conclusion

This chapter provides a brief over view of different types of stated choice experiment designs, including the type of design used herein, that being an efficient pivot design. The chapter provides details of the steps undertaken for generating the pivot efficient experiment design after which the survey used for the study is described. Questions captured via a CAPI survey allowed for general background information of the respondent’s company to be collected and the shippers’ preference captured for alternative options under normal operational conditions and disrupted operations. The next chapter presents details of the data collection method as well as a description of the data analysis undertaken for this research.

CHAPTER FIVE

5 DATA COLLECTION AND DATA DESCRIPTIVE ANALYSIS

5.1 Introduction

This chapter details the data collection process used to empirically test the hypotheses outlined in Chapter 3. The chapter then presents a descriptive analysis of the collected data.

5.2 Data Collection Process

The data used in this research are based on interviews with SC managers working in Sydney, Shenzhen, and Shanghai. Respondent companies were selected to ensure that a wide range of products and industries were represented in the survey. A substantial number of pre-interview telephone calls was carried out to collect general company information and to ensure that the final interview would be conducted with a manager, that had full knowledge/authority over the company’s shipping decisions as well as knowledge of the SC constraints imposed by customers or manufacturing/distribution activities. As a general indication, approximately 10 percent of the phone calls resulted in a successful interview.

A computer aided personal interview (CAPI) software designed and tailored specifically for this research was utilized. The software allowed for a systematic data collection process and ensured the integrity and completeness of the data. The first part of the interview was designed to obtain qualitative data regarding SC operations and transportation decisions. In the second part of the interview, logistics managers were asked to provide company specific information about a containerised import or export shipment, and any delays/disruptions experienced, rates, and transit times. Most interviews lasted one hour on average. One hundred and four respondents were interviewed between September 2006 and April 2008 in three cities. The majority (51 percent) of all companies were exporters while 49 percent were importers. The predominant respondents in Sydney were importers (83 percent), while in Shenzhen and Shanghai they were exporters accounting for 71 and 52 percent respectively (see Table 5-1). A majority of exporters was sought in China because of the country's positive foreign trade account balance.

Table 5-1: Descriptive Summary of Respondent Type

	Sydney	**Shenzhen**	**Shanghai**	**All Chinese**	**All Data**
Sample Size	30	49	25	74	104
Observation	240	392	200	592	832
Importers (0=Importer, 1=Exporter)	83.33%	28.57%	48.00%	35.14%	49.04%
Exporters	16.67%	71.43%	52.00%	64.86%	50.96%

Pre-interview telephone calls were carried out to ensure various industry types would be represented in the final sample, and that respondents had full knowledge of the company's operation management decision making processes. The breakdown per industry and product category in the final sample reflects the composition of Chinese and Australian foreign trade. Table 5-2 illustrates that, based on shipping commodity type, the highest proportion of shipments in China were Electrical Products (20 percent), followed by Electronics (15 percent), Raw Material (12 percent), Chemicals, Textile (nine percent), Mechanical Products, Consumer Products and others (eight percent), Construction Products (seven percent) and Automotive/Parts (three percent), and Other (eight percent) including Home Productions, Ceramics, Furniture, and Tobacco Products. The highest proportions of shipment types in Sydney were Electrical Products (33 percent), followed by Farming/Food (17 percent), Construction Products (13 percent), Textile and Automotive/Parts (10 percent), Consumer Products (seven percent), Mechanical Products, Raw Material and others (three percent).

The official organization role of interviewees' varied widely and included the role of general manager (and general manager in a China branch), sales manager (or marketing department manager), director, director assistant, shipping department manager, project manager, planning and logistics manager, customer representative, operation manager, global sourcing manager, international trade manager, purchasing manager, chief of process and productivity, business department manager, import section manager, export manager, purchasing supervisor, vendor account manager, president, and chairperson.

Table 5-2: Descriptive Summary of Respondent Commodity Type

	Sydney	Shenzhen	Shanghai	All Chinese
Commodity Type	**Percentage**	**Percentage**	**Percentage**	**Percentage**
Electrical Products	33.33	26.53	8.00	20.27
Electronic Products	-	16.33	12.00	14.86
Chemical Products	-	10.20	8.00	9.46
Mechanical Products	3.33	8.16	8.00	8.11
Raw Material	3.33	8.16	20.00	12.16
Consumer Products	6.67	8.16	8.00	8.11
Textile Products	10.00	6.12	16.00	9.46
Construction Products	13.33	6.12	8.00	6.76
Farming/Food	16.67	-	-	-
Automotive/Parts	10.00	2.04	4.00	2.70
Other	3.33	8.16	8.00	8.11
Total	**100.00**	**100.00**	**100.00**	**100.00**

5.3 Descriptive Summaries of Respondent Companies

The survey participants spread over the three cities represented a diverse set of organizations in terms of firm size. Among the three cities, Sydney respondents had the narrowest scope in organization's annual sales, ranging from USD $122,000 to $812 million with a median of USD $41 million. This was followed by Shanghai respondents, whose organization's annual sales ranged from USD $3 million to $10 billion with a median of USD $45 million. Shenzhen respondents' reported annual firm sales with the widest range, with a minimum of USD $500,000 and maximum of USD $14.4 billion and a median value of USD $5 million. In terms of annual TEU volume shipped by sea, Shenzhen had the greatest level of diversity ranging from a single container to a maximum of eight million containers shipped, with a median of 2000 TEUs per year. Firms from Shanghai reported between 20 containers to a maximum of 4.5 million containers shipped annually, with the median number of containers being 500 TEU. Shipments from Sydney firms ranged from 14 to 150,000 containers, with a median of 2000 TEU (see Table 5-3).

Table 5-3: Descriptive Summary of Respondent Companies

	Sydney	**Shenzhen**	**Shanghai**
Sample Size	30	49	25
Observation	240	392	200
Organization Annual Sales ($USD)	**Sydney**	**Min**	122,000
		Max	811,997,000
		Median	40,600,000
		Average	130,003,433
		Standard Deviation	207,960,670
	Shenzhen	**Min**	500,000
		Max	14,400,000,000
		Median	5,000,000
		Average	715,083,878
		Standard Deviation	2,411,928,162
	Shanghai	**Min**	3,000,000
		Max	10,000,000,000
		Median	45,000,000
		Average	748,704,000
		Standard Deviation	2,154,440,227
Organization Annual TEU Volumes	**Sydney**	**Min**	14
		Max	150,000
		Median	2,000
		Average	15,333
		Standard Deviation	33,241
	Shenzhen	**Min**	1
		Max	8,000,000
		Median	300
		Average	275,189
		Standard Deviation	1,231,931
	Shanghai	**Min**	20
		Max	4,534,000
		Median	500
		Average	220,333
		Standard Deviation	914,205

5.4 Descriptive Summaries of Respondent's Current Shipment Information

Seventy-five to eighty percent of interviewed respondents' current shipments were booked through a freight forwarder and 20 to 25 percent were booked via carriers in Sydney and Shenzhen. All Shanghai respondents' shipments were booked by freight forwarders. Most organizations reported assessing the reputation of carriers/freight forwarders during their service selection, with only 12 out of the 104 companies (11.54 percent) suggesting that this was not an important factor influencing their choice. The major attributes reportedly used to assess the reputation of a carrier/forwarder were price/freight rate (70.2 percent); service levels (efficiency, professional, flexibility) (68.27 percent); reputation (29.81 percent); history and whether a recommendation existed or not from some other knowledgeable source (27.9 percent); communication regarding documentations, process, tracing of shipments, and problem solving during emergency (25 percent); reliability (23.08 percent); company size (20.2 percent); shipping capacity and capability (number of shipping lines) (18.27 percent); stability of shipping schedule (15.4 percent); relationship and cooperation with customer and customs (15.4 percent); documentation provided (14.42 percent); KPIs (key performance indicators) (14.4 percent); IT system used (13.5 percent); frequency (9.62 percent); and security and location (7.7 percent).

Table 5-4 displays the shipment information reported for each of the three cities. Freight rates in Shenzhen and Shanghai were reported as being very similar, both ranging from USD $500 to $5500 with a median of USD $1700 per shipment. Sydney had a lower freight rate range varying between USD $500 and $4700, but higher median value around USD $2000 per shipment. The relative cost of inland transportation can be expected to vary by distance between the final destination of the cargo and the proximity of the importer/exporter to a port. The inland transport costs ranged from USD $50 to $1000 with a mode of USD $200. The low mode value is because most companies were located near coastal areas. Regarding how the freight was booked (i.e., Free on Board (FOB) or Cost Insurance Freight (CIF)), the majority (65 percent) was booked as FOB across the three cities with only 37 of the 104 respondents' reporting shipments paid as CIF.

Table 5-4: Descriptive Summary of Current Shipment Information

Freight Rate ($USD)	**Sydney**	**Min**	490
		Max	4,630
		Median	1,975
		Average	2,043
		Standard Deviation	935
	Shenzhen	**Min**	525
		Max	5,350
		Median	1,700
		Average	1,824
		Standard Deviation	922
	Shanghai	**Min**	550
		Max	5,136
		Median	1,700
		Average	2,011
		Standard Deviation	1,200
Freight Booked (CIF=1) or (FOB=0)	**Sydney**	**CIF**	36.67%
		FOB	63.33%
	Shenzhen	**CIF**	36.73%
		FOB	63.27%
	Shanghai	**CIF**	32.00%
		FOB	68.00%

The questionnaire asked respondents to provide data about a recent shipment. This was later used to construct the SP experiment. The range of cargo value per TEU for the current reported shipments was from USD $1500 for raw materials and recycled paper to a maximum of USD $650,000 for automotive bikes across the three cities. The most expensive cargo value per TEU shipment was from Tokyo, Japan to Sydney. For the Sydney sample, the value of goods carried in the most current shipment ranged from USD $4000 to $650,000 with a median of USD $35,000 per TEU. The value of shipments to and from Shanghai was between USD $4200 and $310,000 with a median value of USD $60,000. Shenzhen shipments had the lowest goods value with a range of USD $1500 to $200,000, and a median of USD $18,000. The majority of the most recently reported shipments were booked as being fully containerised in all three cities. Only 20 percent of Sydney respondents, six percent of Shenzhen respondents, and four percent of Shanghai respondents reported that their most current shipment was based on a consolidated container (See Table 5-5).

Table 5-5: Descriptive Summary of Current Shipment Information

Good value/TEU ($USD)	**Sydney**	**Min**	4,100
		Max	649,600
		Median	34,900
		Average	79,567
		Standard Deviation	126,234
	Shenzhen	**Min**	1,500
		Max	200,000
		Median	18,000
		Average	31,787
		Standard Deviation	35,710
	Shanghai	**Min**	4,200
		Max	310,000
		Median	60,000
		Average	83,088
		Standard Deviation	79,572
Current Shipment TEU Volume (Containers)	**Sydney**	**Min**	1
		Max	250
		Median	3
		Average	20
		Standard Deviation	50
	Shenzhen	**Min**	1
		Max	100
		Median	2
		Average	5
		Standard Deviation	15
	Shanghai	**Min**	1
		Max	25
		Median	2
		Average	5
		Standard Deviation	6

The transit time of the most recent trip varied slightly by city. Shipments in Shenzhen experienced a shorter transit time, ranging from six to 38 days, with a median of 24 days. The current trip transit time for Sydney shipments was between 14 and 50 days, with a median of 22 days. Lastly, Shanghai shipments had a wider range of transit times, ranging from 12 to 70 days, with a median of 27 days. Twenty-three out of the 104 respondents' current shipments involved transhipment. The majority of these were through Singapore (13 out of 23), followed by Hong Kong (three out of 23). Other transhipment ports included Bremerhaven, Rotterdam, Kelang, and Osaka. Thirty three percent of Sydney firms reported that their most recent shipment involved transhipment, with Singapore being the dominant transhipment port for both importers and exporters. Twenty-two percent of Shenzhen firms reported their most current shipment as involving transhipment, but transhipment ports were extremely diverse due to heterogeneity in the cargo destination. Although Shanghai firms experienced the longest transit time, only eight percent of the current reported shipments involved transhipment (see Table 5-6).

Table 5-6: Descriptive Summary of Current Shipment Information

Transit Time (Days)	**Sydney**	**Min**	14
		Max	50
		Median	22
		Average	25
		Standard Deviation	10
	Shenzhen	**Min**	6
		Max	38
		Median	24
		Average	23
		Standard Deviation	9
	Shanghai	**Min**	12
		Max	70
		Median	27
		Average	29
		Standard Deviation	12
Current Trip Involved a Transhipment (1=Yes, 0=No)	**Sydney**	**Transhipment**	33.33%
		No Transhipment	66.67%
	Shenzhen	**Transhipment**	22.45%
		No Transhipment	77.55%
	Shanghai	**Transhipment**	8.00%
		No Transhipment	92.00%
Experienced Delay (Days)	**Sydney**	**Min**	0
		Max	25
		Median	1
		Average	3
		Standard Deviation	6
	Shenzhen	**Min**	0
		Max	14
		Median	1
		Average	2
		Standard Deviation	2
	Shanghai	**Min**	0
		Max	10
		Median	0
		Average	1
		Standard Deviation	3

In terms of experiencing a delay during the currently reported shipments, Sydney tended to experience the longest amount of delays of around 25 days, followed by Shenzhen's 14 days and Shanghai's 10 days. Longer transit times and the large number of transhipments during sea transportation are possible causes for the longer delays experienced. Nearly twenty-one percent of respondents claimed their current shipment had experienced more than a three-day delay. The major causes of shipment delay as stated by the respondents are given in Table 5-7. Shipping schedule delay is the dominant factor causing shipment delay, followed by custom/quarantine/regulation related delays, shipping capacity shortages, transhipment delays, bad weather/unexpected situations, inland transportation delays, supplier delays, port congestion, and documentation/information errors.

Table 5-7: Factors Causing Current Shipment Delay

The factors that caused current shipment delay	Importer (%)	Exporter (%)	Sum (%)
Shipping schedule delay	16.3	20.2	37
Custom clearance/(random) inspection / quarantine delay and government regulation delay	14.4	13.5	28
Lacking shipping space/empty containers	13.5	13.5	27
Transhipment delay	14.4	10.6	25
Change shipping routine	12.5	11.5	24
Bad weather, strike, unexpected situation on sea	13.5	7.7	21
Inland transport delay (origin, destination, loading / unloading delay)	4.8	12.5	17
Supplier delay, production delay	5.8	10.6	16
Port delay, port congestion	6.7	6.7	13
Documentation/information error	10.6	1.9	13

5.5 Respondent Companies Experienced Delay and Damage

There was a substantial difference in the annual average percentage of shipment delays experienced amongst respondents from the three cities. Shanghai respondents had the widest range, with values varying between zero and 80 percent, with a median of five percent. This was followed by respondents from Sydney, with a range between two and 72 percent, and a median of 10 percent of annual shipments experiencing some sort of delay. Shipments from Shenzhen were reported as experiencing only zero to 30 percent of annual delay on average, and its median was about five percent (see Table 5-8).

Table 5-8: Descriptive Summary of Respondent Companies Experienced Delay and Damage

Shipment Delay Annually on Average (%)	**Sydney**	**Min**	2
		Max	72
		Median	10
		Average	18
		Standard Deviation	17
	Shenzhen	**Min**	0
		Max	30
		Median	5
		Average	8
		Standard Deviation	8
	Shanghai	**Min**	0
		Max	80
		Median	5
		Average	11
		Standard Deviation	18
Shipment Damage Rate Annually on Average (%)	**Sydney**	**Min**	0
		Max	50
		Median	2
		Average	5
		Standard Deviation	9
	Shenzhen	**Min**	0
		Max	5
		Median	0
		Average	1
		Standard Deviation	1
	Shanghai	**Min**	0
		Max	8
		Median	0
		Average	1
		Standard Deviation	2

In terms of annual damage rate of shipments transported by sea, Shenzhen and Shanghai have similar average values. The minimum damage rate in both cities was zero percent, with a maximum rate for Shenzhen and Shanghai of five percent and eight percent respectively. Sydney respondents reported extremely high rates of damage, up to 50 percent, however the average was five percent.

Lost sales/profit (58 percent) and costs increased (53 percent) were the dominant types of delay costs when managers were asked to describe the delay or disruption costs. In terms of costs increased, this included cargo damage/lost, price discounts, contract penalty, inventory carrying costs and additional administration costs. Increased communication, documentation, and tracking were the major administration costs and workload increases. These costs were different from transport related disruption costs (46 percent), which were highlighted as liner terminal charges, inspection fees, carrier demurrage, custom clearance costs, storage at port, delay box fee, increased transhipment due to missing schedule, port surcharges, reorder shipping space fee, charter fee, empty truck fee, return cargo shipping costs, change routing, or shift to air freight costs. Managers claimed transport delays would miss the sales season and impact on customer promotion plans or manufacturing plans. Thus, customer relationship damage (34 percent) was of high concern under a delay. Delay would also impact service level and damage company's reputation (23 percent) and competitiveness in the market. Respondents were also concerned about delays impacting payment delays and cash flows, as well as increasing lead-time (see Table 5-9).

SC transport delays and disruptions may possibly affect importers and exporters in dissimilar ways. Exporters indicated that delays might force them to offer price discounts, rebates, or penalty payments. Longer delays may even result in the cancellation of orders, the return of cargo, or the auction of the shipment at foreign ports. Contractual and payment terms had a significant impact on exporters' cash flows when a delay took place. As expected, exporters selling EX-WORK or FOB origin were not concerned about cash flow impacts. Exporters were highly concerned about company reputation, service level, and long-term relationships with their retailers. Among importers, importers showed more concern in relation to transport cost increases due to rerouting or mode changes. Wholesalers highlighted higher administrative costs related to customer service, communication, documentation and tracking. Wholesalers and manufacturers that import supplies and raw material were also concerned about higher inventory costs caused by longer lead times. In general, importers also showed a higher concern about the impact of delays on promotions and sales plans, as well as costs associated with custom procedures and inspections.

Table 5-9: Impacts of Supply Chain Transport Delays and Disruptions

Supply chain disruption-related costs	Importer (%)	Exporter (%)	Sum (%)
Lost sales/profit	34	24	58
Increase administration workload and costs	29	24	53
Increase transport costs	25	21	46
Damage customer relationship	13	20	34
Damage reputation	10	13	23
Account receivable and cash flow	2	7	9
Lead time increased	4	3	7

Sixty-nine out of 104 interviewees (66 percent) declared that they already had contingency plans to handle delays and disruptions at an *operational* level. However, at a *strategic* level, only 15.4 percent (16 out of 104) mentioned long-term measures to deal with travel time variability. Long-term measures included lengthening estimated lead times before order, increasing safety stocks and diversifying the network of carriers and suppliers, purchasing insurance, developing new products, investing in IT systems and building risk management team to handle emergency issues.

The results shown in Table 5-10 illustrate companies' responses to a specific delay or disruption. The most prevalent contingency measure to respond to actual delays was the use of alternative shipping routes which include, using more direct line shipping instead of an indirect line to avoid transhipment delays, or expediting the shipment using air or inland trucking to alternative ports. A second major response to tackle delays and disruptions was communication to SC parties to reschedule delivery times or to speed up processing times. In case of a major delay or disruption, managers indicated that when possible, they would tap into their network of alternative suppliers, promote substitute products, or negotiate customer discounts or rebates and apply late delivery penalties.

Table 5-10: Companies' Responses to Contingency Plans for Delay and Disruptions

Detail of contingency plans	Importer (%)	Exporter (%)	Sum (%)
Operational level			
Change shipping schedule/route	18.27	22.12	40
Communication to all parties to reschedule delivery time	14.42	24.04	38
Alternative sourcing/substitute product	12.50	15.38	28
Negotiate price discount/rebate to customers/apply penalty to suppliers	1.92	4.81	7
Strategic level			
Lengthen estimated lead time	3.85	0.96	5
Increase safety stock	6.73		7
Diversify carriers/suppliers base	15.38	9.62	25
Build risk management team	8.65	1.92	11
Invest on IT system improve tracking/develop new product	4.81	1.92	7

5.6 Delays in the Transport Chain

Managers were asked to rank what leg of the import or export movement was most likely to cause delays. According to Sydney and Shanghai respondents, transhipment was the highest ranked for causing shipment delay. In Sydney, delays at the discharge port ranked second and delay caused by other factors ranked third highest, followed by delay at loading port and transport at sea. Inland transport at the origin and destination country was ranked as least likely to cause delay. In Shanghai, delays at the loading port had the second highest score after transhipment, followed by delay at loading port, transport at sea, and delay at discharge port. Inland transport at the origin and destination country, and delay caused by other factors had a similar low score to cause shipment delay. However, the ranking done by Shenzhen managers was very different. According to Shenzhen managers, the clear cause of delays does not originate in any transportation leg but other factors related to manufacturing, customs, supplier-related delays, or bad weather and lack of shipping capacity. Among the transportation-related delays, transhipment was the highest ranked followed by delays at the loading and discharge port, respectively. Shenzhen managers ranked delays that originated in the long haul journey at sea as the least likely to take place (see Table 5-11).

Table 5-11: Ranking of Delays by Type of Transport Activity

Cities (Percentage %)	Transport Related Delay Factors	Delay by Land Trans-port in Country of Origin	Delay by Activities Related to Loading Port	Delay by Trans-port of Products by Sea	Delay by Transs-hipment	Delay by Activities Related to Dis-charge Port	Delay by Land Trans-port in Country of Desti-nation	Delay by Other Factors
Sydney	**Rank 1**	0.00	6.67	13.33	43.33	6.67	3.33	26.67
	Rank 1-2	10.00	26.67	23.33	63.33	33.33	10.00	33.33
Sample Size: 30	**Rank 1-3**	26.67	43.33	36.67	73.33	56.67	30.00	33.33
Observation: 240	**Rank 1-4**	40.00	70.00	63.33	80.00	70.00	40.00	36.67
	Rank 1-5	76.67	86.67	73.33	86.67	90.00	50.00	36.67
	Rank 1-6	93.33	100.00	83.33	93.33	96.67	93.33	40.00
	Rank 1-7	100.00	100.00	100.00	100.00	100.00	100.00	70.00
Shenzhen	**Rank 1**	4.08	14.29	0.00	16.33	14.29	0.00	51.02
	Rank 1-2	18.37	36.73	2.04	40.82	26.53	12.24	63.27
Sample Size: 49	**Rank 1-3**	40.82	79.59	4.08	55.10	36.73	18.37	65.31
Observation: 392	**Rank 1-4**	65.31	89.80	16.33	69.39	57.14	32.65	69.39
	Rank 1-5	83.67	95.92	24.49	89.80	81.63	51.02	71.43
	Rank 1-6	97.96	100.00	48.98	97.96	97.96	85.71	71.43
	Rank 1-7	100.00	100.00	100.00	100.00	100.00	100.00	75.51
Shanghai	**Rank 1**	4.00	8.00	0.00	80.00	0.00	0.00	8.00
	Rank 1-2	4.00	44.00	40.00	80.00	20.00	4.00	8.00
Sample Size: 25	**Rank 1-3**	24.00	52.00	64.00	88.00	52.00	8.00	12.00
Observation: 200	**Rank 1-4**	32.00	80.00	88.00	96.00	76.00	16.00	12.00
	Rank 1-5	56.00	96.00	88.00	96.00	100.00	52.00	12.00
	Rank 1-6	92.00	100.00	100.00	100.00	100.00	96.00	12.00
	Rank 1-7	100.00	100.00	100.00	100.00	100.00	100.00	40.00

5.7 Security Concerns

The vulnerability of transportation infrastructures and its operations was exposed through the terrorist attack of September 11, 2001 and the rampant piracy attacks again raise more concerns on maritime security. However, Meixell and Norbis (2008) reviewed a large amount of relevant literature and reveal that security in the SC is largely absent in transportation choice studies literature. In this research, questions were designed to better understand how increased security regulations, quarantine, and terrorist attacks affect shippers' transport decisions and business.

Seventy-five percent of respondents considered quarantine regulations affect their business, while 25 percent believed it is a rare influence. Regarding increased security regulations in the shipping industry, 46.15 percent of respondents considered it is acceptable, normal, has compulsory regulations, and rarely affects business. They would pre-plan and prepare to satisfy the requirements before loading or producing. Some of them even considered that it increases SC efficiency by ensuring better information flows and better preparation in business operation process. Some considered it improved product quality to match more diverse regional certificates. However, 53.85 percent (56 out of 104 respondents) considered increased security regulation in the shipping industry did affect their business. Table 5-12 summarizes respondents' views of the influence of quarantine and security regulation on shippers' business.

Table 5-12: Impacts of Increased Security Regulation on Shippers' Business

Impacts	In detail
Increased Costs	**<u>Increased Transport Costs</u>** Packing costs increase with more detailed requirements on products, packing, and special certifications (e.g., fumigation) Costs increase on container booking or container detentions Storage costs increase **<u>Costs Increased on Customs or Ports</u>** Inspection or clearance costs increase, security charges increase, Penalty at ports or customs due to incorrect information or documentations **<u>Increases Administration Costs</u>** Workload increase and increased handling costs More requirements on documentations and information Investment in IT systems to improve electronic data interchange (EDI) with customs/3PL systems May increase damage and loss, delay costs, penalty from customers, increased inventory carrying costs
Increased Lead-time, **Reduced Buffer Time**	More preparation for documentations increased waiting time, more confirmation before loading, have to prepare containers earlier (e.g., 24 hours early clearance requires more documentation preparations and earlier container booking) Longer lead-time for security check. (e.g., Israel requires two days earlier for safety inspection due to war)
Increased Delay	Boxes may be delayed and result in missing shipping date Custom random check length in-transit time, increase uncertainty of transportation, increase damage/loss and delay
Impacts on Business Processing	Have to change working system and process to meet regulation requirements (e.g., certain productions are required to match certain CE or UL certifications, as such, have to redesign products or producing process, and packing) More pre-planning and preparation lead to more complicated procedures, increased administration workload, increase attention to detail training
Impacts on Sales and Customer Relationship	Length of waiting time, increased delay, decreased customer service level and satisfaction, impact on sales Penalty from customers, or damage customer relationship

In terms of the risk of a terrorist attack, 55.77 percent respondents did not take it into account when making their transport decisions. However, almost half (44.23 percent) of respondents believed it did affect their transport decisions. Concerning the risk of a terrorist attack, respondents would change or delay their transport plans, modes, change their carriers, forwarders and shipping line. This includes delays or cancelled shipment and shipment plans, and changing destination or loading port, routine, or transport mode. It would influence the contract term between CIF and FOB, and impact insurance terms or current and future insurance costs. Thus, in addition to affecting shippers' transport decisions, worries about risk of terrorist attack also affect shippers' business. Shippers tend to demand more communication, increase their inventory level, look for alternative resources or plans, and impose higher requirements on the certifications or quality of their drivers. They also find it has an impact on their operation costs and their insurance bills and affects their company sales or future sales plans.

5.8 Sea Transport Attributes' Ranking under Normal Operations

Managers were asked to assess the important transport attributes influencing their shipping choice decisions under normal operations. Due to the current pressure from RMB Yuan appreciation, labour cost increases, and export rebate reductions, it was acknowledged universally by managers in Shenzhen that freight rate is the most important determinant factor affecting their transportation decisions, and Shanghai managers scored freight rate and transit time equally as the most important factors (see Table 5-13). Regardless of the transportation cost, Shenzhen and Shanghai managers had similar ranking for the sea transport attributes: transit time had the highest score followed by reliability, damage rate, and frequency. The ranking by Sydney managers was slightly different. Sydney managers assessed reliability as the most important factor when making sea transport decisions under normal operating conditions, followed by freight rate, transit time, damage rate and frequency.

Table 5-13: Ranking of Transportation Attributes Influencing Decision-Making under Normal Operations

Cities (Percentage %)	Transport Attributes	Freight Rate	Transit Time	Reliability	Damage Rate	Frequency
Sydney	**Rank 1**	36.67	10.00	43.33	6.67	3.33
	Rank 1-2	66.67	36.67	66.67	26.67	3.33
Sample Size: 30	**Rank 1-3**	86.67	60.00	86.67	40.00	26.67
Observation: 240	**Rank 1-4**	93.33	90.00	96.67	60.00	60.00
	Rank 1-5	100.00	100.00	100.00	100.00	100.00

Cities (Percentage %)	Transport Attributes	Freight Rate	Transit Time	Reliability	Damage Rate	Frequency
Shenzhen	**Rank 1**	34.69	32.65	22.45	8.16	2.04
Sample Size: 49	**Rank 1-2**	67.35	71.43	36.73	16.33	8.16
Observation: 392	**Rank 1-3**	83.67	79.59	65.31	24.49	46.94
	Rank 1-4	93.88	97.96	89.80	40.82	77.55
	Rank 1-5	100.00	100.00	100.00	100.00	100.00

Cities (Percentage %)	Transport Attributes	Freight Rate	Transit Time	Reliability	Damage Rate	Frequency
Shanghai	**Rank 1**	28.00	28.00	24.00	16.00	4.00
Sample Size: 25	**Rank 1-2**	56.00	44.00	48.00	28.00	24.00
Observation: 200	**Rank 1-3**	76.00	76.00	64.00	36.00	48.00
	Rank 1-4	88.00	88.00	92.00	64.00	68.00
	Rank 1-5	100.00	100.00	100.00	100.00	100.00

5.9 Sea Transport Attributes' Ranking given a Disruption Event

The ranking of sea transport attributes changed when managers were asked to make transport decisions under a two-week disruption scenario. All managers in all three cities considered delay as the most important attribute when making transport decisions under a disrupted operating condition. Reliability was the second highest scored by Sydney and Shanghai managers. However, Sydney managers ranked surcharge as the third highest score, followed by rebate and damage rate; Shanghai managers were concerned more about damage rate, followed by surcharge and rebate under a disrupted scenario. On the contrary, rebate was ranked as the second most important factor by Shenzhen managers, followed by surcharge, reliability, and damage rate.

Table 5-14: Ranking of Transportation Attributes Influencing Decision Making under a Disruption Event

Cities (Percentage %)	Transport Attributes	Surcharge	Rebate	Delay	Reliability	Damage
Sydney	**Rank 1**	13.33	6.67	40.00	36.67	3.33
Sample Size:	**Rank 1-2**	23.33	13.33	80.00	70.00	13.33
30	**Rank 1-3**	60.00	16.67	86.67	96.67	40.00
Observation:	**Rank 1-4**	80.00	46.67	100.00	100.00	73.33
240	**Rank 1-5**	100.00	100.00	100.00	100.00	100.00

Cities (Percentage %)	Transport Attributes	Surcharge	Rebate	Delay	Reliability	Damage
Shenzhen	**Rank 1**	10.20	12.24	63.27	8.16	6.12
Sample Size:	**Rank 1-2**	42.86	14.29	85.71	48.98	8.16
49	**Rank 1-3**	83.67	16.33	100.00	85.71	14.29
Observation:	**Rank 1-4**	91.84	24.49	100.00	100.00	83.67
392	**Rank 1-5**	100.00	100.00	100.00	100.00	100.00

Cities (Percentage %)	Transport Attributes	Surcharge	Rebate	Delay	Reliability	Damage
Shanghai	**Rank 1**	8.00	4.00	52.00	20.00	16.00
Sample Size:	**Rank 1-2**	40.00	12.00	76.00	52.00	20.00
25	**Rank 1-3**	64.00	12.00	96.00	80.00	48.00
Observation:	**Rank 1-4**	100.00	24.00	96.00	96.00	84.00
200	**Rank 1-5**	100.00	100.00	100.00	100.00	100.00

5.10 Conclusions

A descriptive analysis of the data collected is presented in this chapter. The following chapter presents the main results from the data analysis and the tests performed on the hypotheses outlined in Chapter 3.

CHAPTER SIX

6 DATA ANALYSIS AND HYPOTHESES TESTS

6.1 Introduction

This chapter presents the analyses of the collected data and the test results of the hypotheses specified in Chapter Three. Model estimations are carried out utilizing LIMDEP (Nlogit 4.0). This chapter firstly describes the process to select the best-fitting model. The second section examines hypotheses H_1 and H_2 using LCMs; the WTP values obtained after estimating the LCMs are also analysed. The third section tests whether the WTP values have sources of systematic variation, and SURE modelling technique is applied to estimate hypotheses H_3 to H_8. The last section of this chapter summarises the results of the hypotheses tests.

6.2 Selecting the Best Fit Model Form

6.2.1 The Selection Process of the Best Fit Model Form

Data analysis is carried out using LIMDEP (Nlogit 4.0). Based on shippers' utility functions specified in section 4.3.1 (Equations 4.9 and 4.10), two basic MNL models are first estimated without adding any interaction terms to test the key maritime transport service attributes identified in section 3.3. Table 6-1 displays the results of the MNL models under normal and disrupted operating conditions. All attributes in both MNL models are statistically significant as all t-Ratios are larger than 1.96. Therefore, the hypotheses H_1 and H_2 cannot be rejected. The attributes that were significant determinants of shippers' choice of the containerised maritime transportation service under all operating conditions were freight rate, travel time (delay under a disruption), reliability, damage rate, and frequency (under normal operation only). Further, the values of each coefficient are different when comparing MNL models under normal and disrupted operations, as indicated in Table 6-1. For example, keeping all else equal, the marginal utility of transit time/delay increased 2.6 times when a disruption took place. That is, if there is a disruption, reducing transit time/delay days becomes the priority important factor influencing shippers' transport decisions. Thus, H_2 cannot be rejected here. As such, a transport related disruption is likely to affect shippers' WTPs for each key maritime transport service attributes, and lead to a shift in the importance of those service attributes compared to that under normal operation.

Table 6-1: MNL Models under Normal and Disrupted Operations

MNL MODELS	**Under Normal Operation**		**Under a Disruption**		
	(i)		**(ii)**		
Variable	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Ratio=(ii)/(i)**
Freight Rate (Surcharge)	-0.0037	-12.1600	-0.0024	-9.3100	0.6576
Transit Time (Delay)	-0.1400	-10.7800	-0.3640	-15.1800	2.6002
Reliability	0.0955	16.4100	0.0937	17.0900	0.9814
Damage Rate	-0.5505	-5.5600	-0.4538	-3.3100	0.8242
Frequency	0.5461	7.6300			
Log-Likelihood	-823.6400		-780.4290		
Respondents	104		104		
Observations	832		832		

Second, mixed logit (ML) models with interaction tests are examined to estimate the best ML models under both normal and disrupted operations. According to Equation (3.26), to estimate the "part-worth" of an attribute, the WTP can be presented as Equation (6.1) if neither numerator nor denominator interacts with another variable; or Equation (6.2) if both numerator and denominator do interact with another variable. As the final ML model results indicate that both numerator and denominator in the WTP equation interact with other variables, in this case, the Nlogit 4.0 software is unable to estimate the WTP value directly. As such, the WTP values for the selected ML models need to be estimated by using a manual simulation in Excel. Furthermore, the selected ML model with the best model fit is assuming a normal distribution with fixed one standard deviation, as a result, negative and extreme value of WTPs are unavoidable. These extreme values of WTP are meaningless and unpractical (for example the negative values for the reliability and frequency attributes indicate shippers prefer to maritime service with less service frequency and lower on-time reliability, and these values are unpractical). Before finalizing the best fit model, LCMs are further estimated to compare with the ML models. (ML models with interaction tests were produced but not included in this thesis, because the LCM did produce a better model fit and outperform ML model in this research. ML results are available upon request.)

$$WTP_{TT} = \frac{\beta_{TT}}{\beta_{FR}} \qquad (6.1)$$

$$WTP = \frac{\frac{\partial}{\partial x_k}(\beta_1 x_k + \beta_2 x_k x_l)}{\frac{\partial}{\partial x_c}(\beta_3 x_c + \beta_4 x_c x_h)} = \frac{\beta_1 + \beta_2 x_l}{\beta_3 + \beta_4 x_h} \qquad (6.2)$$

Third, as suggested by Green and Hensher (2003) and other researchers' findings regarding the merits of LCMs discussed in section 3.6.2, we compare the ML and the LCMs to finalize the best fit model for the research purposes of this study. A comparison is carried out and reported in the following section.

6.2.2 A Comparison of LCM and ML Models

For purposes of comparison, LCM and ML models were estimated without interaction terms. Table 6-2 and Table 6-3 display the goodness of fit of the three estimated models: MNL, ML and LCM. The detailed estimation results are reported in Table 6-2 under normal operation and Table 6-3 under a disrupted operating condition.

First, comparing the model goodness of fit based on the log likelihood values shown in Table 6-2 and Table 6-3 under both normal and disrupted operating conditions, the ML models and LCMs outperform the simpler MNLs. However, it is inappropriate to compare models only based on the log likelihood value without taking into account the number of estimated parameters (Greene and Hensher 2003). Therefore, other statistical measures determining the model fit, such as Pseudo R-squared, AIC, BIC, CAIC are necessary. All these measures indicate that LCMs statistically outperform ML models under normal and disrupted operating conditions. Based on the smallest CAIC value, we selected the two classes LCM under normal operations and three classes LCM under a disruption as the best fit models for the current study (more details of determining the best fit number of classes under a disruption will be specified in the next section).

In addition to the statistical model fit, it is also very important to have a model that can produce behaviourally reasonable results. Looking at Table 6-2, the standard deviation is about 2.26 times greater than the mean for freight rate and transit time attributes in the ML model assuming a triangular distribution. This implies that more than 15 percent of respondents will have a positive sign for freight rate and transit time parameters. It also suggests that more than 15 percent of respondents prefer higher freight rates and longer transit times in maritime transport service under normal operation. Similarly, the standard deviation is about 7.14 times greater than the mean for the damage rate attribute. This implies that more than 37.5 percent of respondents have a positive sign for the damage rate parameter, which suggests those respondents prefer a higher damage rate during their maritime transport decisions. This result is nonsensical and impractical. Obviously, in this study, it is unavoidable that a certain number of respondents would have extreme and behaviourally unreasonable results in the ML models even assuming random parameters of normal or triangular distribution. A similar conclusion could also be drawn under a disrupted operating condition based on the ML model results in **Table 6-3**.

Therefore, although ML models provide more flexibility in preference heterogeneity estimation and have a better statistical model fit, a LCM could avoid extreme and nonsensical parameter estimations, and help researchers capture more practical and behaviourally sensible results. As such, the LCMs are selected as the best fit models for this study.

The next section conducts an analysis based on the MNL and LCM results.

Table 6-2: Comparison between MNL, ML and LCM under Normal Operations

Under Normal Operation Models	MNL		ML (T distribution)		LCM Class 1		LCM Class 2	
Variable	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**
Freight Rate	-0.0037	-12.1600	-0.0079	-11.0200	-0.0060	-7.5400	-0.0014	-2.7100
(Std Dev.)			0.0180	14.5700				
Transit Time	-0.1400	-10.7800	-0.2221	-7.7500	-0.1035	-5.4600	-0.2276	-6.1200
(Std Dev.)			0.5028	7.0100				
Reliability	0.0955	16.4100	0.1899	10.2200	0.1224	13.3700	0.0515	2.8000
(Std Dev.)			0.2972	7.9900				
Damage Rate	-0.5505	-5.5600	-0.6386	-2.7900	-0.3476	-2.2100	-0.9479	-4.0700
(Std Dev.)			4.5614	5.6400				
Frequency	0.5461	7.6300	0.7688	5.6800	0.5194	4.9000	0.5660	3.4600
(Std Dev.)			2.6004	6.6800				
Latent Class Probability					0.7236	9.6600	0.2764	3.6900
Log-Likelihood	-823.6400		-715.8165		-781.9853			
Pseudo R^2			0.3794		0.3220			
Number of Parameters	8		13		15			
AIC/N	1.9991		1.7520		1.9158			
BIC/N	2.0446		1.8258		2.0010			
CAIC/N	1.9091		1.5993		1.5965			
Respondents	104		104		104			
Observations	832		832		832			

Table 6-3: Comparison between MNL, ML Model and LCM under a Disruption Event

With a Disruption Models	MNL		ML (N distribution)		LCM Class 1		LCM Class 2		LCM Class 3	
Variable	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**
Freight Rate	-0.0024	-9.3100	-0.0072	-4.3960	-0.0030	-4.6400	-0.0027	-4.6800	-0.0130	-7.6600
(Std Dev.)			0.0084	6.9150						
Transit Time	-0.3640	-15.1800	-1.0852	-7.9750	-1.0583	-9.9000	-0.3017	-4.5400	-0.3458	-6.3600
(Std Dev.)			0.8200	7.7890						
Reliability	0.0937	17.0900	0.1842	10.3580	0.1601	10.5400	0.1329	8.6100	0.0514	3.9200
(Std Dev.)			0.1274	5.4500						
Damage Rate	-0.4538	-3.3100	-1.4902	-4.4220	-0.2909	-0.7900	-2.0342	-4.9700	-0.3055	-0.9100
(Std Dev.)			1.8165	4.9340						
Latent Class Probability					0.5551	9.4100	0.2379	4.3600	0.2071	5.0800
Log-likelihood	-780.4290		-568.5915		-594.9780					
Pseudo R^2			0.5070		0.4842					
Number of Parameters	7		11		17					
AIC/N	1.8929		1.3932		1.4711					
BIC/N	1.9326		1.4557		1.5676					
CAIC/N	1.8153		1.2656		0.9649					
Respondents	104		104		104					
Observations	832		832		832					

6.3 Latent Class Models Examine Hypotheses (H_1-H_2)

To identify shippers' relative preference for containerised maritime transport service attributes and the heterogeneity of preferences between respondents, the MNL model and LCM are utilized to analyse the data. In addition, LCMs can identify not only the importance of the service attributes to the different classes, but also the determinants of class membership (Naik-Panvelkar et al. 2012). The data collected in the third section of the interviews are first utilized to estimate the importance of service attributes under normal operating conditions. The data collected in the fourth section of the interviews are used to estimate the parameters assuming transport delays caused by a disruption event.

6.3.1 Testing Hypothesis H_1

6.3.1.1 Determinant Attributes Affecting Shippers' Maritime Transportation Decisions

Table 6-4 sets out the MNL and LCM results under normal operations. First, the MNL model with a log-likelihood of –823.64 has all five service attributes statistically significant with expected signs at the 95 percent confidence level. Thus, it is safe to reject the null hypothesis for H_1. In other words, the determinant factors affecting shippers' transport decision are freight rate, transit time, reliability, damage rate, and frequency in containerised maritime transportation service under normal operating conditions. The mean coefficients of the attributes statistically significant with negative signs indicate that an increase in freight rate, transit time, and damage rate attributes generates a decrease in the shippers' utility, all else being equal. The positive and significant mean coefficients of the attributes indicate that shippers prefer a maritime transportation service with a higher percentage of on-time reliability and more sailing frequency. It can be also noted that the mean coefficient of freight rate attribute has the lowest value. This implies that the marginal impact of a unit change in freight rate (on the propensity to change from the current solution to a hypothetical one) is much smaller compared with other service attributes, having all else constant. By contrast, damage rate and frequency attributes have a much higher value for their mean coefficients, which means the marginal impact of damage rate and frequency attributes for shippers' utility are much higher than other attributes ceteris paribus. As such, the MNL model results reveal that shippers have a stronger preference for better maritime service in terms of damage rates and service frequency than other key maritime service attributes. The relative importance of significant maritime service attributes in the MNL model is illustrated in Figure 6-1.

Second, the LCM results reveal that shippers' preferences for a containerised maritime transport service are heterogeneous, since the LCM had a better log-likelihood value (–788.56) than the MNL model (–823.64). As such, respondents are allocated into two different classes based on their latent heterogeneities under normal operation.

It is necessary to verify that the model should have only two classes and not three or four before analysing the LCM results further. Through the 'Testing down' method, the number of 'C' classes in the LCM was estimated for varying number of classes. Four classes followed by three classes of LCMs were tested and failed to find a fit model. Consequently, the two classes LCM was examined and offered an excellent goodness of fit along with the general statistical significance of all its parameters. Therefore, the two classes LCM is selected under normal operation. Figure 6-2 presents the relative importance of the maritime service attributes for the two classes.

As shown in Table 6-4 and Figure 6-2, under normal operation, respondents are allocated into two different classes according to their latent heterogeneities. The probability of respondents being allocated to Class 1 and Class 2 is 73.26 and 27.64 percent, respectively. Respondents in both classes consider all service attributes are important factors influencing their maritime transport decisions as all coefficients of these five attributes are statistically significant with expected signs at the 95 percent confidence level. Damage rate followed by transit time and freight rate have negative and significant coefficients, which suggest that shippers largely prefer a maritime service with a much lower damage rate, shorter transit time, and cheaper freight rate. The positive and significant coefficients of the frequency and reliability attributes indicate that an improvement in the frequency or reliability attributes would increase the likelihood of choosing the service by shippers in both classes.

However, the relative importance of each service attribute is different to respondents in different classes based on their preference heterogeneities. According to the value of each parameter and the utility function (Equation 6.3), all else being equal, the LCM results indicate that respondents in Class 1 are more sensitive to service frequency, followed by damage rate, reliability, transit time, and freight rate. On the other hand, respondents in Class

2 greatly valued damage rate, followed by frequency, transit time, reliability, and freight rate. In addition, individuals in Class 1 are slightly more sensitive to the increase of freight rate and on-time reliability compared with shippers in Class 2. Whereas, respondents in Class 2 consider damage rate and transit time attributes to be extremely important when making their maritime transport decisions. Shippers in Class 1 account for approximately 72 percent of the samples.

$$U_{iq} = \partial_i + \beta_{fr} FR_{iq} + \beta_{tt} TT_{iq} + \beta_{rl} RL_{iq} + \beta_{dm} DM_{iq} + \beta_{fq} FQ_{iq} \quad (6.3)$$

Table 6-4: MNL and LCM Model Results under Normal Operations

Under Normal Operation Models	**MNL**		**LCM**			
			Class 1		**Class 2**	
Variable	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**
Freight Rate	-0.0037	-12.1600	-0.0060	-7.5400	-0.0014	-2.7100
(Std Dev.)						
Transit Time	-0.1400	-10.7800	-0.1035	-5.4600	-0.2276	-6.1200
(Std Dev.)						
Reliability	0.0955	16.4100	0.1224	13.3700	0.0515	2.8000
(Std Dev.)						
Damage Rate	-0.5505	-5.5600	-0.3476	-2.2100	-0.9479	-4.0700
(Std Dev.)						
Frequency	0.5461	7.6300	0.5194	4.9000	0.5660	3.4600
(Std Dev.)						
Latent Class Probability			0.7236	9.6600	0.2764	3.6900
Log-Likelihood	-823.6400		-781.9853			
Pseudo R^2			0.3220			
Number of Parameters	8		15			
AIC/N	1.9991		1.9158			
BIC/N	2.0446		2.0010			
CAIC/N	1.9091		1.5965			
Respondents	104		104			
Observations	832		832			

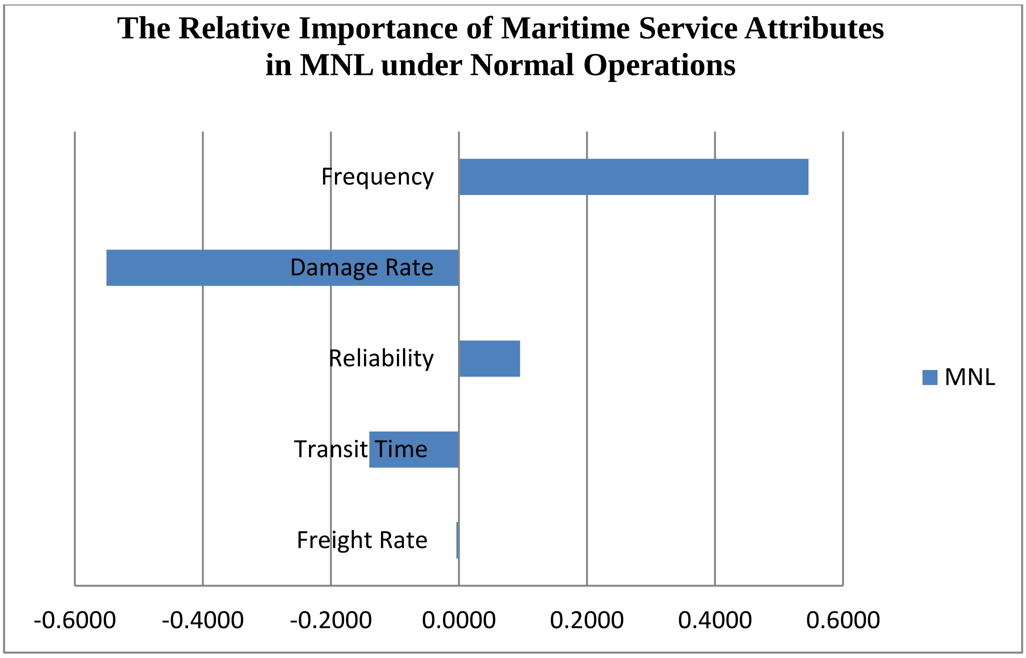


Figure 6-1: The Relative Importance of Maritime Service Attributes in MNL under Normal Operations

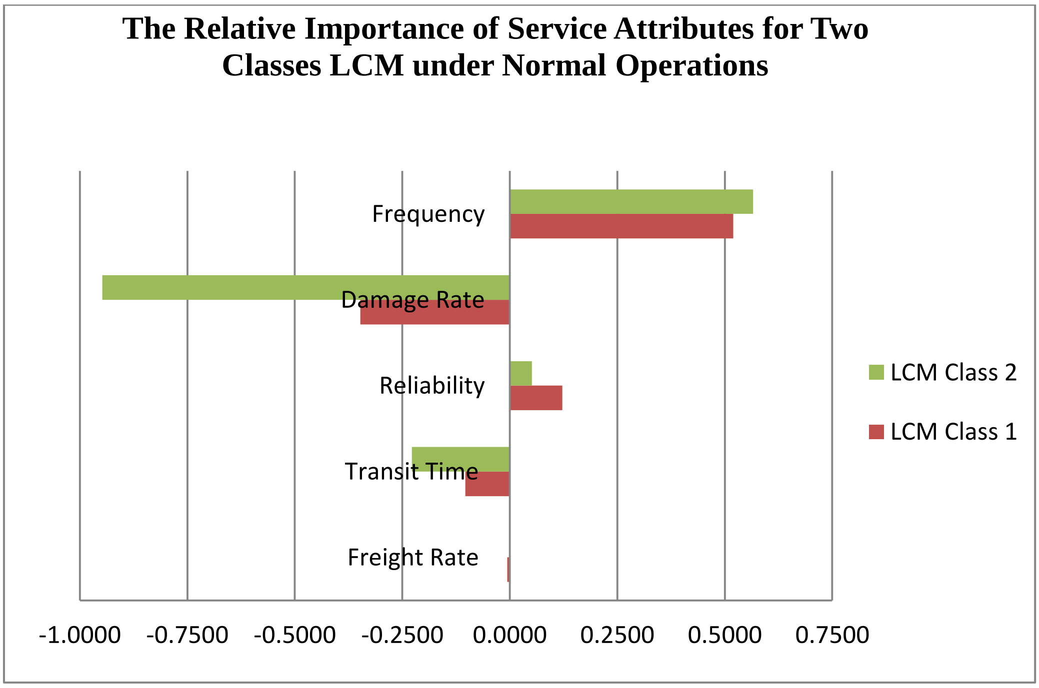


Figure 6-2: The Relative Importance of Maritime Service Attributes for Two Classes LCM under Normal Operations

6.3.1.2 The Value of Important Maritime Service Attributes

In addition to the investigation of the relative importance of different attributes, the values of the key maritime service attributes are also calculated to evaluate the impact of service attributes on maritime transportation choice and utilized for further quantifying the costs of a disruption in a later section. Freight rates collected in three cities were all converted to American dollars as stated in Chapter Five. Thus, the values of containerised maritime service attributes are all in USD ($) in this study.

According to the theoretical framework of estimating attribute's 'part-worth' value in Chapter Three (Equation 3.23), we calculate shippers' willingness to pay for maritime transportation service improvements using the coefficient estimates of the MNL and LCMs under normal operation. The WTP values in MNL and LCMs are presented in Table 6-5, and the value difference of the attributes between the MNL model and the two classes LCM is illustrated in Figure 6-3 (The ratio of a service attribute to the cost coefficient yields the monetary value of the attribute at the margin and gives an idea of how changes in an attribute are traded off against a monetary change in transport costs. In this study, these are value of time/delay (VOT), value of reliability (VOR), value of damage rate (VOD), and value of frequency (VOF)).

As shown in Table 6-5 the MNL model under normal operating conditions suggests, on average per TEU, a WTP for a one percent reduction in damage rate of USD $149.60 as being the largest WTP value; the second highest is the mean WTP for an additional sailing service per week valued at USD $148.40, followed by the mean WTP for a one day reduction in transit time valued at USD $38.04, and the mean WTP for a one percent increase in on-time reliability valued at USD $25.95. The values of WTP for the damage rate and frequency attributes are over USD $145 per TEU, but the values of WTP for transit time and reliability attributes in maritime transport service are less than USD $40 per TEU. These results imply that for the sample analysed, damage rate and frequency are the most precious service attributes required by the containerised maritime transport service. They are about fivefold the value of time and reliability under normal operating conditions.

The mean values of the maritime service attributes differ a great deal across the MNL model and the two classes LCM. Based on Table 6-5 and Figure 6-3, it can be easily distinguished that the mean values of the attributes are divided into low value segment (Class 1) and high value segment (Class 2) in the LCM, and the mean values of the attributes generated by the MNL model is in the medium level. In the Class 2 segment of the LCM, all mean values of service attributes are higher than those in Class 1 and the MNL model. Particularly, the damage rate attribute has the highest mean value of WTP at USD $687 for a one percent reduction in damages, followed by frequency, transit time and reliability attributes. This suggests that individual respondents in this segment, on average per TEU, are willing to pay USD $687 for a one percent reduction in damage rate, $410 for an additional delivery per week, $165 for a one day reduction in transit time, and $37 for a one percent increase in on-time reliability. The values of WTP for all maritime service attributes are lower for respondents allocated in Class 1 segment. Their WTPs for an additional service per week is valued at USD $87; for a one percent reduction in damage rate is valued at $58; for a one percent increase in on-time reliability is valued at $20, and for a one day reduction in transit time is valued at $17. The probability of sampled respondents falling into Class 1 segment is 72.36 percent, while, 27.64 percent of respondents would fall into the Class 2 segment.

The advantages of the LCM relative to the MNL models are: 1) LCM allows for identifying distinct groups of shippers' difference in preferences for containerised maritime transport service; 2) LCM produces distinct values of WTP for maritime service attributes for different segments; 3) in the LCM, the range of WTP values and the market share of each Class segment can provide useful information for all stakeholders in the maritime industry.

Table 6-5: The Value of Maritime Service Attributes under Normal Operations

$WTP_i = \frac{\beta_i}{\beta_{FR}}$	**USD $**	**LCM**	
	MNL	**Class 1**	**Class 2**
Transit Time (for a one day reduction in transit)	38.04	17.28	164.91
Reliability (for a one percent increase in on-time reliability)	25.95	20.44	37.32
Damage Rate (for a one percent reduction in damage rate)	149.60	58.03	686.89
Frequency (for an additional service per week)	148.40	86.70	410.14

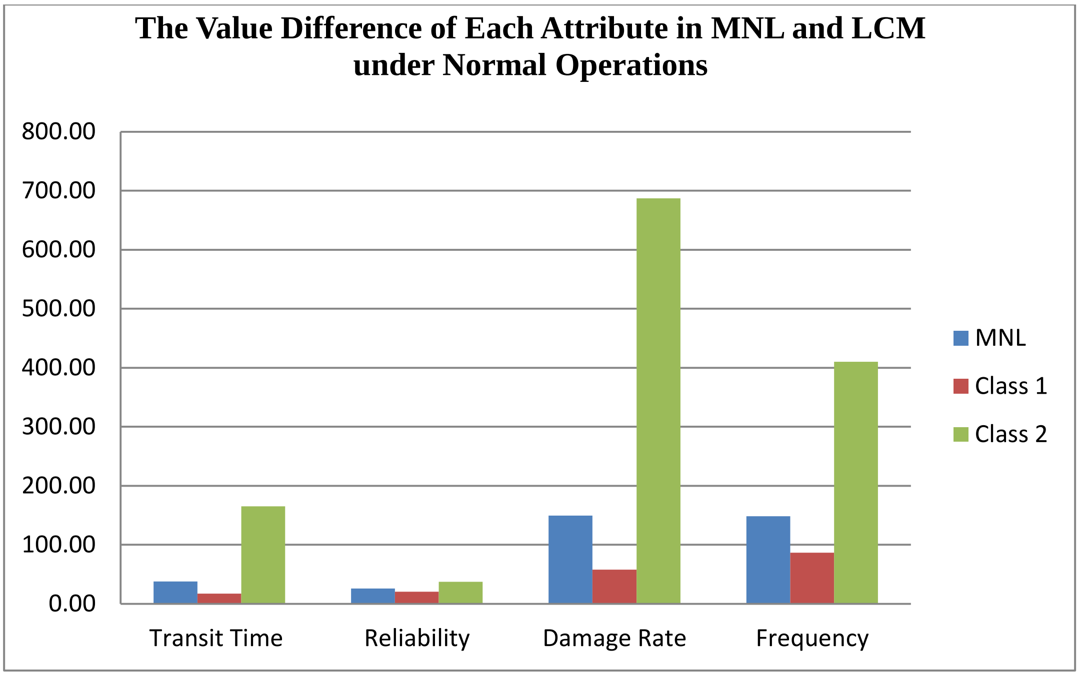


Figure 6-3: The Value Difference of Each Attribute in MNL and LCM under Normal Operations

The individual WTPs for the maritime service attributes in the LCM can be calculated in the LIMDEP (Nlogit 4.0) through writing the command for WTP. Table 6-6 presents the minimum, the maximum, the mean, and the standard deviation for 104 individual WTPs for the maritime service attributes in the LCM under normal operations.

Table 6-6: Individual WTP in LCM under Normal Operations

WTP (USD$)	Transit time	Reliability	Damage Rate	Frequency
MIN	17.29	20.44	58.08	86.75
MAX	164.71	37.27	686.04	409.63
MEAN	49.70	24.14	196.13	157.73
STD. DEV	55.48	6.33	236.32	121.51

6.3.2 Testing Hypothesis H_2

Choice options for the disruption scenario in the fourth part of the survey were described by four attributes. As a disruption event was assumed to occur suddenly while containers were in transit, the frequency attribute was removed, and freight rate, transit time, reliability and damage rate remained. However, freight rate is expressed as surcharge or rebate, and transit time is expressed as extra delay days in this section. Surcharge stands for the expediting cost and rebate is compensation for suffering longer delay. The MNL model and LCM are also utilized to examine hypothesis H_2 listed in Chapter Three. A comparison is also carried out to examine the difference between normal and disrupted operations.

6.3.2.1 A Disruption Affecting the Importance of Maritime Transport Attributes

The 'Testing down' method was still applied to estimate the number of 'C' classes in the LCMs under a disruption scenario. Table 6-7 lists the statistical measures for various classes LCM results moving from six classes to two. As discussed in section 3.6.3, it is difficult to determine whether decreases in the Log-likelihood, BIC or AIC formulas is due to an increase in the number of parameters estimated as a result of having more classes or whether the improvement is due to greater explanatory power of the model. To account for this, we apply the CAIC which has been shown to provide better evidence as to model fit as an additional supportive statistic measure to guide model selection. These statistical indicators assist to verify whether it is worth improving the Log-likelihood value and the goodness of model fit by adding additional classes to the model, which in turn would increase the number of parameters and the complexity of the model. As shown in Table 6-7, the four classes LCM produces the lowest CAIC value, suggesting that this model provides the statistical best fit for the data set under a disruption scenario. However, as the number of classes increased from three to four, the number of parameters increased from 17 to 27, and as a result increased the complexity of the model which led to instability in the parameter estimates. Furthermore, examining Table 6-8, the comparison between three classes and four classes suggest that the coefficient of the damage rate attribute has an unexpected positive sign for Class 1, whilst the coefficients for the freight rate/surcharge and damage rate attributes in Class 3, as well as the coefficient for the damage rate in Class 4 are statistically insignificant. As such, considering the behavioural sensibility and the interpretation of model results, we adopted the three classes LCM as the finalizing model under a disrupted condition for the research purpose of this thesis.

Table 6-7: Criteria for Determining the Optimal Number of Classes in LCM under a Disruption

LCMs	**2 classes**	**3 classes**	**4 classes**	**5 classes**	**6 classes**
Pseudo R^2	0.4499	0.4842	0.5145	0.5413	0.5405
LL	-634.5308	-594.9780	-559.9980	-529.0971	-529.9311
K	11	17	27	39	47
C	2	3	4	5	6
C-1	1	2	3	4	5
H = C - 1	1	2	3	4	5
N	832	832	832	832	832
CAIC	1100.7219	802.7749	295.1319	-440.0283	-1094.8846
CAIC/N	1.3230	0.9649	0.3547	-0.5289	-1.3160
AIC	1291.0615	1223.9559	1173.9959	1136.1941	1153.8622
AIC/N	1.5518	1.4711	1.4111	1.3656	1.3869
BIC	1343.0237	1304.2611	1301.5394	1320.4236	1375.8823
BIC/N	1.6142	1.5676	1.5644	1.5870	1.6537

Table 6-8: Comparison of Three and Four Classes LCMs under a Disruption Event

With a Disruption	**LCM**						**LCM**							
	Class 1		**Class 2**		**Class 3**		**Class 1**		**Class 2**		**Class 3**		**Class 4**	
Variable	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**
Freight Rate	-0.0030	-4.6400	-0.0027	-4.6800	-0.0130	-7.6600	-0.0047	-4.5500	-0.0024	-4.4800	-0.0006	-0.3200	-0.0130	-7.5400
(Std Dev.)														
Transit Time	-1.0583	-9.9000	-0.3017	-4.5400	-0.3458	-6.3600	-1.1981	-7.0400	-0.2911	-5.2800	-2.6314	-2.7000	-0.3414	-6.2000
(Std Dev.)														
Reliability	0.1601	10.5400	0.1329	8.6100	0.0514	3.9200	0.1047	4.9700	0.1348	9.0700	0.4667	3.6100	0.0526	3.9500
(Std Dev.)														
Damage Rate	-0.2909	-0.7900	-2.0342	-4.9700	-0.3055	-0.9100	1.1205	1.8400	-1.9063	-5.4600	-6.6439	-1.9300	-0.2832	-0.8000
(Std Dev.)														
Latent Class Probability	0.5551	9.4100	0.2379	4.3600	0.2071	5.0800	0.2530	5.2300	0.2577	5.4400	0.2829	5.5700	0.2063	5.0500
Log-likelihood	-594.9780						-559.9980							
Pseudo-R^2	0.4842						0.5145							
Number of Parameters	17						27							
AIC/N	1.4711						1.4111							
BIC/N	1.5676						1.5644							
CAIC/N	0.9649						0.3547							
Respondents	104						104							
Observations	832						832							

Table 6-9 reports the MNL and the three Classes LCM results under a disrupted operating condition. The MNL model with the log-likelihood of –780.43 has all four attributes statistically significant with expected signs at the 95 percent confidence level. It reveals that the salient factors influencing shippers' transport decisions under a disruption are surcharge/rebate, delays, reliability, and damage rate. The negative and significant coefficients of the attributes suggest that the probability of shippers choosing a hypothetical solution under a disruption event would decrease if surcharge, delays, and damage rate increase. However simultaneously, ceteris paribus, an improvement in reliability attribute produces a positive effect on shippers' logistics preference as the coefficient of the reliability attribute is statistically significant with a positive sign. In addition, the coefficient of damage rate attribute under a disruption has the highest value, followed by the transit time, reliability and freight cost/surcharge attributes. This means that when facing a disruption event, the marginal impact of a unit changes in damage rate and transit time on shippers' utility is much higher than that of reliability and freight cost attributes. As such, the MNL model results reveal that a transport related SCD can cause a shift in shippers' logistics preferences and WTPs for containerised maritime transport service attributes. The relative importance of salient maritime service attributes under a disruption event in the MNL model is illustrated in Figure 6-4.

Similarly, as the LCM produces a better log-likelihood value (-594.98) than the MNL model (-780.43), shippers' preferences for maritime transportation service are heterogeneous when facing a disruption. The relative importance of the maritime service attributes under a disruption for the three classes in LCM is shown in Figure 6-5.

Unlike the MNL model results, the coefficients of the damage rate attribute are statistically insignificant at 95 percent confidence level for respondents in Class 1 and Class 3 of the LCM. This indicates respondents allocated these two classes did not consider damage rate in the maritime service to be important when making their transport decision under a disrupted operating conditions. On the contrary, all attributes are statistically significant at 95 percent confidence for shippers in Class 2, particularly the damage rate attribute which is valued extremely high in this segment. The high negative and statistically significant coefficient for damage rate in Class 2 implies that shippers in this class want lower damage rates for maritime transportation services when facing a disruption event. Their likelihood of choosing a hypothetical solution to mitigate the impacts of a disruption event would decrease if the damage rate in the service increases. Thus, the determinant maritime service attributes influencing shippers' transport decisions for respondents in Class 2 are damage rate, followed by transit time, reliability, and freight rate/surcharge.

Respondents in Class 1 are more sensitive to a unit change of transit time and reliability attributes during a disruption, as the marginal contribution to shippers' preference utilities is statistically significant and higher for these attributes, keeping all else constant (see utility function as Equation 6.4 under a disruption). Remarkably, respondents in Class 1 weight greatly the importance of transit time/delay and reliability attributes compared with shippers in the other two classes when facing a transport related SCD. It implies ceteris paribus, shippers allocated in Class 1 are more likely to choose a hypothetical solution to mitigate the impacts of a disruption if the delay days and on-time reliability of delay mitigation could be improved. Meanwhile, respondents in Class 3 are more sensitive to the transit time attribute, followed by reliability and freight rate/surcharge attributes. In particular, respondents in Class 3 have a strong sensitivity to a unit change in freight rate/surcharge compared with shippers allocated to the other two classes, as it has the highest coefficient value of this attribute among all classes. Since the LCM allocates respondents into three segments based on their latent preference heterogeneities, the segmentation in the LCM indicates that the latent influence, to some extent, is related to an individual's WTP for the various maritime service attributes. The probability of sampled respondents falling into each segment is 55.51 percent, 23.79 percent, and 20.71 percent for Class 1, Class 2, and Class 3, respectively.

$$U_{iq} = \partial_i + \beta_{sr}SR_{iq} + \beta_{dl}DL_{iq} + \beta_{rl}RL_{iq} + \beta_{dm}DM_{iq} \quad (6.4)$$

Table 6-9: MNL and LCM Results under a Disruption Event

With a Disruption MODELS	**MNL**		**LCM**					
			Class 1		**Class 2**		**Class 3**	
Variable	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**	**Coefficient**	**t-Ratio**
Freight Rate	-0.0024	-9.3100	-0.0030	-4.6400	-0.0027	-4.6800	-0.0130	-7.6600
Transit Time	-0.3640	-15.1800	-1.0583	-9.9000	-0.3017	-4.5400	-0.3458	-6.3600
Reliability	0.0937	17.0900	0.1601	10.5400	0.1329	8.6100	0.0514	3.9200
Damage Rate	-0.4538	-3.3100	-0.2909	-0.7900	-2.0342	-4.9700	-0.3055	-0.9100
Latent Class Probability			0.5551	9.4100	0.2379	4.3600	0.2071	5.0800
Log-likelihood	-780.4290		-594.9780					
Pseudo R^2			0.4842					
Number of Parameters	7		17					
AIC/N	1.8929		1.4711					
BIC/N	1.9326		1.5676					
CAIC/N	1.8153		0.9649					
Respondents	104		104					
Observations	832		832					

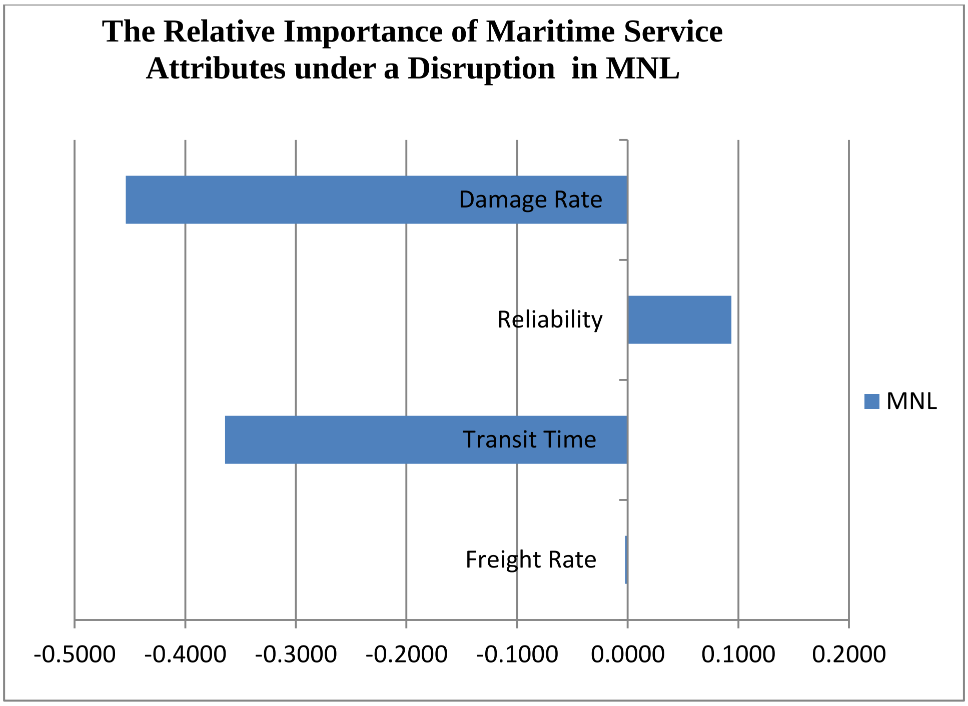


Figure 6-4: The Relative Importance of Service Attributes under a Disruption in MNL

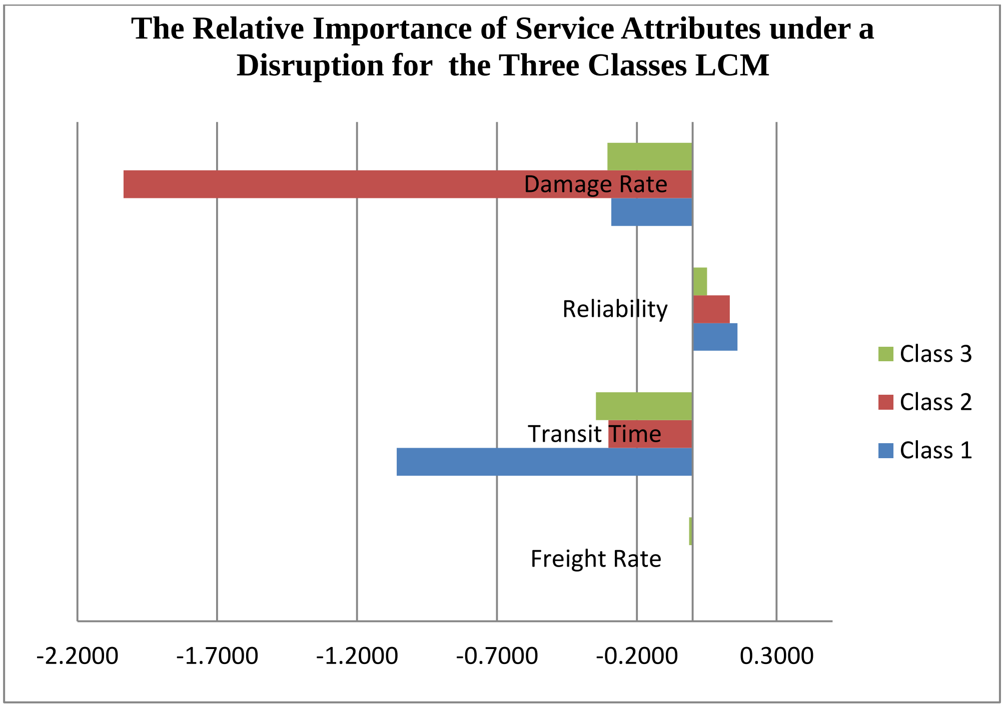


Figure 6-5: The Relative Importance of Service Attributes under a Disruption for the Three Classes LCM

6.3.2.2 The Values of the Important Maritime Service Attributes under a Disruption

The values of maritime service attributes calculating by the coefficient estimates of the MNL and LCMs under a disruption event are presented in Table 6-10. The value difference of each attribute between the MNL model and the three classes LCM is illustrated in Figure 6-6.

As indicated in Table 6-10, the MNL model for an improvement in maritime service during a disruption event suggests per average TEU, the value of WTP for a one percent reduction in damage rate is valued the most at USD $187.50. This is followed by the mean WTP for a one day mitigation in the length of delay valued at USD $150.40 and the mean WTP for a one percent increase in on-time reliability of delay mitigation/extension after a disruption event valued at USD $38.72. Regarding an improvement in maritime service under a disruption event, the values of WTP for damage rate and transit time/delay attributes are over USD $150, which is about fivefold the value of reliability attribute for an increase in the reliability of delay mitigation.

Respondents' valuation of maritime service attributes is also heterogeneous under a disruption event and divides into three value segments in the LCM. The damage rate attribute is statistically insignificant at the five percent level in Class 1 and Class 3. This implies that shippers in Class 1 and Class 3 did not consider the damage rate attribute to be a significant factor influencing their transport decisions when facing a SCD. However, shippers in Class 2 value the damage rate attribute at a price of USD $751 for a one percent reduction in damage, on average per TEU, followed by $111 for a one day mitigation in the length of delay, and $49 for a one percent increase in on-time reliability of delay mitigation/extension after a disruption event. Respondents in Class 3 had extremely low values for the reliability and transit time/delays attributes compared with shippers in the other two classes. Respondents in Class 1 considered the mitigation of the length of delay as the most important factor determining their expedited solutions for a disruption event. This means that individual respondents in this segment, are willing to pay $348 for a one day mitigation in delay, and $53 for a one percent increase in on-time reliability of delay mitigation on average per TEU. The identification of distinct groups of shippers' difference in preferences for containerised maritime transport service, distinct values of WTP for different segments, and the range of WTP values in each market segment can be beneficial to all stakeholders in the maritime industry.

Table 6-10: The Value of Service Attributes under a Disruption

$WTP_i = \frac{\beta_i}{\beta_{FR}}$ (USD $)	MNL	LCM		
		Class 1	Class 2	Class 3
Transit Time/Delay (for a one day mitigation in the length of delays)	150.40	348.14	111.34	26.58
Reliability (for a one percent increase in on-time reliability of delay mitigation)	38.72	52.65	49.04	3.95
Damage Rate (for in a one percent reduction in damage rate)	187.50		750.64	

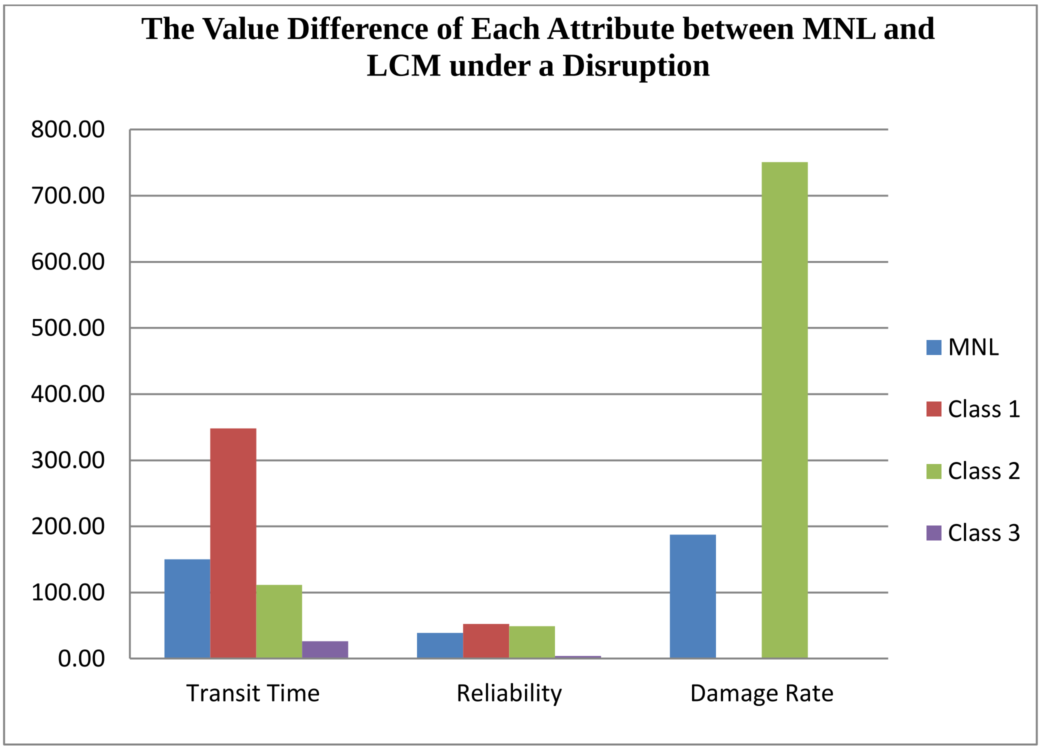


Figure 6-6: The Value Difference of Each Attribute between MNL and LCM under a Disruption

The individual WTPs for the maritime service attributes under disrupted operating conditions were calculated through LIMDEP (Nlogit 4.0). Table 6-11 presents the minimum, maximum, the mean, and the standard deviation for 104 individual WTPs for the maritime service attributes under a disruption scenario.

Table 6-11: Individual WTP in LCM under a Disruption

WTP (USD$)	Transit time/Delay	Reliability	Damage Rate
MIN	26.58	3.95	23.48
MAX	347.83	52.60	750.66
MEAN	224.45	41.23	228.62
STD. DEV	134.71	19.32	258.09

6.3.2.3 The Attributes' Value Changes between Normal and Disrupted Operations

According to Louviere, Hensher and Swait (2000), it is not meaningful to compare absolute parameter estimates across models due to scale differences, but it is very informative to evaluate and contrast the WTP indicators which are scale free. To further quantify a transport related disruption costs, the values of WTP for maritime service attributes between normal and disrupted operating conditions are therefore compared.

First, contrasts between WTP indicators under normal and disrupted operations based on the MNL models are carried out as shown in Table 6-12 and Figure 6-7. These results indicate that the WTPs for all maritime service attributes change significantly between normal and abnormal operating conditions. The value of WTP for transit time attribute would increase 3.95 times on average if a disruption took place. This implies that managers are willing to pay 3.95 times more monetary value to reduce a one day delay in transit when facing a transport related SCD. This may in part be due to the fact that transit time under normal operation is predictable, and it is usually planned in the safety stock calculation; contrary to this, delay caused by a disruption event is unexpected and unprepared for, as a result, it is hard to predict the exact delay days. As such, respondents greatly value the transit time/delay attribute if a disruption takes place. This was demonstrated by the managers in the interviews when they stated that air freight becomes an attractive solution in the case of disruptions. The value of WTP for a one percent increase in on-time reliability also increased 1.49 times compared to that value under normal operations. Disruptions are sudden events and as such, the reliability attribute becomes increasingly important. Higher reliability during a disruption event implies shippers could have more reliable information and plan for their contingency plan. The value of WTP for a one percent reduction in the damage rate attribute slightly increased 1.25 times. Delay caused by a disruption also can result in an increase in cargo damages and loss. In consideration of stock-outs and inventory control, shippers would prefer to pay more to avoid cargo damages or losses under a disruption, as shippers are unable to afford a damaged shipment. Frequency of service is not a relevant factor when preparing a response to a specific disruption.

Table 6-12: The Value Changes of Maritime Attributes between Normal and Disrupted Operating Conditions in MNL

	(1)	**(2)**	**(3)=(2/1)**
MNL	**Normal**	**Disruption**	**Ratio**
Transit Time	38.04	150.40	3.95
Reliability	25.95	38.72	1.49
Damage Rate	149.60	187.50	1.25
Frequency	148.40		

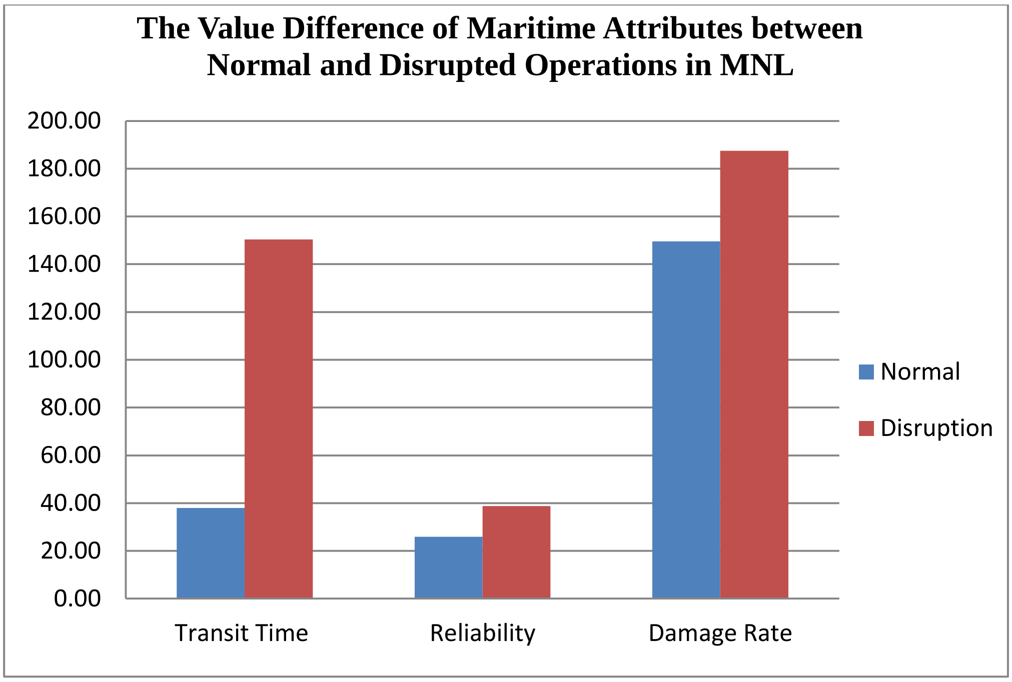


Figure 6-7: The Value Difference of Maritime Attributes between Normal and Disrupted Operating Conditions in MNL

Second, the WTP measures derived from the LCMs differ a great deal when comparing their values between normal and disrupted operating conditions. Respondents' latent preference heterogeneity produced two segments (low and high) under normal operations and three segments (low, medium, and high) under a disruption event. We compare the minimum, maximum, mean and standard deviation of the individual WTP indicators in LCMs instead of the values of WTP in different market segments between normal and abnormal operations. Comparing the values of WTP in LCMs between normal and abnormal operations (see Table 6-13 and Figure 6-8), the lowest value of WTP is USD $17.29 for a one day reduction in transit time under normal operation, correspondingly, the lowest WTP for a one day mitigation in delays under a disruption event is $26.58. The lowest WTP for transit time between normal and disrupted circumstances increased 1.54 times. Further, the highest WTP for transit time increased 2.11 times from USD $164.71 to $347.83 between normal and disrupted operations. The average WTP value for transit time increased 4.52 times from USD $49.70 under normal operation to $224.45 facing a disruption. The standard deviation also increased 2.43 times for the value of transit time between normal and disrupted operations. This large variation in the value of transit time for container shipping implies shippers' WTP to shorten transit time varied and increased between normal and disrupted operations. That can explain why a portion of respondents considered air-freight an attractive alternative in case of disruptions, at least, it is worth expediting part of the shipment to avoid or mitigate stock-out and other disruption costs. Similarly, the WTP for a one percent increase in on-time reliability during a disruption, on average per TEU, increased 1.71 times from USD $24.14 to $41.23 with the standard deviation increasing 3.05 times from $6.33 to $19.32. However, for respondents less willing to pay to increase on-time reliability, the WTP for the reliability attribute decreased when a disruption takes place. That implies some respondents still greatly valued reliability, while some considered the importance of reliability to be insignificant if a disruption happens. Finally, the WTP for the damage rate attribute, on average increased 1.17 times from USD $196.13 to $228.62 with the standard deviation increasing 1.09 times from $236.32 to $258.09 per TEU. Remarkably, for respondents with the lowest WTP for the damage rate attribute, their WTPs for damage rate decreased. That is, they considered damage rate an unimportant factor influencing their transport decision under a disruption event. All this suggests that managers consider shortening the length of delay the most important determinant affecting their transport decisions under a disruption event. They would focus on expediting the shipment rather than increasing on-time reliability and reducing shipment damages when facing a disruption.

Therefore, the hypothesis 2 cannot be rejected. A sudden occurrence of transport related SCD could significantly change the values of WTP for maritime service attributes: transit time, reliability, and damage rate.

Figure 6-9 to Figure 6-12 indicate the spreads of each individual's WTP for maritime service attributes in LCMs between normal and abnormal operating conditions. These individual WTP figures indicated that there is preference heterogeneity between different shippers.

Table 6-13: The Value Changes of Attributes between Normal and Disrupted Operations in LCMs

LCM individual	WTP	Normal Operation	Disruption	Ratio
Transit Time	Min	17.29	26.58	**1.54**
	Max	164.71	347.83	**2.11**
	Mean	49.70	224.45	**4.52**
	Std Dev.	55.48	134.71	**2.43**
Reliability	Min	20.44	3.95	**0.19**
	Max	37.27	52.60	**1.41**
	Mean	24.14	41.23	**1.71**
	Std Dev.	6.33	19.32	**3.05**
Damage Rate	Min	58.08	23.48	**0.40**
	Max	686.04	750.66	**1.09**
	Mean	196.13	228.62	**1.17**
	Std Dev.	236.32	258.09	**1.09**
Frequency	Min	86.75		
	Max	409.63		
	Mean	157.73		
	Std Dev.	121.51		

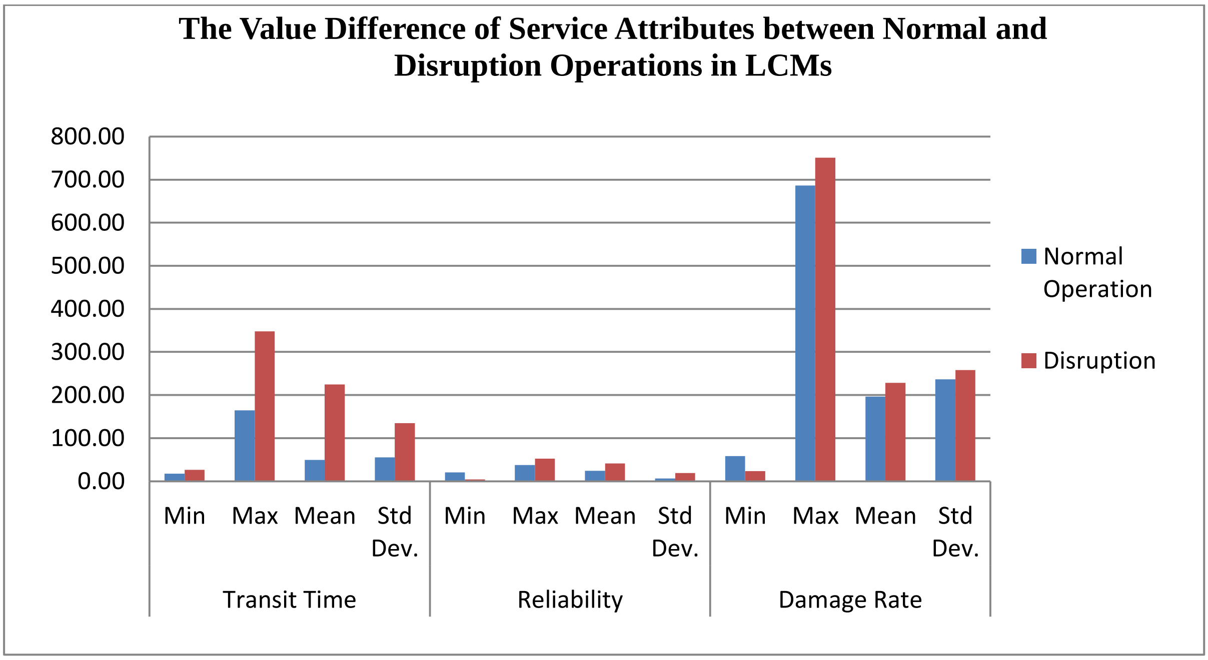


Figure 6-8: The Value Difference of Maritime Service Attributes between Normal and Disrupted Operations in LCMs

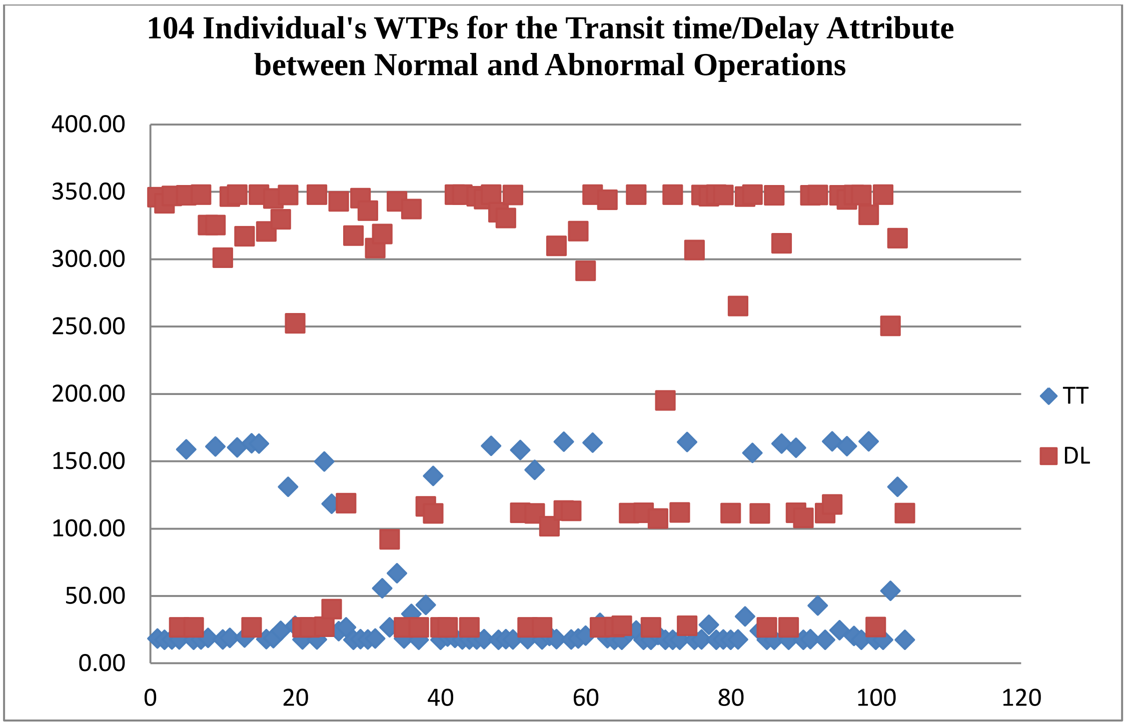


Figure 6-9: Individual WTPs between Normal and Abnormal Operations: Transit time/Delay

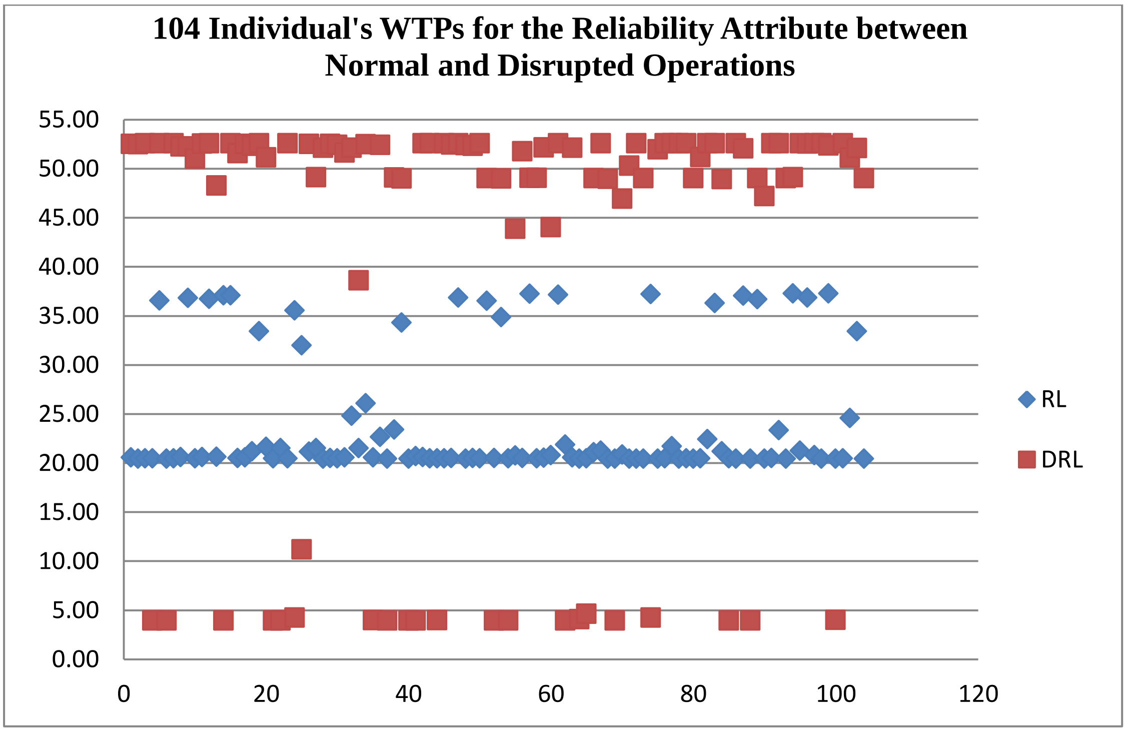


Figure 6-10: Individual WTPs between Normal and Abnormal Operations: Reliability

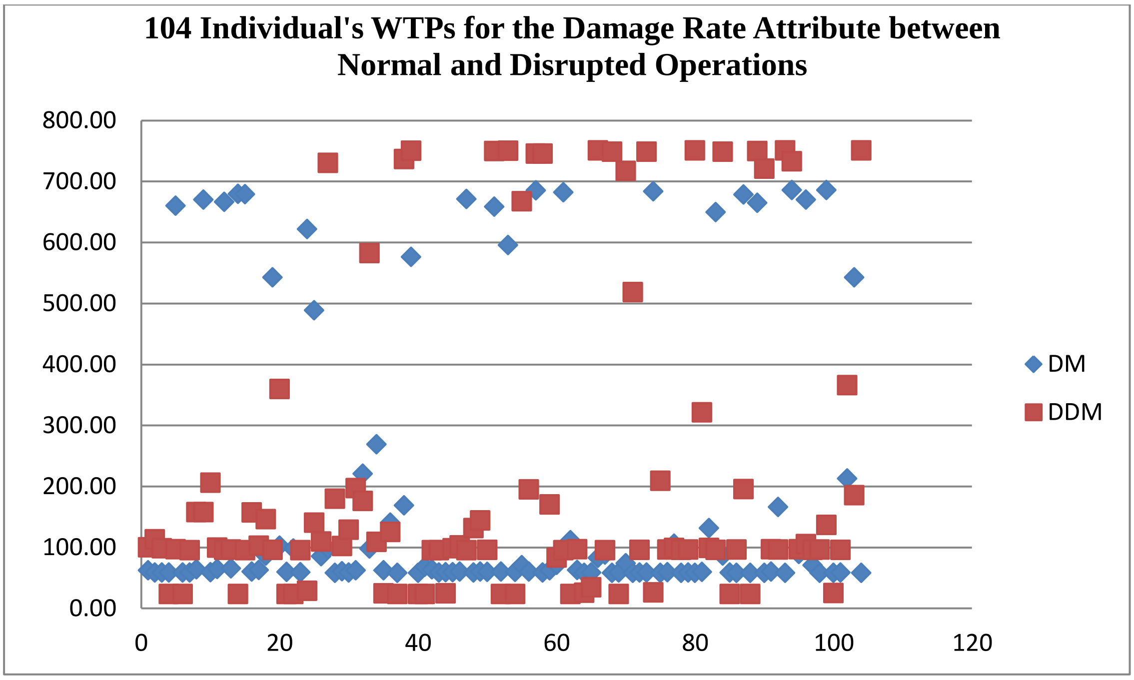


Figure 6-11: Individual WTPs between Normal and Abnormal Operations: Damage Rate

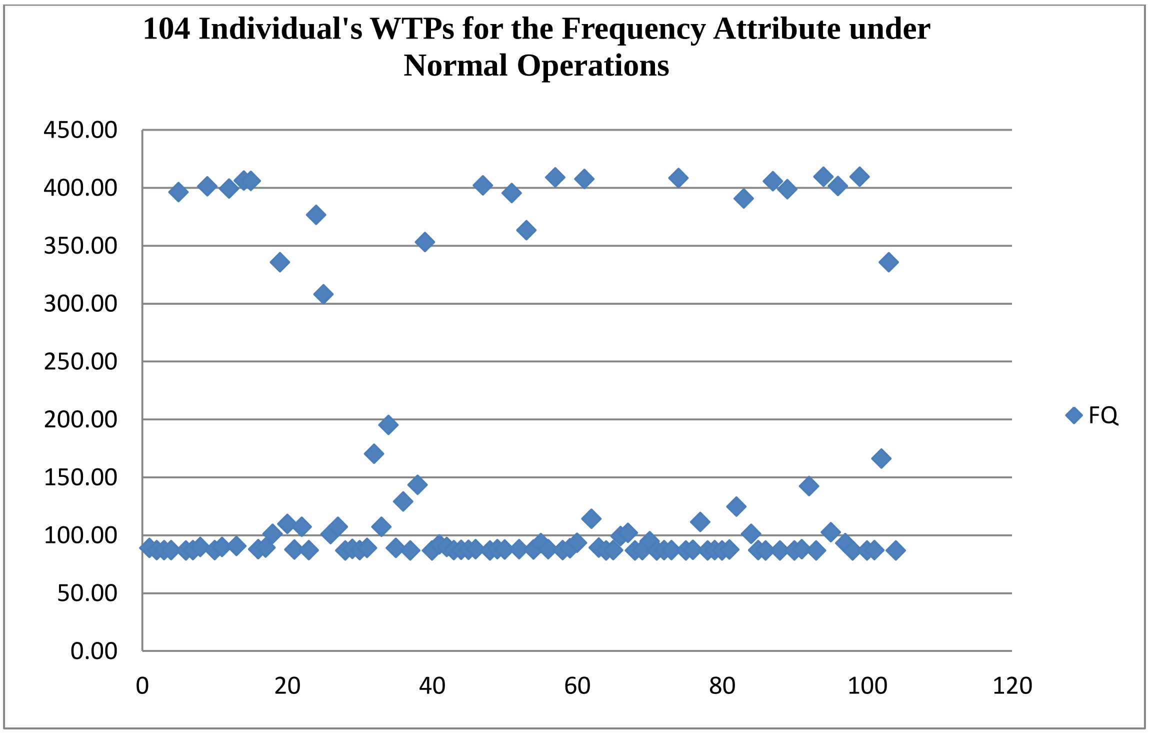


Figure 6-12: Individual WTPs for Frequency under Normal Operations

6.3.3 Remarks H_1 and H_2 Testing

Damage rate, frequency, reliability, transit time, and freight rate are found to take precedence over other selection criteria, and each attribute has a different contribution to shippers' WTP in maritime transport decisions under normal operations. Thus, hypothesis 1 cannot be rejected.

Damage rate, delays, reliability, and surcharges are also found to take precedence over other potential affected factors and contribute different values to shippers' choice behaviour in containerised maritime transportation decisions under a disruption event. Further, the WTP for each important service attribute changed significantly between normal and abnormal operating conditions. This value differentiation indicates that shippers evaluate maritime service attributes differently when facing a disruption event. Thus, the determinants for containerised maritime transportation vary between normal and disrupted conditions. These results help to understand and quantify the maritime transport related disruption costs. The analysis results indicate that the values of WTP for each maritime attribute would be increased when a disruption takes place, particularly, the economic costs of delay and expediting can be severely underestimated using a normal average WTP value. Therefore, hypothesis 2 cannot be rejected.

In summary, the LCMs have revealed two segments (low and high mean WTP) under normal operation, and three segments of apparent low (Class 3), medium (Class 1) and high (Class 2) mean WTPs under a disruption event. This segmentation is very informative. It indicates that the latent influences, to some extent, are related to an individual's WTP for a maritime service attribute no matter whether under normal or disrupted operating conditions. That is shippers' preference heterogeneity exists between respondents. Thus, based on the mean WTPs generated by the final LCMs, a series of SURE models are utilised to estimate and determine potential sources of influence on the WTP of each maritime transport attribute with and without a disruption.

6.4 Seemingly Unrelated Regression Models (SURE) Examine Hypotheses 3-8

As H_1 and H_2 cannot be rejected, further regression tests are applied to examine which individual respondent's characteristics would influence shippers' WTP on each maritime transport service attribute under different operating circumstances.

Before further analysis of the SURE models, it is important to verify the reasons for applying SURE models instead of LCMs with interaction terms in this study. The LCM estimates the preference/parameters variation, while the SURE model could estimate the systematic sources of variations in the WTPs rather than the parameters variations. Thus, the SURE models have the advantage of estimating the variations in the WTPs directly. This overcomes the necessity of mapping the parameters systematic variations one by one in the LCMs. They can also provide similar quantitative information but avoid the huge workload of running ANOVAs to test each WTP generated in the LCM in each segment to examine the systematic sources of variations in shippers' WTPs for maritime service attributes.

To identify the potential sources of influence on the mean WTPs reported in Table 6-13, a series of SURE models are estimated using the 104 individual's WTPs generated by the LCMs in the last section. Since the WTP values for all maritime attributes under normal and disrupted operations are derived from the same set of respondents, it is highly likely that the error terms will be correlated. However, SURE models allow for simultaneous estimation of regression models where the error terms might be correlated, as discussed in Chapter Three.

To examine hypotheses 3 to 8 listed in Chapter 3, several independent variables were included in each SURE model: geographic location; production characteristics; company characteristics; company/SC management strategies variables; and shipment specific trip information variables. Some variables have been subdivided to differentiate the utility functions for different shippers according to individual respondent's particular characteristics: geographic locations; cargo values; production industry type; organization sales sizes; shipment travel times; and recent shipment delay days.

Three groups are distinguished with respect to the company geographical locations: Shenzhen (49), Shanghai (25), and Sydney (30). With respect to the organization annual sales sizes, three further groups were subdivided: those firms with organization sales of less than USD $10,000,000 annually (39), those with sales between USD $10,000,000 and $100,000,000

(34), and those with sales above USD $100,000,000 (31). With respect to the cargo value per TEU, the data are divided into three additional groups: those shipments with cargo value per TEU less than USD $30,000 (48), those with goods value between USD $30,000 and $70,000 (29), and those with goods value above USD $70,000 per TEU (27). With respect to the shipment transit time, three groups are distinguished: those shipments with transit time less than 22 days (43), transit time between 22 days and 32 days (37), and transit time above 32 days (24). With respect to the current shipment experienced delay days, two groups are formed: those shipments experienced delay days less than 4 days (90), and those shipments experienced delay equal to or larger than 4 days (14).

Classification based on the type of goods was made: electronics products (37), constructions (19), garments (12), chemicals (10), mechanicals (15), food (7), and consumable products (9). The data are also divided into two groups according to whether the firm is an exporter (53) or importer (51); whether the firm assesses the reputation of carrier/forwarder during selection (92) or does not assess carriers' reputation (12); whether the firm applies JIT management strategy (46) or does not apply JIT (58); whether the firm has contingency plans to handle disruptions (69) or has no contingency plan for disruptions (35); whether the firm considers a terrorist attack would affect its transport decisions (47) or does not (57); whether the current shipment involves a transhipment (23) or without a transhipment (81); whether a shipment is paid by FOB (67) or CIF (37); and whether a shipment is consolidation (10) or not (94). Independent variables included in the SURE models are instrumented as Table 6-16.

Since the independent variables in this study are qualitative variables, it is hard to maintain the assumption that quantitative variables would provide, where linearity in the marginal utility occurs as one moves from one level of the attribute to another. However, it is common practice to dummy code qualitative variables in researches to allow for possible non-linearities occurring in the marginal utilities between levels. Thus, dummy coding is utilized for each independent variable in this research. In dummy coding, $L - 1$ new variables are created, where L is the number of levels of the variable being recoded. The newly created variables will be associated with $L - 1$ levels of the original variable. When the original level appears in the data, the associated dummy variable takes the value 1; otherwise, it is zero. As such, the last level, referred to as the base level, will be equal to zero for all dummy coded variables. Taking geographic location variables as an example, the dummy codings are shown in Table 6-14 where Shanghai is treated as the base level.

Table 6-14: Dummy Coding for Geographical Locations Variables: Different Cities

City	Linear code	Dummy 1 Shenzhen	Dummy 2 Sydney	Base Level Shanghai
Shanghai	0	0	0	0
Shenzhen	1	1	0	0
Sydney	2	0	1	0

In the case of linear coding, the utility function will be equal to

$$U_{iq} = \alpha_i + \beta_{City}City + \sum_k \beta_k x_k \quad (6.5)$$

where α_i is an alternative specific constant equal to zero for one alternative; β_{City} is the marginal utility associated with city *i;* and β_k is associated with attribute *k*. Ceteris paribus, a one unit change in city (e.g., going from Shanghai to Shenzhen) will result in a β_{City} change in utility.

The marginal utility for dummy coding differs from Equation (6.5) becoming

$$U_{iq} = \alpha_i + \beta_{Shenzhen}Shenzhen_{iq} + \beta_{Sydney}Sydney_{iq} + \sum_k \beta_k x_k \quad (6.6)$$

Now, assuming all else being equal, the marginal utility for Shenzhen will be equal to $\alpha_i + \beta_{Shenzhen}$ whilst the marginal utility of Sydney will be $\alpha_i + \beta_{Sydney}$. The marginal utility of Shanghai will simply be α_i. That is, the base level is confounded with the alternative specific constant. As such, the remaining dummy variables are interpreted relative to the alternative specific constant, ceteris paribus. Similarly, different goods value per TEU has a similar utility function, as well as for all other independent variables:

$$U_{iq} = \alpha_i + \beta_{lowvalue}Lowvalue_{iq} + \beta_{mediumvalue}Mediumvalue_{iq} + \sum_k \beta_k x_k \quad (6.7)$$

Dependent variables in this analysis are the important maritime transport service attributes identified in the last section: transit time (TT), reliability (RL), damage rate (DM), and frequency (FQ) under normal operation; and delay (DL), reliability (DRL), and damage rate (DDM) under a disruption event.

The SURE models look for systematic sources of variations in the WTPs of maritime service attributes. They provide estimations of the influence of product characteristics, shipment characteristics, and company/SC characteristics on shippers' preferences of maritime transportation service. The regression equations for the final SURE models under normal and abnormal operating conditions are the following (see Appendix A: The Independent Variables Operationalisation and Abbreviation):

(1) Under normal operating condition, the SURE model regression equations are:

$$TT_{iq} = \alpha_i + \beta_{EP}EP_{iq} + \beta_{AR}AR_{iq} + \beta_{TER}TER_{iq} + \beta_{L1}L1_{iq} + \beta_{TD1}TD1_{iq} + \beta_{I2}I2_{iq} + \beta_{I3}I3_{iq}$$

$$RL_{iq} = \alpha_i + \beta_{EP}EP_{iq} + \beta_{AR}AR_{iq} + \beta_{TER}TER_{iq} + \beta_{L1}L1_{iq} + \beta_{TD1}TD1_{iq} + \beta_{I2}I2_{iq} + \beta_{I3}I3_{iq}$$

$$DM_{iq} = \alpha_i + \beta_{EP}EP_{iq} + \beta_{AR}AR_{iq} + \beta_{TER}TER_{iq} + \beta_{L1}L1_{iq} + \beta_{TD1}TD1_{iq} + \beta_{I2}I2_{iq} + \beta_{I3}I3_{iq}$$

$$FQ_{iq} = \alpha_i + \beta_{EP}EP_{iq} + \beta_{AR}AR_{iq} + \beta_{TER}TER_{iq} + \beta_{L1}L1_{iq} + \beta_{TD1}TD1_{iq} + \beta_{I2}I2_{iq} + \beta_{I3}I3_{iq}$$

Under normal operation, the right hand sides of the equations are the same. That means factors influencing shippers' maritime transport preference are the same without a disruption.

(2) Under a disrupted operating condition, the SURE model regression equations are:

$$DL_{iq} = \alpha_i + \beta_{EP}EP_{iq} + \beta_{JIT}JIT_{iq} + \beta_{L1}L1_{iq} + \beta_{L3}L3_{iq} + \beta_{OS1}OS1_{iq} + \beta_{OS2}OS2_{iq} + \beta_{I1}I1_{iq} + \beta_{I2}I2_{iq} + \beta_{I3}I3_{iq} + \beta_{I5}I5_{iq} + \beta_{I6}I6_{iq} + \beta_{I7}I7_{iq}$$

$$DRL_{iq} = \alpha_i + \beta_{EP}EP_{iq} + \beta_{FOB}FOB_{iq} + \beta_{CP}CP_{iq} + \beta_{OS1}OS1_{iq} + \beta_{OS2}OS2_{iq} + \beta_{GV1}GV1_{iq} + \beta_{GV2}GV2_{iq} + \beta_{I1}I1_{iq} + \beta_{I3}I3_{iq} + \beta_{I5}I5_{iq} + \beta_{I6}I6_{iq}$$

$$DDM_{iq} = \alpha_i + \beta_{JIT}JIT_{iq} + \beta_{FOB}FOB_{iq} + \beta_{CP}CP_{iq} + \beta_{L1}L1_{iq} + \beta_{L3}L3_{iq} + \beta_{OS1}OS1_{iq} + \beta_{GV1}GV1_{iq} + \beta_{GV2}GV2_{iq} + \beta_{I1}I1_{iq} + \beta_{I2}I2_{iq} + \beta_{I7}I7_{iq}$$

When a disruption takes place, the right hand sides of the equations are different. This means factors influencing shippers' preference for maritime service attributes are diverse when facing a disruption.

Table 6-15 summarises the SURE model results under both normal and disrupted operating conditions. The results indicate that SURE models for both normal and disrupted operations are statistically significant.

Table 6-15: The SURE Model Results

SURE Equations		**Obs.**	**Parm.**	R^2	**Adjusted** R^2
Normal Operation	**Transit time**	104	8	0.2331[1]	0.1772
	Reliability	104	8	0.2331	0.1772
	Damage	104	8	0.2331	0.1772
	Frequency	104	8	0.2331	0.1772
Disruption	**Delay**	104	13	0.2769	0.1815
	Reliability	104	12	0.1679	0.0684
	Damage	104	12	0.3772	0.3028

Table 6-16 summarizes all variables that are statistically significant in the SURE models under normal and disrupted operations.

[1] The R^2 results for each attributes are the same as the WTPs under normal operations for transit-time, reliability, damage and frequency attributes derived from a LCM model are perfectly correlated due to the way that they are calculated. That is, they are probability weightings (using the class assignment probabilities) of the class specific parameter estimates, and as the class assignment probabilities must sum to one, the resulting estimates will be correlated, as to the WTP values.

Table 6-16: The SURE Models Results under Normal and Disrupted Operations

Hypotheses	Independent Variables	Transit Time				Reliability				Damage				Frequency	
		Normal Operation		Disruption		Normal Operation		Disruption		Normal Operation		Disruption		Normal Operation	
		Parm.	t-ratio	Parm.	t-ratio	Parm.	t-ratio	Parm.	t-ratio	Parm.	t-ratio	Parm.	t-ratio	Parm.	t-ratio
	Constant	86.9688	5.97	93.5659	2.84	-28.3887	-17.07	-35.7836	-8.03	354.6250	5.71	514.7810	7.47	-239.2190	-7.49
H3: Geographic locations	Shenzhen	-38.8906	-3.07[2]	64.0741	3.37	4.4375	3.07			-165.6880	-3.07	-198.6810	-3.37	85.1719	3.07
	Sydney			34.4861	1.95							-106.9360	-1.95		
H4: Production Characteristics	Low Value Goods							8.1614	3.41			-179.2000	-3.41		
	Medium Value Goods							10.1349	4.07			-222.5280	-4.07		
	Electronics			115.9940	3.89			-8.6783	-2.03			-169.1250	-3.43		
	Constructions	-33.6875	-2.61	63.4683	3.59	3.8433	2.61			-143.4690	-2.61	-196.8000	-3.59	73.7656	2.61
	Garments	-43.6719	-2.79	99.6613	2.45	4.9868	2.80	-14.0745	-2.45	-186.0470	-2.79			95.6563	2.79
	Chemicals														
	Mechanicals			79.6314	2.25			-11.2455	-2.25						
	Foods			127.0830	2.58			-17.9468	-2.58						
	Consumables			57.4878	2.47							-178.2570	-2.47		
H5: Company Characteristics	Exporter	34.2422	3.16	-74.6916	-2.97	-3.9058	-3.16	10.5483	2.97	145.8440	3.16			-74.9688	-3.16
	Small Firms			56.3051	1.93			-12.4452	-2.90			98.6582	2.05		
	Medium Firms			94.8854	3.29			-13.4003	-3.29						
H6: Management strategies	NOT Assess Reputation	-27.2031	-1.73			3.1055	1.73			-116.0000	-1.73			59.6406	1.73
	With Contingency Plans							-5.1038	-2.50			112.0640	2.50		
	NOT applied JIT			-22.7749	-1.76							70.6206	1.76		
H7: Trip specific Characteristics	Shipment paid by CIF							7.1858	3.57			-157.7770	-3.57		
	Short Transit Time	-18.8164	-1.90			2.1470	1.90			-80.1406	-1.90			41.1953	1.90

[2] The t-ratio results under normal operations are the same as the WTPs for derived from a LCM model are perfectly correlated due to the way that they are calculated. That is, they are probability weightings (using the class assignment probabilities) of the class specific parameter estimates, and as the class assignment probabilities must sum to one, the resulting estimates will be correlated, as to the WTP values.

	Medium Transit Time								
H8: Maritime Security Issues	**No Preparedness for Potential Terrorisms and Risks during its transport decisions**	-25.9609	-2.23	2.9629	2.23	-110.6250	-2.24	56.8125	2.23
R^2		0.2331	0.2769	0.2331	0.1679	0.2331	0.3772	0.2331	
Adjusted R^2		0.1772	0.1815	0.1772	0.0684	0.1772	0.3028	0.1772	

Examining Table 6-16 that the factors influencing shippers' maritime service preferences are exactly the same for the transit time, reliability, damage rate, and frequency attributes under normal operations. The factors that are statistically significant and influence shippers' preferences under normal operations are geographic location (Shenzhen); industry types (constructions and garments); exporters; assessing carriers' reputation; shipment transit time; and preparedness for terrorist attacks. When a disruption takes place, factors influencing shippers' logistics preferences are changed. Comparing the transit time (Delay) attribute between normal and disrupted operations, exporters, geographic location (Shenzhen), and industry types (constructions and garments) factors remain statistically significant and still impact shippers' preferences for reducing transit time/delay under a disruption event. Factors that assessing carriers' reputation, shipment transit time, and preparedness for terrorist attacks become statistically insignificant for the transit time attribute during a disruption event. Meanwhile, more factors become statistically significant influencing shippers' preferences for reducing transit time/delay under a disruption event. These include JIT, geographic location (Sydney), organisation sales sizes, and industry types (electronics, machinery, foods, and consumables).

Similarly, factors influencing shippers' preferences for the reliability and damage rate attributes vary between normal and disrupted operations. Except for the variables of exporter and industry types (garments), factors statistically significant influencing shippers' preferences for the reliability attribute are different under a disruption. These include shipment payment terms as CIF or FOB, whether firms with contingency plans, organisation sales sizes (small and medium), goods value per TEU (small and medium), and industry types (electronics, machinery, and foods). For the damage rate attribute, JIT, shipment payment terms as CIF/FOB, whether firms with contingency plans, geographic location (Sydney), organisation sales sizes (small), goods value per TEU (small and medium), and industry types (electronics and consumables) become statistically significant influencing shippers' preferences; while factors of assessing carriers' reputation, shipment transit time, and preparedness for terrorist attacks become statistically insignificant for the damage rate attribute under a disruption.

More detail of the analysis of the hypotheses testing results for H_3 to H_8 is presented in the following sections.

6.4.1 Examining Hypothesis 3

An examination of the SURE model results (see Table 6-17, a pull-out section of Table 6-16) reveals that a respondent's company geographical location appears to have a significant influence on shipper's WTP for each maritime transport service attribute under all operating conditions.

Table 6-17: The SURE Results Testing the Influences of Geographic Locations under Normal and Disrupted Operations

H3	Transit Time		Reliability		Damage		Frequency	
	Normal Operation		Normal Operation		Normal Operation		Normal Operation	
	parameter	t-ratio	parameter	t-ratio	parameter	t-ratio	parameter	t-ratio
Constant	86.97	5.97	-28.39	-17.07	354.63	5.71	-239.22	-7.49
Shenzhen	-38.89	-3.07	4.44	3.07	-165.69	-3.07	85.17	3.07
Sydney								

H3	Transit Time		Reliability		Damage	
	Disruption		Disruption		Disruption	
	parameter	t-ratio	parameter	t-ratio	parameter	t-ratio
Constant	93.57	2.84	-35.78	-8.03	514.78	7.47
Shenzhen	64.07	3.37			-198.68	-3.37
Sydney	34.49	1.95			-106.94	-1.95

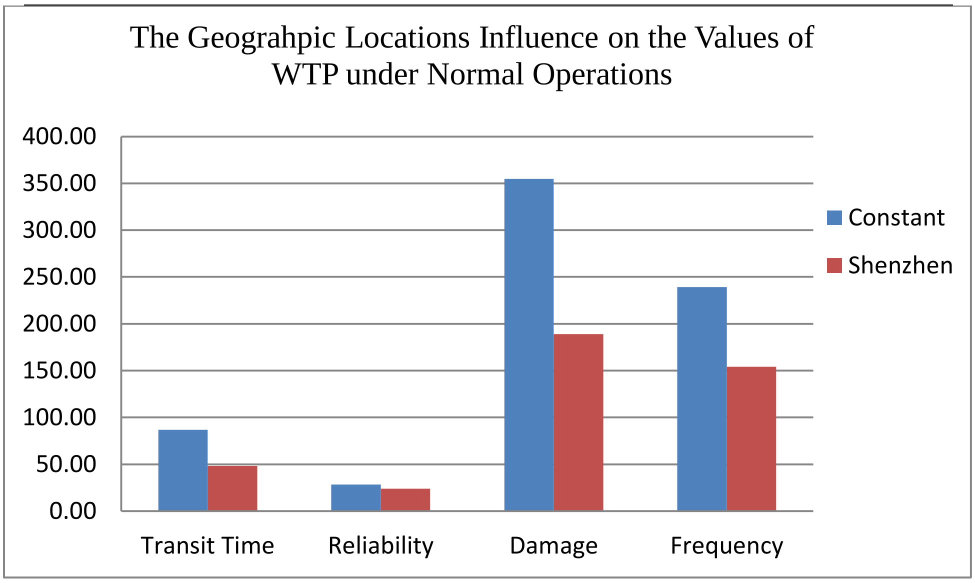
As discussed for dummy coding in the last section, the marginal utility function of the geographic locations dummy coding is presented as:

$$U_{iq} = \alpha_i + \beta_{Shenzhen} Shenzhen_{iq} + \beta_{Sydney} Sydney_{iq} + \sum_k \beta_k x_k \quad (6.6)$$

Under normal operation, the results presented in Table 6-17 illustrate that all else being equal, the impact of geographic location (Shenzhen) on the WTPs for each maritime service attribute is statistically significant while all parameters for geographic location dummy variables (Sydney) are statistically insignificant. This indicates, ceteris paribus, the marginal utility of Sydney will collapse to the base level of α_i. Thus, shippers located in Shanghai and Sydney will have the same level of WTPs for all maritime service attributes. As such, keeping everything else constant, shippers in Shanghai and Sydney are willing to pay USD $354.63 for a one percent reduction in damage rate, $239.22 for an increase of additional sailing per week, $86.97 for a one day reduction in transit time, and $28.39 for a one percent increase in on-time arrival reliability. Meanwhile, all dependent variables are statistically significant to the independent dummy variable: Shenzhen. That is, having all else equal, the marginal utility for shippers in Shenzhen will be equal to $\alpha_i + \beta_{Shenzhen}$. As all $\beta_{Shenzhen}$ for each attribute have opposite signs with the alternative specific constant α_i, it means shippers in Shenzhen have lower values of WTP to improve maritime service attributes than shippers in Shanghai and Sydney. As such, all else being equal, when shippers move from Shanghai or Sydney to Shenzhen, their WTPs for a one percent reduction in damage rate will decrease by USD $165.69, for an increase of additional sailing per week will decrease by $85.17, for a one day reduction in transit time will decrease by $38.89, and for a one percent increase in on-time arrival reliability will decrease by $4.44. Table 6-18 with figure presents the absolute values of WTP for each maritime service attribute for shippers in Shenzhen, and shippers in Shanghai and Sydney (equal constant) under normal operations.

Table 6-18 with figure: The Geographic Locations Influence on the Values of WTP under Normal Operations

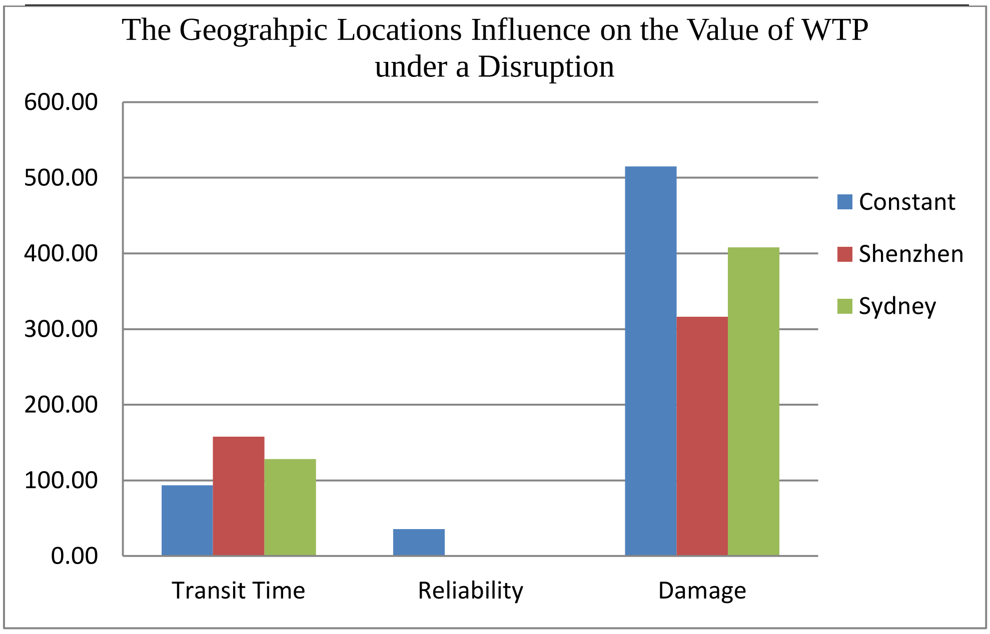
H3: Normal	Transit Time	Reliability	Damage	Frequency
Constant	86.97	28.39	354.63	239.22
Shenzhen	48.08	23.95	188.94	154.05



When a disruption takes place, shippers' WTPs to reduce the impacts of a transport related SCD for each maritime service attribute vary by different geographic locations. The results presented in Table 6-17 reveal that no matter Shenzhen or Sydney, all t-ratios for parameters of the reliability attribute are statistically insignificant. That is, the marginal utility of geographic locations (Shenzhen or Sydney) for the reliability attribute will collapse to the base level. As such, geographic locations do not have any impact on shippers' WTP for the reliability attribute during a disruption. Based on the Equation (6.6), the utility function of the reliability attribute under a disruption event for shippers in three cities will all equal to α_i, which is the alternative specific constant. Thus, shippers no matter in Shenzhen, Shanghai, or Sydney all have an equivalent WTP valued at USD $35.78 for a one percent improvement in on-time reliability of delay mitigation. However, the results presented in Table 6-17 indicate that the WTPs of shippers in three cities are statistically significantly different for the transit time and damage rate attributes under a disrupted operating condition. As the variation of shippers' WTPs for the transit time attribute has the same sign as the alternative specific constant α_i, it means, having all other sources constant, shippers in Shanghai have the lowest WTP for a one day reduction in delay valued at USD $93.57, followed by shippers in Sydney valued at \$128.05 (93.57+34.49), and shippers in Shenzhen valued at \$157.64 (93.57+64.07). On the contrary, the variation of shippers' WTPs for the damage rate attribute has an opposite sign to the alternative specific constant α_i. That is, the WTPs for a one percent reduction in damage rate under a disruption is highest for shippers in Shanghai followed by shippers in Sydney and Shenzhen. In other words, when a disruption takes place, all else being equal, shippers in Shanghai have the highest WTP for a one percent reduction in the damage rate attribute at the value of USD \$514.78, followed by shippers in Sydney at the value of \$407.85 (514.78-106.94), and shippers in Shenzhen at the value of \$316.10 (514.78-198.68). Table 6-19 with figure illustrates the absolute values of WTP of shippers in different cities for maritime service attributes under a disrupted operating condition.

Table 6-19 with figure: The Geographic Locations Influence the Value of WTP under a Disruption

H_3: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
Shenzhen	157.64		316.10
Sydney	128.05		407.85



With regard to Hypothesis 3, the above results demonstrate that companies in different geographic locations have different WTP values for the maritime transport service attributes under all operating conditions. Therefore, H_3 cannot be rejected based on the above SURE model results.

6.4.2 Examining Hypothesis 4

6.4.2.1 Examining the Impacts of Goods Value on Shippers' WTPs

Examining Table 6-16, under normal operations, all parameters are statistically insignificant for independent variables of low value goods and medium value goods. This indicates that the shipment cargo value per TEU has an insignificant impact on shippers' WTPs for each maritime service attribute under normal operations. Based on utility function equation (6.7), as $\beta_{lowvalue}$ and $\beta_{mediumvalue}$ are statistically insignificant, ceteris paribus, the marginal utility no matter for low, medium, or high value goods containers will all equal the alternative specific constant α_i. That is, all else being constant, under normal operations for containers shipping for any value of goods, shippers' WTP for a one percent reduction in damage rate is USD $354.63; for an increase of additional sailing per week is $239.22; for a one day reduction in transit time is $86.97; and for a one percent increase in on-time reliability is $28.39.

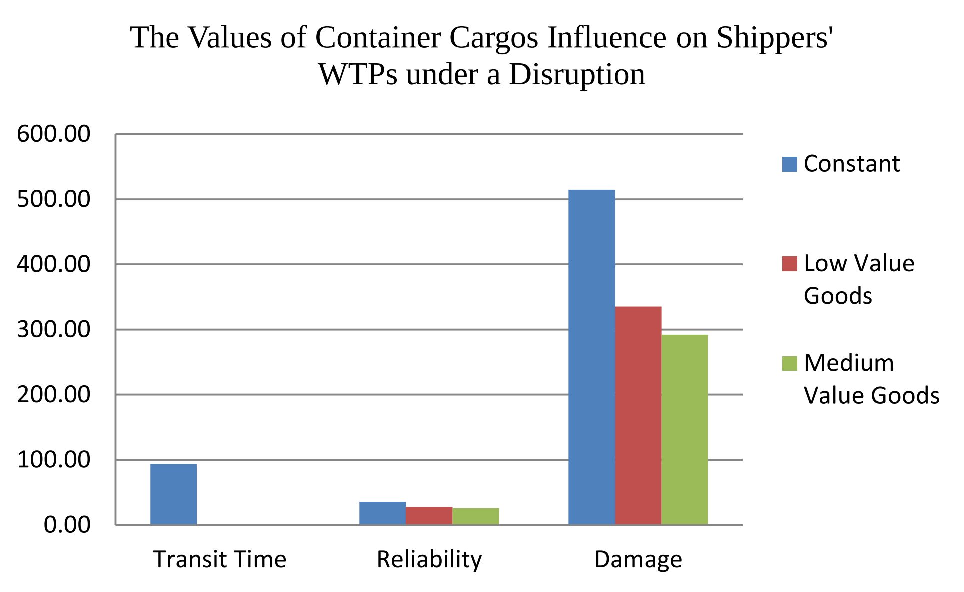
$$U_{iq} = \alpha_i + \beta_{lowvalue} Lowvalue_{iq} + \beta_{mediumvalue} Mediumvalue_{iq} + \sum_k \beta_k x_k \tag{6.7}$$

When a disruption takes place, the parameters for the transit time attribute are still statistically insignificant. That is, all else being equal, shippers shipping different cargo value containers have equivalent value of WTP for a one day reduction in delay, at the value of the alternative specific constant α_i, USD $93.57. Meanwhile, all parameters become statistically significant for the reliability and damage rate attributes for both low value and medium value independent variables. That is, shipping different cargo value containers would have significant impacts on shippers' WTPs for an improvement of reduced damage rate and increased reliability of delay mitigation. As the coefficients of the reliability and damage rate attributes all have opposite signs to the alternative specific constant α_i and the coefficients of medium value goods variable are slightly higher than that of the low value goods variable (USD $43.33 (|-222.53-179.20|) higher for the damage rate attribute and $1.97 (10.13-8.18) higher for the reliability attribute). As such, shippers shipping high value goods have the highest WTPs for reducing damage rate and increasing on-time reliability of delay mitigation, followed by shippers shipping low value and medium value goods. In other words, shippers transporting high value goods (the goods value larger than USD $70,000 per TEU) tend to pay the highest WTPs for an improvement in on-time reliability of delay mitigation (USD $35.78) and damage rate attribute ($514.78) compared with shippers shipping medium and low value goods (for containers' goods value less than USD $70,000 per TEU). Further, shippers shipping low value goods have a slightly higher WTP (USD $43.33 higher) for a one percent reduction in damage rate compared with shippers for medium value goods (the goods value between USD $30,000 and $70,000 per TEU). Finally, shippers shipping medium and low value goods have very close values of WTP for a one percent increase in on-time reliability of delay mitigation. Table 6-20 and attached figure presents the absolute WTP values for each maritime attribute for shippers transporting different value cargoes containers.

Thus, the containers' goods value per TEU has significant and distinct impacts on shippers' WTPs for maritime service attributes under a disrupted operating condition. Shippers shipping containers' cargoes value larger than USD $70,000 per TEU would most likely to pay for a reduced damage rate and an increased on-time reliability of delay mitigation. On the contrary, shippers of container cargoes with values less than $70,000 per TEU would have lower WTPs to improve the damage rate attribute and on-time reliability of delay mitigation.

Table 6-20 with figure: The Values of Container Cargoes Influence on the WTPs under a Disruption

H_4: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
Low Value Goods		27.62	335.58
Medium Value Goods		25.65	292.25



6.4.2.2 Examining the Impacts of Cargo Industry Type on Shippers' WTPs

Based on the utility function of industry type (Equation 6.8), the absolute WTP values for shippers in each industry could be quantified with and without a disruption.

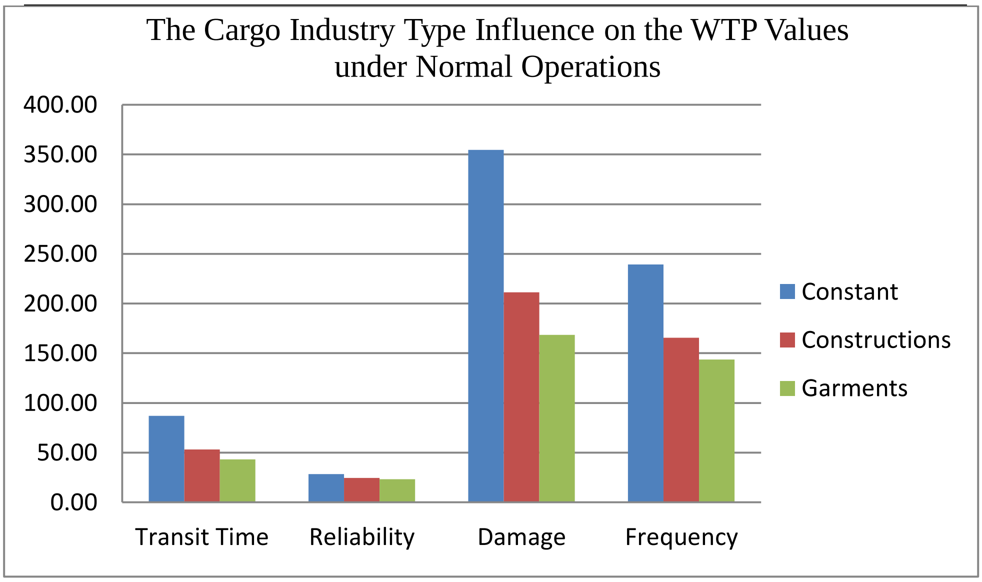
$$U_{iq} = \alpha_i + \beta_{Industry_{iq}} Industry_{iq} + \sum_k \beta_k x_k \quad (6.8)$$

Examining the impacts of cargo industry type on shippers' WTPs for maritime service under normal operation, the parameters for the productions of electronics, chemical, machinery, foods, and consumables are statistically insignificant, and the parameters for the productions of constructions and garments are statistically significant (see Table 6-16). According to Equation (6.8), $\beta_{Industry_{iq}}$ equals zero, as a result, shippers shipping electronics, chemical, machinery, foods, and consumable products all have equivalent WTPs to improve each maritime service attribute, at the value of the alternative specific constant α_i. Meanwhile, all

$\beta_{Industry_{iq}}$ are statistically significant for shippers shipping constructions and garments products, as such, the utility function of those shippers for each maritime service attribute can be presented as $U_{iq} = \alpha_i + \beta_{Industry_{iq}} Industry_{iq}$, ceteris paribus. Since the coefficients of constructions and garments industries have opposite signs with the alternative specific constant α_i and the coefficients of garments variable are higher than that of construction variable, all else being equal, shippers shipping containers of garments have the lowest WTPs to improve maritime service attributes followed by shippers shipping containers of constructions products. Table 6-21 and Figure presents the absolute WTP values for shippers shipping different industries' cargoes under normal operations.

Table 6-21 with figure: The Absolute WTP Values for Different Industry Products under Normal Operations

H4: Normal	Transit Time	Reliability	Damage	Frequency
Constant	86.97	28.39	354.63	239.22
Constructions	53.28	24.55	211.16	165.45
Garments	43.30	23.40	168.58	143.56

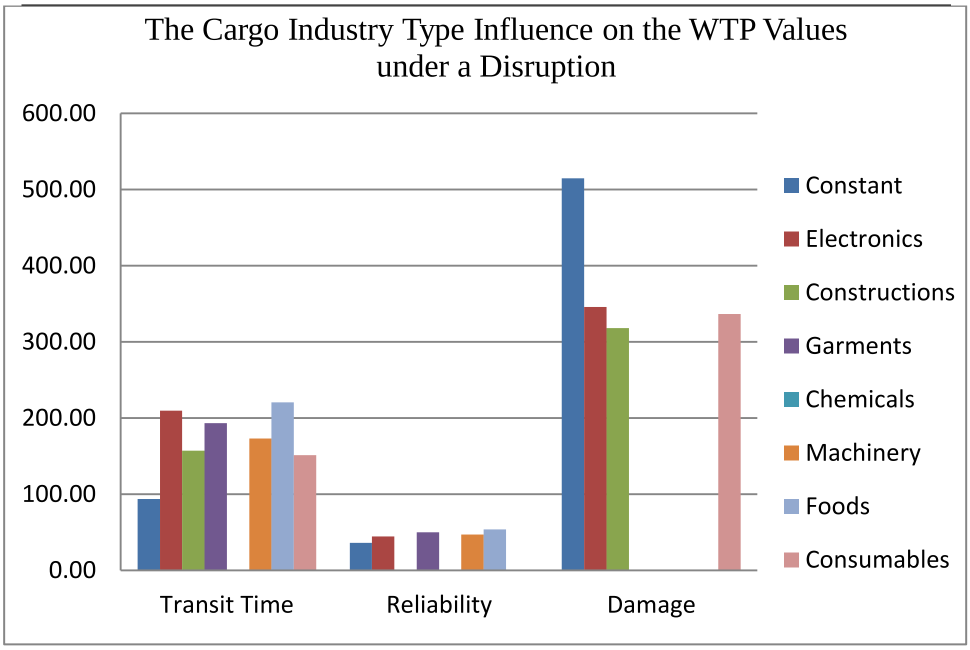


The results presented in Table 6-21 indicate that shippers shipping electronics, chemical, machinery, foods, and consumable products are willing to pay, on average per TEU, USD$354.63 for a one percent reduction in damage rate; $239.22 for an increase of additional sailing per week; $86.97 for a one day reduction in transit time; and $28.39 for a one percent increase in on-time arrival reliability under normal operations. Meanwhile, shippers shipping garment products have the lowest WTP for each maritime service attribute, their WTPs for damage rate and transit time are about 50 percent lower than that of shippers shipping other industrial type cargoes in the survey.

When a disruption takes place, different types of goods in shipping containers significantly affect shippers' WTPs for maritime attributes (See Table 6-16). With respect to the WTP values for a one day reduction in delay, the parameter is statistically significant with the highest positive value for shippers shipping containers of foods products. Based on the utility function (Equation 6.8), it indicates that all other factors being equal, shippers transporting containers of food products have the highest value of WTP for a one day reduction in delay at the value of USD $220.65 (93.57+127.08), followed by shippers delivering electronic goods, garments, machinery, constructions, consumables, chemicals and other products. Shippers shipping chemicals and other products have the lowest WTP for a one day reduction in delay, on average per TEU, USD$93.57 (see Table 6-22). With respect to the WTP for a one percent increase in on-time reliability of delay mitigation, shippers in the foods industry have the highest WTP at USD$53.73 (|-35.78-17.95|), followed by shippers in garments, machinery, and electronics industries; while shippers in construction, chemicals, consumable, and others industries have the lowest WTP value of $35.78 for the reliability attribute. Simultaneously, shippers delivering construction products have the lowest WTP value of USD $317.98 (514.78-196.80) for a one percent reduction in damage rate during a disruption, followed by shippers shipping consumable and electronic products. On the contrary, shippers shipping foods, machinery, chemicals, garments, and others industries products have the highest value of WTP for a one percent reduction in damage rate under a disruption, at USD$514.78. It is about 1.5 times higher compared with shippers in construction, consumable, and electronic industries. Table 6-22 and figure presents the absolute WTP values for shippers shipping different industries products.

Table 6-22 with figure: The Absolute WTP Values for Shippers Shipping Different Industries Products under a Disruption

H4: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
Electronics	209.56	44.46	345.66
Constructions	157.03		317.98
Garments	193.23	49.86	
Chemicals			
Machinery	173.20	47.03	
Foods	220.65	53.73	
Consumables	151.05		336.52



6.4.3 Examining Hypothesis 5

6.4.3.1 Examining Different Impacts on WTPs from Exporters and Importers

As shown in Table 6-16, all parameters are statistically significant for the exporter variable at 95 percent confidence level for all maritime service attributes under normal operations. This indicates the company's business role as an exporter or importer has a significant impact on the variation of shippers' WTPs for maritime service attributes. Table 6-23 with figure presents the absolute values of WTP for importers and exporters under normal operating conditions.

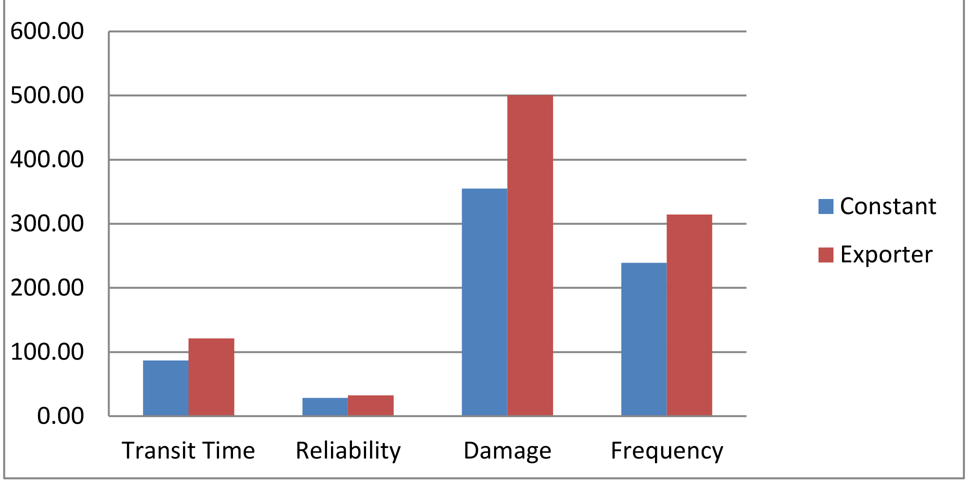
Under normal operations, based on utility function Equation (6.9), since all $\beta_{Exporter}$ are statistically significant with the same signs to the alternative specific α_i, exporters are willing to pay $\beta_{Exporter}$ monetary value higher to improve all maritime service attributes relative to importers, all other factors kept constant. As shown in Table 6-16, exporters are willing to pay USD$145.84 higher than importers to reduce a one percent damage rate; $74.97 higher to increase an additional sailing per week; $34.24 higher to reduce a one day in transit time, and $3.91 higher to increase a one percent on-time reliability. This may be because shipments' damage rate and the length of shipments' transit time could influence some exporters' accounts receivable or continuous trading/business relationship.

$$U_{iq} = \alpha_i + \beta_{Exporter} Exporter_{iq} + \sum_k \beta_k x_k \quad (6.9)$$

Table 6-23 with figure: The WTP Value for Exporters and Importers under Normal Operations

H5: Normal	Transit Time	Reliability	Damage	Frequency
Constant	86.97	28.39	354.63	239.22
Exporter	121.21	32.29	500.47	314.19

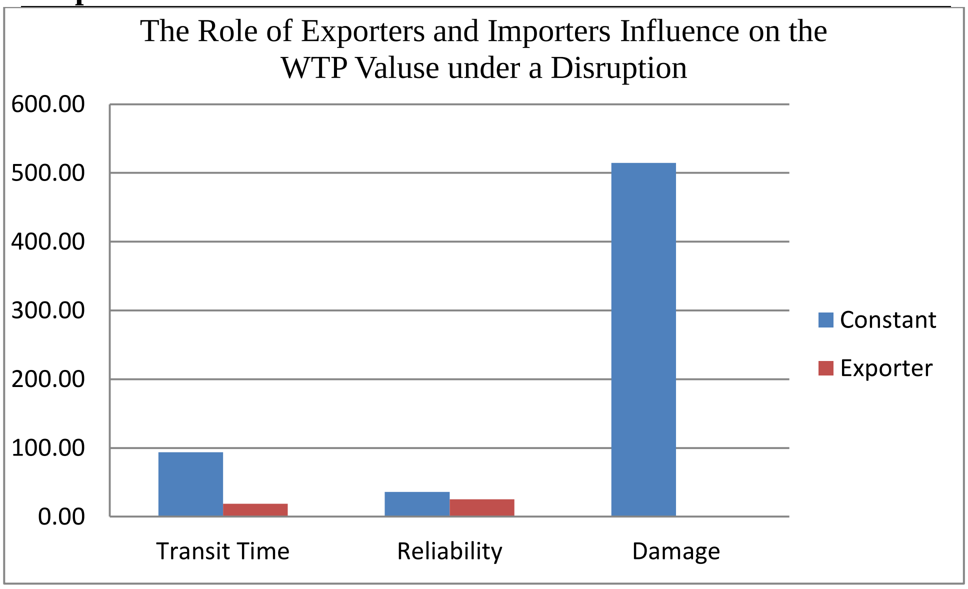
The Role of Exporters and Importers Influence on the WTP Value under Normal Operations



Under disrupted operating conditions, as the parameters $\beta_{Exporter}$ for the transit time and reliability attributes are statistically significant with opposite signs to the alternative specific constant α_i , and hence according to Equation (6.9), exporters are less likely to pay to reduce transit time and increase on-time reliability of delay mitigation. Ceteris paribus, importers are willing to pay USD$74.69 higher than exporters for a one day reduction in delays, and $10.55 higher for a one percent increase in on-time reliability of delay mitigation. Meanwhile, the parameter $\beta_{Exporter}$ for the damage rate attribute is statistically insignificant. This indicates, all else being equal, exporters and importers will have an equivalent WTP value for a one percent reduction in damage rate when facing a disruption event, at the value of USD $514.78. TableTable 6-24 with figure presents the absolute values of WTP for importers and exporters under a disruption.

Table 6-24 with figure: The WTP Value for Exporters and Importers under a Disruption

H5: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
Exporters	18.87	25.24	



6.4.3.2 Examining Impacts of Organization Sales Sizes

Organizations' annual sales sizes appear to have insignificant influence on shippers' WTPs for maritime service attributes under normal operations, as all dummy variables for organization sales sizes ($\beta_{Smallfirm}$ and $\beta_{Mediumfirm}$) are statistically insignificant (see Table 6-16). Thus, all shippers, no matter how large, will have equivalent WTPs for all maritime service attributes equivalent to the value of given by the alternative specific constant α_i , ceteris paribus.

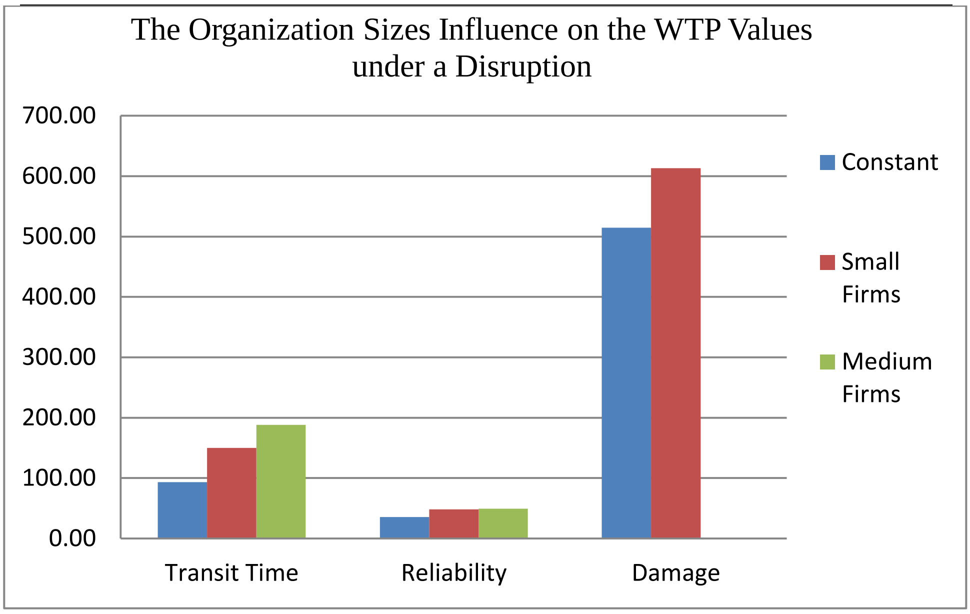
However, shippers of different firm sizes present diverse preferences for maritime service attributes under a disruption event. First, small size firms (organization annual sales sizes less than USD $10,000,000) have the strongest intensity of preference for a one percent reduction in damage rate. Their WTP value is USD $98.66 higher than that of shippers of medium and large sales sizes (organization annual sales sizes larger than USD $10,000,000), all else being equal. Second, medium sizes firms (organization annual sales range from USD $10,000,000 to $100,000,000) are willing to pay the highest for a one day reduction in delay. Their WTP value is USD $188.45 (93.57+94.88) and about double that of shippers of large firms, ceteris paribus; and this WTP value for shippers of small firms is $149.88 (93.57+56.31), and $93.57 for shippers of large firms. Finally, large firms appear to have the lowest WTP value for a one percent increase in on-time reliability of delay mitigation at the value of USD $35.78, while, small and medium size firms are willing to pay $12.45 and $13.40 higher, respectively. According to utility function (Equation 6.10), the WTP values for different firm sizes are presented as Table 6-25 with accompanying figure.

$$U_{iq} = \alpha_i + \beta_{Smallfirm} Smallfirm_{iq} + \beta_{Mediumfirm} Mediumfirm_{iq} + \sum_k \beta_k x_k \qquad (6.10)$$

Thus, hypothesis 5 cannot be rejected based on the above SURE model results.

Table 6-25 with figure: The Organization Sizes Influence on the WTP Values under a Disruption

H5: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
Small Firms	149.87	48.23	613.44
Medium Firms	188.45	49.18	



6.4.4 Examining Hypothesis 6

6.4.4.1 Examining the WTP Difference for Shippers Not Assessing Reputation during Carrier Selection

As shown in Table 6-16, all parameters are statistically significant for the variable of not assessing carrier reputation under normal operations, and become statistically insignificant under disrupted operating condition.

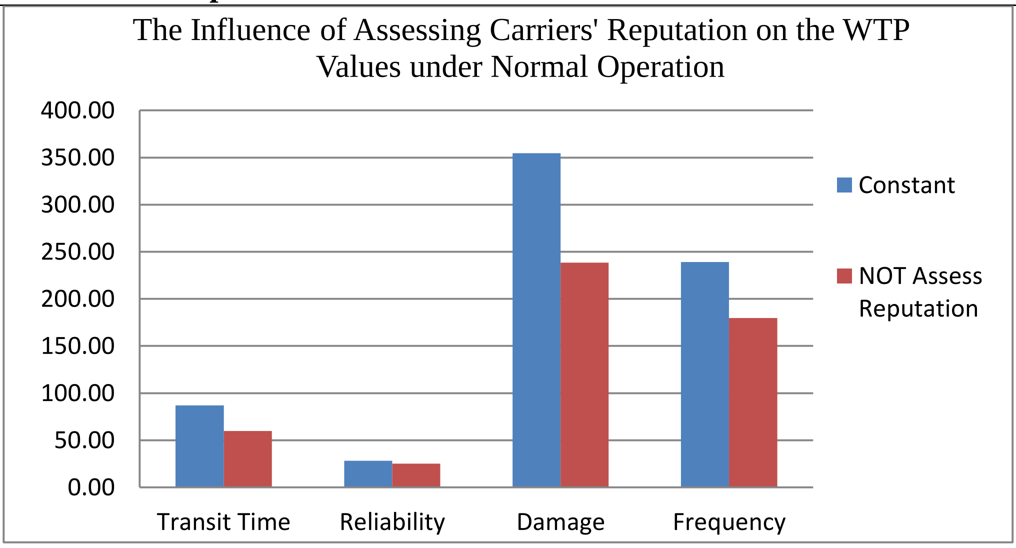
Based on the utility function (Equation 6.11), the SURE model results reveal that under normal operations, the parameter $\beta_{notassessreputation}$ are statistically significant and have opposite signs to the alternative specific constant α_i. Thus, all else being equal, shippers assessing carrier reputation during their transport decisions would have a WTP $\beta_{notassessreputation}$ monetary value higher for all maritime service attributes than shippers not assessing carrier reputation.

As such, ceteris paribus, under normal operating conditions, shippers assessing carrier reputation during their transport decisions are willing to pay USD $354.63 for a one percent reduction in damage rate, which is $116 higher than that of shippers not assessing carriers' reputation. Similarly, all else kept constant, shippers assessing carrier reputation are willing to pay USD $59.64 higher for an increase in additional sailings per week; $27.20 higher for a one day reduction in transit time; and $3.11 higher for a one percent increase in on-time reliability than that of shippers not assessing carriers' reputation. The WTP values for shippers assessing and not assessing carriers' reputation under normal operation are presented as Table 6-26 and figure.

$$U_{iq} = \alpha_i + \beta_{Notassessreputation} Notassessreputation_{iq} + \sum_k \beta_k x_k \qquad (6.11)$$

Table 6-26 with figure: The WTP Values for Shippers Assessing and Not Assessing Carriers/Forwarders Reputation

H6: Normal	Transit Time	Reliability	Damage	Frequency
Constant	86.97	28.39	354.63	239.22
NOT Assess Reputation	59.77	25.28	238.63	179.58



If there is a disruption, the SURE model results reveal that the parameters $\beta_{notassessreputation}$ are statistically insignificant. This means, ceteris paribus, all shippers no matter whether they assess carriers' reputation or not during their transport decisions would have the same values of WTP for all maritime service attributes at the value of the alternative specific constant α_i. That is, all shippers are willing to pay USD $514.78 for a one percent reduction in damage rate, $93.57 for a one day reduction in delay, and $35.78 for a one percent increase in on-time reliability of delay mitigation when facing a disruption event irrespective of whether they assess the reputation or not of potential carriers.

6.4.4.2 Examining the WTPs for Companies with Contingency Plans

The marginal utility function for shippers with and without contingency plans in their company management strategies can be presented as Equation (6.12). The SURE model results in Table 6-16 illustrate that the parameters of the contingency plan variable ($\beta_{withcontingencyplan}$) are statistically insignificant for all maritime service attributes under normal operations. Therefore, under normal operations, $\beta_{withcontingencyplan}$ equal zero, as a result, the marginal utility for firms both with and without contingency plans will all simply equal the alternative specific constant α_i. That is, holding all other factors constant, all shippers will all have equivalent WTP values for all maritime service attributes at the value of constant α_i.

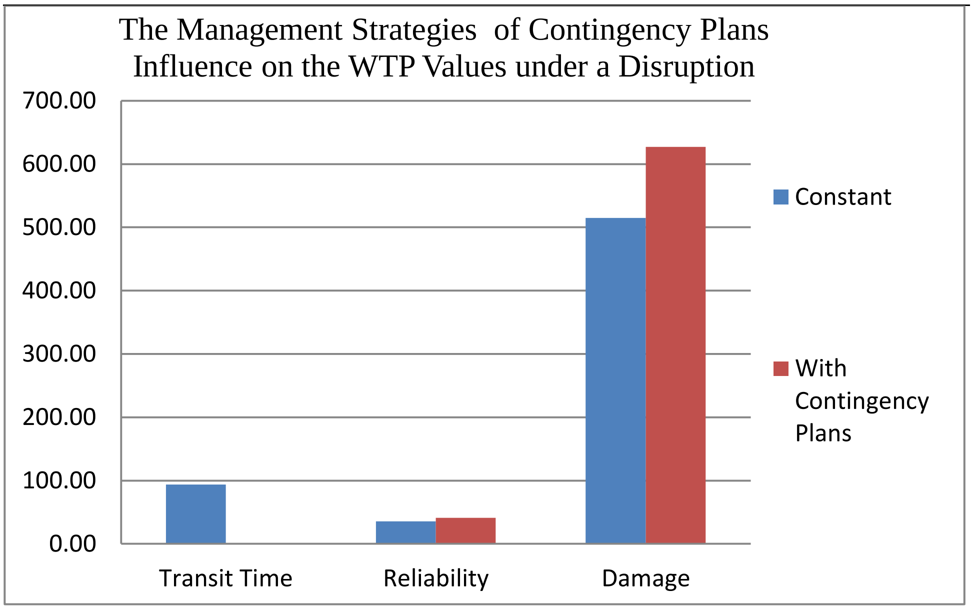
$$U_{iq} = \alpha_i + \beta_{Withcontingencyplan} Withcontingencyplan_{iq} + \sum_k \beta_k x_k \tag{6.12}$$

However, under disrupted operating conditions, as shown in Table 6-16, $\beta_{withcontingencyplan}$ becomes statistically significant for the reliability and damage rate attributes, and have the same signs with the alternative specific constant α_i. As a result, ceteris paribus, the marginal utility of firms with contingency plans will be $\alpha_i + \beta_{withcontingencyplan}$, and that of firms without contingency plans will be confounded with the alternative specific constant α_i. Therefore, all else being constant, managers in firms with contingency plans are willing to pay $\beta_{withcontingencyplan}$ monetary value higher for all maritime service attributes than managers in firms without contingency plans when facing a disruption event. That is, all else being equal, under a disruption, the WTP values for managers in firms with contingency plans is USD $112.06 higher for a one percent reduction in damage rate than that of managers in firms without contingency plans; and $5.10 higher for a one percent increase in on-time reliability of delay mitigation than that of managers in firms without contingency plans.

Similarly, all else being equal, the WTP values for a one percent increase in on-time reliability of delay mitigation is $5.10 higher for managers in firms with contingency plans than those managers in firms without contingency plans. Table 6-27 with figure presents the WTP values for managers in firms with and without contingency plans under a disruption scenario.

Table 6-27 with figure: The WTP Values for Managers in Firms with and without Contingency Plans under a Disruption

H6: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
With Contingency Plans		40.89	626.85



6.4.4.3 Examining the Impacts of JIT Policy on Shippers' WTPs

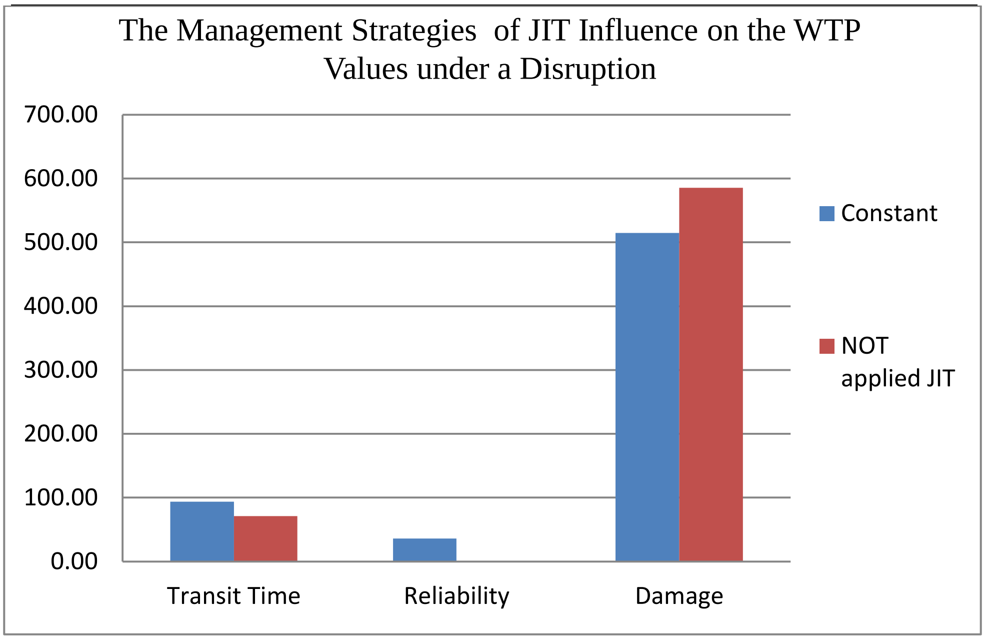
Under normal operations, as shown in Table 6-16, all parameters are statistically insignificant for the variable of not applying JIT policy (β_{notJIT}). As such, under normal operating conditions, ceteris paribus, shippers, no matter whether apply JIT or not, will all have equivalent WTP values for maritime service attributes at the value of the alternative specific constant α_i (see Equation 6.13).

$$U_{iq} = \alpha_i + \beta_{NotJIT} NotJIT_{iq} + \sum_k \beta_k x_k \tag{6.13}$$

However, under disrupted operating conditions, the SURE model results indicate that the parameters β_{notJIT} become statistically significant to the transit time and damage rate attributes. Since the parameters β_{notJIT} is statistically insignificant for the reliability attribute, it means all else being constant, the WTP value for a one percent increase in on-time reliability of delay mitigation is equivalent for all shippers no matter whether they apply JIT policy or not, at the value of the alternative specific constant α_i. The marginal utility for the transit time and damage rate attributes will be $\alpha_i + \beta_{notJIT}$ for firms not applying a JIT policy. As the parameter β_{notJIT} for the transit time attribute has an opposite sign to the alternative specific constant α_i, this indicates that the WTP value of shippers applying a JIT policy for a one day reduction in delay is USD \$93.57 and this value is \$22.77 higher than that of shippers not applying JIT policy in their management strategy, ceteris paribus. Simultaneously, the parameter β_{notJIT} for the damage rate attribute has the same sign to the alternative specific constant α_i, as such, the WTP of shippers applying a JIT policy for a one percent reduction in damage rate is USD \$514.78 and this value is \$70.62 less than that of shippers not applying a JIT policy, holding all else constant. Table 6-28 with figure presents the WTP values for managers in firms both applying and not applying a JIT management policy.

Table 6-28 with figure: The WTP Values for Managers in Firms Not Applying JIT under a Disruption Event

H6: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
NOT Applying JIT	70.79		585.40



6.4.5 Examining Hypothesis 7

6.4.5.1 Examining the Impacts of Shipment Payment Terms on Shippers' WTPs

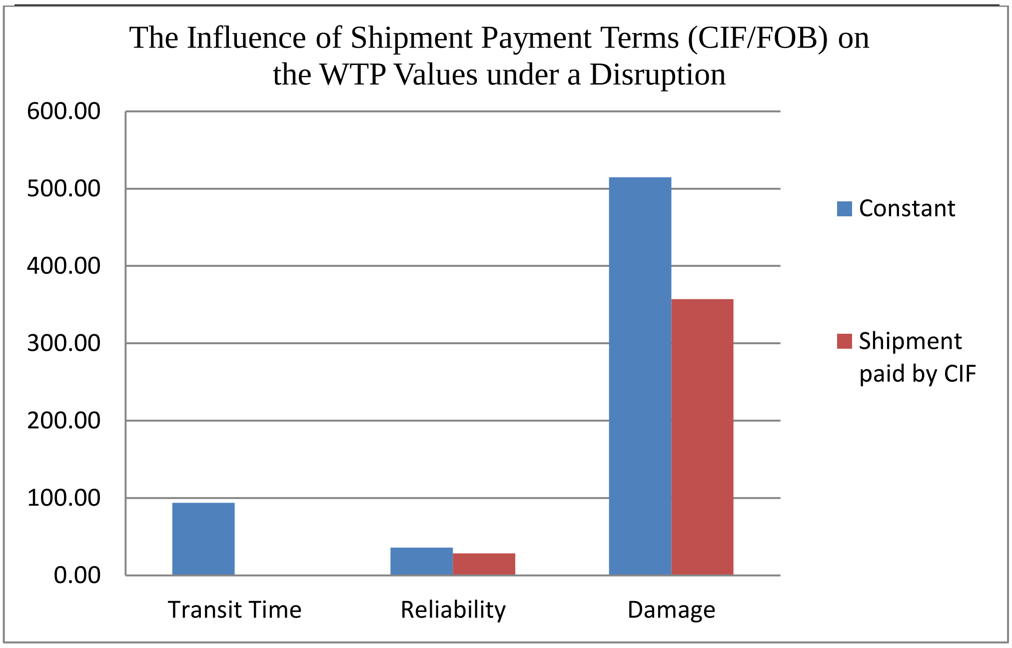
Under normal operations, the SURE model results indicate that the parameters of shipment payment terms (β_{CIF}) for all maritime service attributes are statistically insignificant (see Table 6-16). Thus, shippers' shipments payment terms have no influence on their WTP values for maritime service attributes under normal operating condition. Based on the utility function of shipment payment terms (Equation 6.14), shippers' WTP values for their shipments under both CIF and FOB payment terms will equal the alternative specific constant α_i, having all else constant.

$$U_{iq} = \alpha_i + \beta_{CIF} CIF_{iq} + \sum_k \beta_k x_k \qquad (6.14)$$

However, if there is a disruption, shippers' payment terms of CIF or FOB for their containers will affect their WTPs for maritime service attributes. As shown in Table 6-16, the parameters β_{CIF} are statistically significant for the reliability and damage rate attributes and statistically insignificant for the transit time attribute under a disruption. That is, ceteris paribus, shippers' WTPs for shipments paid by CIF and FOB will be $\alpha_i + \beta_{CIF}$ and α_i , respectively. As β_{CIF} are statistically insignificant for the transit time attribute during a disruption, all else being equal, the WTP for a one day reduction in delay will be α_i , which is USD $93.57, for all shippers no matter their shipments paid by CIF or FOB. Further, as the parameters β_{CIF} are statistically significant with opposite signs to the alternative specific constant α_i for the reliability and damage rate attributes, as such, shippers' WTPs of shipments paid by CIF will be β_{CIF} dollars lower than that of shipments paid by FOB for both reliability and damage rate attributes, all else being equal. That is, shippers' WTP value for a one percent reduction in damage rate is USD $514.78 for shipments paid by FOB, and it is $157.78 lower for shipments paid by CIF, all other factors being equal. Simultaneously, shippers' WTP value for a one percent increase in on-time reliability of delay mitigation is $35.78 for shipments paid by FOB, and it is $7.19 lower for shipments paid by CIF. Shippers' WTP values for shipments paid by CIF and FOB under a disruption are presented in Table 6-29 with figure.

Table 6-29 with figure: Shippers' WTP Values for Shipments Paid by CIF and FOB under a Disruption

H7: Disruption	Transit Time	Reliability	Damage
Constant	93.57	35.78	514.78
Shipment paid by CIF		28.60	357.00



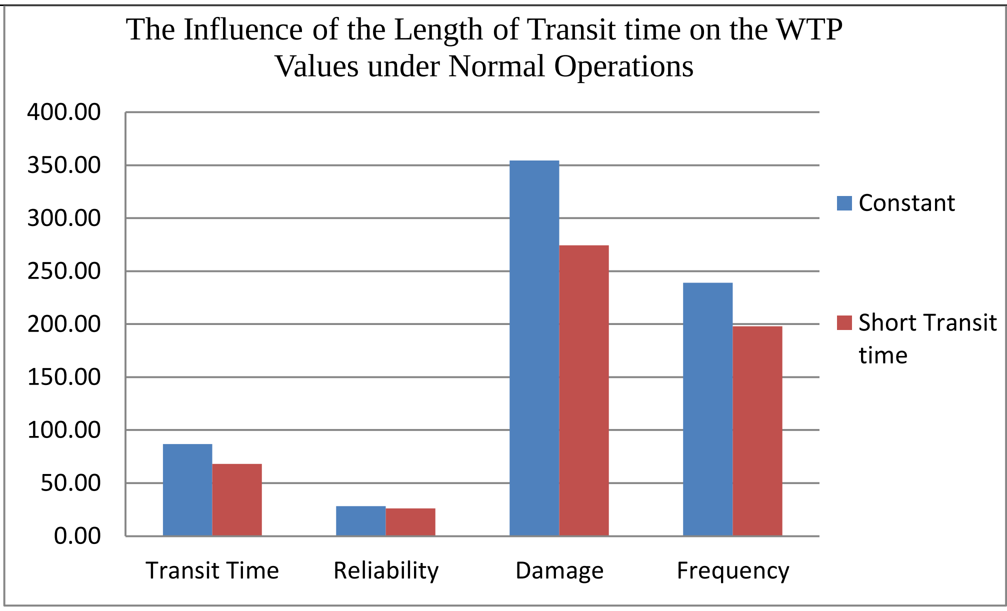
6.4.5.2 Examining the Impacts of the Length of Shipment Transit Time on Shippers' WTPs

Examining the impacts of the length of shipments transit time on shippers' WTP values, the utility function for transit time can be presented as Equation (6.15). The SURE model results (see Table 6-16) indicate that under normal operations, shippers' WTP values are not different unless their shipment transit time is less than 22 days (short transit time), since all parameters for the independent variables of medium transit time are statistically insignificant ($\beta_{Mediumtransit}$ are statistically equal to zero). As such, the WTP values for all maritime service attributes are equivalent for shippers whose shipments transit time is longer than 22 days (medium and long transit time), at the value of the alternative specific constant α_i, ceteris paribus. Further, assuming a 90 percent confidence level, the parameters $\beta_{shorttrans\,it}$ for short transit time shipments are statistically significant with opposite signs to the alternative specific constant α_i. As such, holding all other factors constant, shipments' transit time going from a short transit time (less than 22 days) to medium (between 22 and 32 days) and long transit time (more than 32 days) will result in a $\beta_{shorttrans\,it}$ monetary value increase in shippers' WTPs for all maritime service attributes under normal operations. That is, keeping everything else constant, shippers, whose shipments transit time is longer than 22 days (for all medium and long transit time shipments), are willing to pay USD $354.63 for a one percent reduction in damage rate, and this value of WTP will be $80.14 lower for shippers whose shipments transit time is short (less than 22 days). Similarly, ceteris paribus, shippers, whose shipments transit time shorter than 22 days tend to pay USD $41.20, $18.82, and $2.15 dollars less to improve the frequency, transit time and damage rate attributes, respectively. Table 6-30 with figure presents shippers' WTP values for different transit time shipments under normal operations.

$$U_{iq} = \alpha_i + \beta_{Shorttransit} Shorttransittime_{iq} + \beta_{Mediumtransit} Mediumtransittime_{iq} + \sum_k \beta_k x_k \quad (6.15)$$

Table 6-30 with figure: Shippers' WTP Values for Different Transit Time Shipments under Normal Operations

	Transit Time	Reliability	Damage	Frequency
Constant	86.97	28.39	354.63	239.22
Short Transit time	68.15	26.24	274.48	198.02



If there is a disruption, the SURE model results in Table 6-16 suggest that all parameters are statistically insignificant for all shippers regardless of short or medium shipment transit times ($\beta_{Shorttransit}$ and $\beta_{Mediumtransit}$ are statistically equal to zero). That is, the length of shipments transit time makes no difference to shippers' WTPs when facing a disruption event. In other words, the WTP values for all maritime service attributes are equivalent for all shippers no matter their shipments transit time is short, medium or long, and at the value of the alternative specific constant α_i, ceteris paribus.

Thus, with regards to Hypothesis 7, managers will have different WTP values for maritime transportation service attributes for shipments paid by FOB or CIF under a disruption event, and for shipments which transit time is shorter than 22 days under normal operations. As a result, H_7 cannot be rejected based on the above SURE model results.

6.4.6 Examining Hypothesis 8

6.4.6.1 Examining the WTPs of Shippers Not Preparing for Security and Related Risk Issues in Their Transport Decisions

The utility function of shippers' preparedness for a potential terrorist incident in maritime can be presented as Equation (6.16).

$$U_{iq} = \alpha_i + \beta_{Terrorist} Notprepareterrorist_{iq} + \sum_k \beta_k x_k \tag{6.16}$$

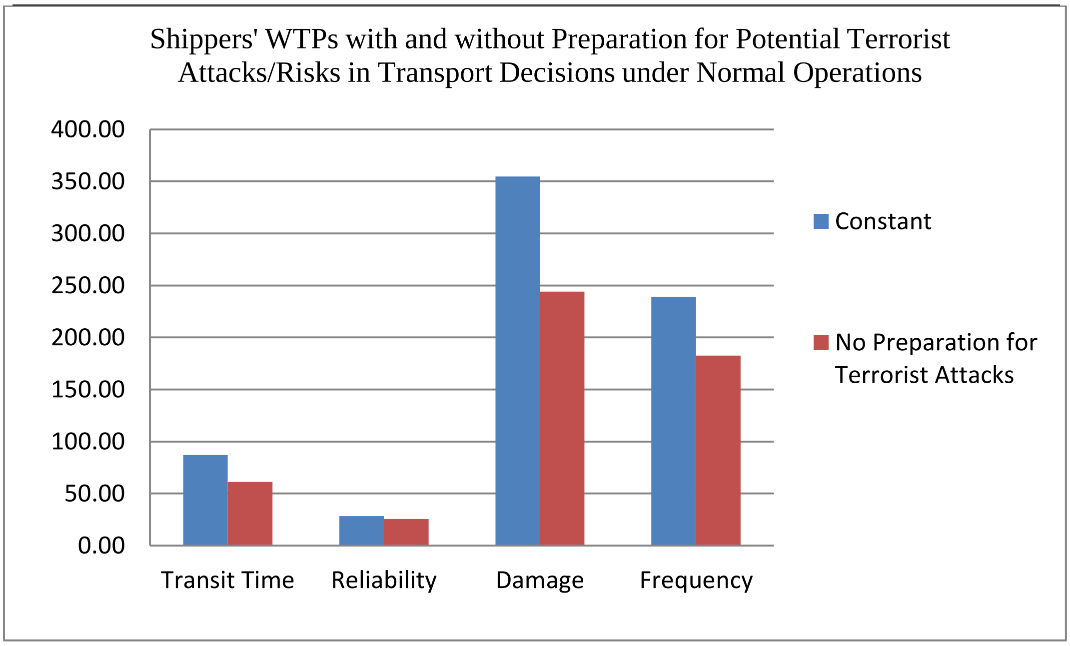
It can be seen from the SURE model results (Table 6-16) that under normal operations, shippers' WTP values for each maritime service attribute vary with shippers' preparation for a potential terrorist attack in their transport decisions, as all parameters are statistically significant ($\beta_{terrorist}$ are not statistically equal to zero). That is, under normal operations, the WTP values for each maritime service attribute for shippers prepared for potential terrorist attacks and other related risks when making transport decisions is equal α_i, and the WTPs for shippers without any such preparation for is equal to $\alpha_i + \beta_{terrorist}$. The parameters $\beta_{terrorist}$

all have an opposite sign to the alternative specific constant α_i and as a result, ceteris paribus, the WTPs for each maritime service attribute for shippers who are prepared are equal to $\beta_{terrorist}$ in monetary value higher than that of shippers without any such preparation. In other words, shippers preparing for potential terrorist attacks and other related risks during their transport decisions are will to pay USD $354.63 for a one percent reduction in damage rate, $239.22 for an increase in additional sailing per week, $86.97 for a one day reduction in transit time, and $28.39 for a one percent increase in on-time reliability, and these values of WTP for shippers without any preparation for potential terrorist attacks and risks in their shipment transportation are lower, at the values of USD $244.00 (354.63-110.63), $182.4(|-239.22+56.82|), $61.01(86.97-25.96), and $25.43(|-28.39+2.96|), respectively.

Table 6-31 with figure presents shippers' WTP values with and without preparation for potential terrorist attacks and risks under normal operating conditions.

Table 6-31 with figure: Shippers' WTP Values with and without Preparation for Potential Terrorist Attacks and Risks

H8: Normal	Transit Time	Reliability	Damage	Frequency
Constant	86.97	28.39	354.63	239.22
No Preparation for Terrorist Attacks	61.01	25.43	244.00	182.41



However, the parameters $\beta_{terrorist}$ become statistically insignificant if there is a disruption. As such, shippers no matter whether they are prepared for potential terrorist attacks and other related risks will all have equivalent WTPs for each maritime service attribute, at the value of the alternative specific constant α_i , all else being equal.

All in all, Hypothesis 8 cannot be rejected based on the above results.

6.5 Conclusion and Summary of the Results of the Hypotheses Tests

The data collected in the survey under normal and disrupted operating conditions are analysed, and the eight hypotheses are examined using LCMs and SURE models in this chapter. The first and second hypotheses are examined using LCMs, and the remaining hypotheses are examined using SURE models.

The first and second hypotheses identify the important maritime transport service attributes considered in transport decisions made under normal and disrupted operational conditions. They are designed also to examine the importance of those attributes and the changes of WTPs between normal and disrupted operations. H_1 and H_2 cannot be rejected, therefore, in containerised maritime transportation, the determinant attributes affecting shippers' transportation decisions under normal operations include freight rate, transit time, reliability, damage rate, and frequency (this finding is consistent with previous related research). However, if there is a disruption, the importance of those attributes and shippers' WTP values for each attribute can change significantly. The costs of a maritime related disruption can be quantified by comparing the difference of WTP values between normal and disrupted operations (the results of the comparison indicate that the costs of a maritime related disruption for each attribute are underestimated). In addition, the classification of different latent classes in the LCMs indicates that shippers' preferences regarding maritime service are heterogeneous.

To identify the heterogeneous sources influencing shippers' preferences, the SURE models are utilized to examine H_3 to H_8. H_3 examines the influence of company geographic location on shippers' WTPs for maritime service attributes. As shown in the SURE model results, H_3 cannot be rejected. Both under normal and abnormal operating conditions, shippers located in different geographic locations will have different WTP values for maritime service attributes. Further, the WTPs for these attributes are significantly different between normal and disruption operations.

H_4 examines whether shippers shipping different industrial products of differing value would have diverse WTPs for containerised maritime transport service attributes under both normal and disrupted working conditions. The analysis results indicate the H_4 cannot be rejected. Shippers shipping different industrial products will have different WTPs for maritime service attributes under all operating conditions, and their WTPs change significantly when they facing a SCD. Further, shippers shipping different valued goods will also have different WTPs for maritime service attributes only when facing a disruption event, and their WTPs change significantly when they face a maritime transport related SCD.

H_5 is designed to investigate whether all shippers have equivalent WTPs for containerised maritime transport service under normal and abnormal operations, independent of their company characteristics, such as nature of business (importers and exporters) and firm size. According to the SURE test results, H_5 cannot be rejected. Exporters have higher WTP values for each maritime service attribute than importers under normal operating condition; inversely, when facing a disruption event, importers will have higher WTP values to improve the transit time and reliability attributes than exporters. In terms of the impacts of organization size on the WTPs, the analysis results suggest that firm size would have no influence on shippers' WTPs under normal operation. However, if there is a disruption event, shippers of small firms will have the highest costs for damage; shippers of middle size companies will have the highest WTP for reducing delay by one day, followed by small firms; and small and medium firms will have slightly higher WTP values than large firms for a one percent increase in on-time reliability of delay mitigation.

To test the influence of different management strategies on shippers' WTPs, H_6 is examined. The model results indicate that under normal operations, shippers assessing carriers/forwarders' reputation will have higher WTPs for each maritime service attribute than that of shipper's not assessing carriers/forwarders' reputation during their transportation decisions. If there is a disruption event, shippers having contingency plans in their management strategies will have higher WTP values to increase a one percent on-time reliability of delay mitigation and to reduce a one percent damage rate than that of shippers without contingency plans. Finally, shippers applying a JIT policy in their SCM will have higher WTP for a one-day reduction in delay than shippers not applying a JIT policy, but their WTP for a one percent reduction in damage rate is lower than that of shippers not applying JIT. Therefore, H_6 cannot be rejected.

H_7 cannot be rejected as specific shipment characteristics could affect shippers' preferences differently. Under a disrupted operating condition, shippers whose shipments paid by FOB will have higher WTP values for a one percent increase in on-time reliability of delay mitigation and a one percent decrease in damage rate than that of shippers whose shipments paid by CIF. The length of shipment transit time, only for those shipments' transit time longer than 22 days, could make a difference to shippers' WTP values for containerised maritime service attributes under normal operating conditions. That is, under normal operations, ceteris paribus, shippers, whose shipment transit time is longer than 22 days, prefer to pay higher to improve all maritime service attributes than shippers whose shipments transit time is shorter than 22 days.

To investigate the impacts of potential security issues and risks in maritime transportation on shippers' WTPs, H_8 is examined. The model results suggest H_8 cannot be rejected. Under normal operations, shippers considering and preparing for the potential terrorist attacks and risks during their maritime transport decisions would have significantly higher WTP values for all maritime service attributes than that of shippers not considering and preparing for the potential terrorist incidents and risks.

This chapter analyses the model results and examines the hypotheses. The next chapter further discusses the model results and its industry implications.

CHAPTER SEVEN

7 DISCUSSION AND INDUSTRY IMPLICATIONS

7.1 Introduction

This thesis investigates the importance of containerised maritime transportation service attributes under scenarios of normal versus disrupted operations. This thesis further quantifies disruption costs through the evaluation and comparison of shippers' WTPs for various maritime service attributes under the two operational conditions. Furthermore, this thesis also examines whether the WTPs for maritime transport service attributes differ according to the product being shipped, the company doing the shipping, the characteristics of the SC and shipping firm including operational details such as whether JIT operations are used, the company's annual sales, organization size, and production value. This chapter presents further discussion of the research findings and the industry implications derived from this research.

7.2 Discussions of the Importance of Maritime Transport Service Attributes

7.2.1 Identify Important Maritime Service Attributes With and Without a Disruption

Identifying important transport service attributes can significantly contribute to the decision making process of transport shippers, service providers offering customization services, investors, and policy makers. A number of researchers have investigated the important factors that influence transportation choice decisions in different segments, such as Brooks (1984; 1985), McGinnis (1990), Lambert, Lewis and Stock (1993), Crum and Allen (1997), Tiwari, Itoh and Doi (2003), Danielis, Marcucci and Rotaris (2005), Beuthe and Bouffioux (2008), and Feo-Valero et al. (2011). Nevertheless, only a small amount of research has been conducted examining maritime transportation choices, especially, under a disruption event.

This research firstly asked respondents to rank the importance of the studied maritime service attributes according to their experience/perception without considering any econometric model choices (perception analysis). Under normal operations, the results suggest that shippers in China give the highest ranking to freight rates, followed by transit time, reliability, damage, and frequency, and shippers in Sydney focus more on reliability and then freight rate, transit time, damage, and frequency. This ranking differentiation indicates that logistics managers in China are cost-oriented, and that logistics managers in Sydney are reliability oriented due either to geographic location differences or culture differences. The strong emphasis on costs in part can be explained by high logistics costs, complexity of the administration of the transportation system, and deregulation in customs management in China. Under a two-week disruption scenario, the managers' ranking of sea transport attributes is different. Delay becomes the highest priority service attribute to improve for respondents in all cities. It implies that the primary concern is to mitigate delay and shorten in-transit time during a disruption. Reliability is the second highest scored attribute by Sydney and Shanghai managers, and the ranking of costs (rebate and surcharges) and damage rate is trversed in these two cities. Meanwhile, Shenzhen respondents ranked costs (rebate and surcharges) second followed by reliability and damage rate.

The research further investigates the priorities of the important maritime service attributes through discrete choice models. Under normal operations, the MNL model results reveal that the dominant attributes influencing shippers' containerised transportation decisions are damage rate, followed by frequency, transit time, reliability, and freight rate. It also reveals that shippers in containerised maritime chains value quality attributes more than price. This is in line with Danielis, Marcucci and Rotaris (2005) findings of a strong preference for quality attributes over costs. However, safety/damage rate and frequency here are strongly preferred over reliability in Danielis, Marcucci and Rotaris' (2005) study. This differentiation can be explained by the studied transport mode being different in both studies. Moreover, containerised maritime transportations involve multimodal transportations and handling at ports and customs so the damage rate attribute is of greater concern. Further, the MNL model results are significantly different from what shippers reported in their priorities ranking in the interview. This discrepancy in this study exposes that shippers have different preference priorities based on experience or knowledge (perceptions) and when they are forced to trade off these priorities. It hints that logistics managers think they value costs in maritime transport decisions, whereas, they really value service quality, such as safety, frequency, travel time, and reliability instead of price during real data choice scenarios. Whereas, under a disruption scenario, the damage rate is the dominant factor followed by delay, reliability, and costs (surcharge or rebate) in the MNL model.

The research analyses in further depth the importance of those maritime attributes through LCMs and reveals that shippers' preferences for a containerised maritime transport service are heterogeneous. Across the sampled population, under normal operations, 72.89 percent of respondents considered frequency as the determinant factor influencing their container shipping decisions, followed by damage rate, reliability, transit time, and freight rate during their container shipping decisions. Meanwhile, 27.11 percent of respondents considered damage rate as the dominant factor followed by frequency, transit time, reliability, and freight rate. Under a disruption scenario, the LCM categorized three different combinations of attribute preference due to sample heterogeneity. Nearly 24 percent of respondents considered damage rate as the main factor followed by delay, reliability, and costs (surcharge or rebate). The other two groups of respondents gave priority to delay followed by reliability and costs (surcharge or rebate), and the importance of damage rate for those respondents is insignificant. To identify the resources that might cause the heterogeneities of shippers' preferences for quality attributes in maritime transportation, further investigation and discussion of the heterogeneities is carried out in a later section.

7.2.2 Quantify the Values of Maritime Attributes and the Costs of a Disruption

This thesis quantifies the value of maritime service attributes under normal and disruption operations. The WTP results are presented in Table 7-1. The mean and standard deviation in the LCM are generated from 104 individual samples. The results indicate that the WTP for a one day reduction in transit time increases, on average, 4.52 times when facing a disruption event. This can explain air shipments becoming an attractive and feasible alternative/contingency plan to expedite at least part of the shipment to mitigate stock-out costs and other disruption costs in case of disruptions. The WTP for a one percent increase in on-time reliability increases almost doubles (1.71 times) compared between normal and disrupted operating conditions. It is reasonable from an inventory control perspective as inventory carrying costs can be decreased if reliability increases under a disruption. The WTP for a one percent reduction in the damage rate attribute slightly increases by 1.17 times in the LCM during a disruption. This indicates that managers emphasise expediting the shipment and increasing travel time reliability rather than reducing damage rate when facing a disruption event.

Table 7-1: The Value Changes of Maritime Attributes between Normal and Disrupted Operations in the LCMs

LCM individual	WTP	Normal Operation	Disruption	Ratio
Transit Time	**Min**	17.29	26.58	**1.54**
	Max	164.71	347.83	**2.11**
	Mean	49.70	224.45	**4.52**
	Std Dev.	55.48	134.71	**2.43**
Reliability	**Min**	20.44	3.95	**0.19**
	Max	37.27	52.60	**1.41**
	Mean	24.14	41.23	**1.71**
	Std Dev.	6.33	19.32	**3.05**
Damage Rate	**Min**	58.08	23.48	**0.40**
	Max	686.04	750.66	**1.09**
	Mean	196.13	228.62	**1.17**
	Std Dev.	236.32	258.09	**1.09**
Frequency	**Min**	86.75		
	Max	409.63		
	Mean	157.73		
	Std Dev.	121.51		

7.2.3 Implications of the Importance and Value Estimations of Maritime Service Attributes

This thesis further identifies logistics managers' preferences for containerised maritime transport service attributes. Firstly, it reveals that the ranking of the importance of maritime service attributes is different between managers' knowledge/perceptions and when they are forced to trade-the attributes off between one another. That is, the discrete choice modelling results illustrate how managers tried to balance and trade-off between each attribute, while the ranking results from managers perceptions are evaluated simply based on their experience and knowledge. This finding suggests that discrete choice modelling methods can provide more precise results than rankings based solely on managers' experience/perceptions. Further, the LCM can provide more practical and segmental detailed results relative to MNL and ML models.

Secondly, this study estimates logistics managers' preferences for containerised maritime transport service attributes through MNL models and LCMs. Under normal operations, the MNL model results indicate that for the sample analysed, damage rate and frequency are the most precious attributes of a containerised maritime transport service and they score about fivefold the value of time and reliability. However, the LCM results further reveal that the sampled respondents' preference is heterogeneous. The probability of sampled respondents falling into a higher value segment which has strong sensitivity for damage rate, followed by frequency, transit time and reliability is 27.64 percent, while 72.36 percent of respondents falling into a lower value segment, which is strongly sensitive to frequency, followed by damage rate, reliability, and transit time, and all of the latter's values are much lower than those of the higher value segment. Although both models generated slightly different weights/coefficients for each attribute, both models' results indicate a strong preference for quality attributes over cost. This finding is consistent with that of Danielis, Marcucci and Rotaris (2005) for the importance of freight service attributes. This study identified a high WTP for quality attributes in a containerised maritime transport service, especially for damage rate and frequency, followed by transit time and reliability. Such results indicate a high demand for quality improvement in maritime transportation, including increased safety, frequency, reliability, and decreased transit time. This demand matches the logistics industry challenges identified by Meixell and Norbis (2008) which implies that shippers seek a maritime service with more frequency, higher reliability, and less damage to tackle the capacity shortage, unreliable scheduling, and security concerns in containerised maritime transportation.

Third, this thesis identifies the dominant service attributes needed to be improved if there is a disruption in containerised maritime transport service. The majority of respondents considered that reducing a one day delay during a disruption is a primary driver, while about 24 percent of sampled respondents in the LCM consider a reduction in damage rate is the primary concern, followed by a reduction in delay and increase in on-time reliability according to the firm's production and company characteristics. Identifying the priority quality service attributes in maritime under a disruption can provide valuable information for shipping lines, carriers, ports, governments, and sectoral authorities and other actors to improve efficiency, and to reduce delays and congestions.

Fourth, this thesis estimates the value of maritime transport service attributes under both normal and disrupted operating conditions and distinguishes the differences between the precious quality attributes in maritime service under different operating conditions. The monetary values of each quality attribute can give an idea of how changes in quality attributes are traded off against a monetary change in transport costs under normal and disruption operations. Under normal operation, the MNL model results indicate that damage rate and frequency are the most precious attributes in improving containerised maritime service. Shippers tend to give a higher value to secure their cargoes and to increase the regularity of maritime services. The high value of frequency in maritime service is identical to the findings of Bergantino and Bolis (2005), but slightly different regarding the high value of damage rate here. In addition, the LCM results further distinguish that the samples are categorized into two classes holding different values of frequency, damage rate, reliability, and transit time. This suggests that there is heterogeneity across the sampled population. Further, when facing a disruption event, the value of time increased above fourfold, followed by reliability and damage rate. This indicates shippers have a high preference to reduce one day delays and increase a one percent on-time reliability under a disruption circumstance. It suggests that time becomes the most precious attribute if a disruption takes place, followed by reliability and damage rate. Again, the LCM results suggest heterogeneity among the sampled population. Only respondents in Class 2 have a high value for damage rate, followed by delay/time and reliability. Other class respondents, especially, Class 1 respondents highly valued the time/delay and reliability attributes. Thus, the findings in this study suggest that the sampled population is heterogeneous in the maritime service. This requires further investigation to determine what factors might be responsible for causing such heterogeneity.

7.3 Discussions of the Influence of Production, Company Characteristics, Management Strategy and Shipment Specific Characteristics on the Values of Maritime Service Attributes

7.3.1 The Influence of the Company's Geographical Locations on Shippers' WTPs

The SURE model results analysis in Chapter Six identified that the company's geographic locations have a significant influence on shippers' WTPs in containerised maritime transport decisions. Under normal operations, shippers located in Sydney and Shanghai appear to have similar preferences and WTP values for damage rate, frequency, transit time, and reliability. However, shippers located in Shenzhen have lower WTP values for all maritime service attributes compared with shippers in Sydney and Shanghai. This difference can be explained by the fact that the goods value shipped in Sydney and Shanghai is higher, as some of them are high technology products and high value equipment. According to the sampled data, above 65 percent of respondents in Shenzhen have shipping container cargo values which are less than USD $30,000 per TEU. By contrast, more than 80 percent and 60 percent of respondents in Shanghai and Sydney respectively have shipping containers of a value more than USD $30,000 per TEU. Particularly, nearly 40 percent of respondents located in Shanghai and Sydney have shipping container values of more than USD $70,000 per TEU. Furthermore, a large proportion of respondents in Shenzhen are small (61 percent) and medium (16 percent) sized companies shipping low value goods, such as electronic products, raw materials and recycled paper. Thus, the lower value of WTPs for shippers in Shenzhen is affected by its economy structure, organization sizes, and product type and value.

Therefore, shippers located in different regions are willing to pay differently to improve different maritime service quality attributes under normal operations. This is important for shippers' transport decisions, as well as for maritime industry service providers' marketing segmentation and service quality improvement. This finding is opposite to Danielis, Marcucci and Rotaris (2005) who found there is not a large difference among regions in road transport decisions. This is possibly because the determinants of shippers' preferences in different transport modes are diverse. Shippers' preferences for transport service attributes in different modes demand a narrowed down analysis.

When there is a disruption, the geographic locations have a distinct impact on shippers' WTPs. Damage rate is still a determinant factor for shippers in Shanghai. Their WTP value to reduce by one percent the damage rate under a disruption is more than USD $100 per TEU higher than that for shippers in Sydney and nearly $200 per TEU higher than that of shippers in Shenzhen. This can be explained by the fact that about 84 percent of Shanghai shippers' shipping containers' cargoes values are more than USD $30,000 per TEU and 40 percent of these are more than $70,000 per TEU. Thus, the higher goods value per TEU, the higher WTP for damage rate when facing a disruption. However, shippers in Shenzhen have the highest WTP value for a one day reduction in delay, followed by shippers in Sydney and Shanghai. The highest WTP value of reducing delay for Shenzhen shippers can be explained by a large proportion of respondents in Shenzhen being SMEs (77 percent) which have less capability to handle delay impacts caused by a disruption; as a result, they are willing to pay more to shorten the delay days to avoid sales/demand disruptions. As Sydney shippers ship the highest proportion (17 percent) of goods classified within the foods industry, it is reasonable that they are willing to pay more to mitigate the length of delay days and avoid loss for perishable foods. Thus, shippers in different geographic locations shipping various types of goods at different values are seeking different solutions or strategies to tackle disruption impacts through focusing on different priorities of service attributes.

7.3.2 The Influence of Production Characteristics

7.3.2.1 The Influence of Containers' Goods Value on Shippers' WTPs

The shipment cargo value per TEU affects logistics managers' WTP significantly between the various maritime service attributes, as a clear variation can be found in the SURE model results. Under normal operations, shipment cargo values per TEU have an insignificant influence on shippers' WTPs. That is, shippers shipping containerised goods at different values will have equivalent WTP values for all maritime service attributes, all else being equal. In contrast, when facing a disruption, shippers shipping high value goods containers (more than USD $70000 per TEU) are willing to pay more to reduce by one percent the damage rate and to increase by one percent on-time reliability compared to shippers shipping low and medium value goods containers. This again confirms that cargo safety (loss/damage) and on-time arrival reliability are of great concern for shippers transporting high value goods containers, as their costs of damage and delay are much higher than those shippers shipping low and medium value goods containers.

In short, the shipping containers' cargo value affects shippers' maritime transport decisions to different extents when facing a disruption. This finding reinforces the results of Beuthe and Bouffioux (2008) that shippers' preferences for transport attributes vary according to the different values of their transported cargoes. In addition, this study further elaborates the influence of different goods value on shippers' WTPs for containerised maritime transport service attributes according to shippers' company characteristics and shipment specific characteristics under normal and abnormal operations.

7.3.2.2 The Influence of Cargo Industry Types on Shippers' WTPs

Different categories of goods transported exert a strong influence on shippers' transport preference. Clothing is more cost sensitive, and furniture is more time and reliability sensitive among the sampled road transport respondents (Danielis, Marcucci and Rotaris 2005). Shippers of minerals, fertilisers, and agricultural products pay more attention to time, reliability, and flexibility than costs, but shippers of metal products are concerned more about costs (Beuthe and Bouffioux 2008).

The analysis in this study also reveals that shippers' preferences for maritime services vary over different product categories. Under normal operations, all respondents were more sensitive to damage rate and frequency, followed by transit time and reliability. However, shippers for construction and garments products seem to have lower WTP values to improve these maritime service attributes compared with other product categories.

Under a SCD event, shippers' WTP values of each transport service attribute change according to the cargo categories shipped. Shippers shipping containers of food, including fresh and preserved fruits, wheat and meat are inclined to have the highest WTP values for a one day reduction in delay and a one percent increase in on-time reliability. This is reasonable due to the short-life cycle for perishable goods in food categories. This hints that shortening the length of delay and increasing on-time reliability are the primary requirements for shippers shipping food categories products when facing a transport related disruption. Meanwhile, shippers of garments, chemicals, machinery, and food product categories have a higher value of WTP for a one percent reduction in damage rate under a disruption, as the costs of damage/loss for these product categories could be much higher, particularly, the costs of damage of chemical products.

Therefore, this finding is in line with previous studies that shippers' preferences for transport attributes are diversified according to their shipping cargoes categories. Further, this study identifies that shippers' primary preferences for containerised maritime transport attributes vary with different product categories being shipped under a disruption.

7.3.3 The Influence of Company Characteristics on Shippers' Preference

7.3.3.1 The Difference Impact between Exporters and Importers on Their WTPs

This study reveals that under normal operation, exporters appear to value improving maritime service attributes more highly than importers do. From the perspective of importers, fulfilling the sale orders on time and customer satisfaction are the top priorities, thus, normally importers would have a reasonable level of stock on hand to support their sales. As a result, importers would be less willing to pay to improve maritime service attributes under normal operations, as they have enough inventory planned in the lead-time. However, exporters are willing to pay more to reduce damage rate, transit time, and increase on-time reliability and service frequency, particularly exporters from China, because of their low products' profit margin, worse situation in account receivables, and higher damager/loss and longer transit time during multimodal transports before their containers are loaded on the vessels or delivered to buyers.

The SURE results indicate that under a disrupted operating condition, importers and exporters would have an equivalent WTP value for a one percent reduction in damage rate. However, importers would have higher WTP values for a one day reduction in delay and a one percent increase in on-time reliability. This is because importers would pursue measures that can shorten the length of delay and ensure on-time reliability to satisfy market demand and customers' requirements. In addition, about 70 percent of the exporter respondents' shipments were paid by FOB term. It can also partly explain why exporters are willing to pay less than importers to improve maritime service attributes during a disruption.

After Kent and Parker (1999) first examined and identified that there are significant different carrier selection criteria between import and export shippers/carriers in international containership, this study again confirms the diversity preference of maritime service attributes between importers and exporters through discrete choice model and SURE model methods. Additionally, the preference differentiations between importers and exporters under a disruption scenario are further identified.

7.3.3.2 Influence of Organization Size on Shippers' WTPs

The analysis results in this study suggest that organization annual sales size would have an insignificant influence on shippers' WTPs for maritime service attributes under normal operation. Inversely, under a disrupted scenario, different organization sales sizes appear to have significant impacts on shippers' preference for maritime service attributes. Firstly, the small size companies greatly value damage/loss under a disruption. This might be interpreted as small size companies have less capacity to bear the risk of sales loss and cost increase. As a result, they could endure less damage or loss in their transportation and the costs increase due to higher damage. Second, the intensity of preference for reliability is very similar between SMEs, and their WTP values for on-time reliability are slightly higher than those of large size firms. Finally, medium companies have the highest value for a reduction of a one day delay in transit followed by small and large companies. Large companies could have more shipments in a certain time period. Thus, one shipment delay in a large size firm could be easily replenished or fulfilled by a subsequent shipment. In addition, a large company generally attaches more importance to the contingency plans dealing with disruptions than SMEs do. Consequently, the large companies are normally reluctant to pay more to reduce a one day delay in-transit relative to SMEs, when facing a disruption event. On the contrary, SMEs rarely have a large volume of shipments or substituted shipments to overcome the risk of transport delay and SCDs. Further, SMEs take little count of contingency plans compared with large companies. Therefore, shippers of SMEs prefer to pay higher costs to shorten the length of delay under a transport disruption.

Danielis, Marcucci and Rotaris (2005) identify that firm size is negatively related to the intensity of preference for quality attributes under normal operation. This study has a different point of view in contrast to Danielis, Marcucci and Rotaris (2005) study. The analysis results here suggest organization size has an insignificant influence on shippers' preference for maritime service attributes under normal operating conditions; however, shippers' organization annual sales size affects significantly the intensity of preference for maritime service attributes when facing a disruption.

7.3.4 The Influence of Company/Supply Chain Management Strategies

7.3.4.1 The Importance of Assessing Carrier Reputation on Shippers' Preference

Nearly 90 percent of survey respondents considered the reputation of carrier/freight forwarder as an important criterion during their transport selection; only 12 out 104 respondents indicated that assessing carriers' reputation was not a significant factor influencing their transport selection. The SURE model results indicate that whether assessing carriers' reputation significantly affects shippers' preferences for maritime service attributes only under normal operating condition. That is, under normal operations, ceteris paribus, shippers assessing carriers' reputation during their carriers/forwarders selection process would have higher WTP values for all maritime service attributes than that of shippers not assessing carriers' reputation. Those shippers are quality oriented during their carriers/forwarders selection process, while, others who do not assess carrier reputation are more cost oriented and unlikely to pay more to improve maritime service quality. From the shippers' perspectives, the higher reputation the carrier has the better quality of service it can provide. These results reflect that carriers' reputation is somehow related to maritime transport safety and schedule punctuality under normal operation, and most shippers strongly prefer safe and punctual containerised maritime transportation service.

7.3.4.2 The Preference of Companies with Contingency Plans

The model results show that contingency plans in company's management strategies seem to have an insignificant impact on shippers' preferences for maritime service attributes under normal operation. However, when a disruption takes place, shippers having contingency plans appear to have a stronger preference to improve container cargo safety and on-time reliability. This is because shippers with contingency plans have extended lead time or increased safety stocks in their daily normal operations. As a result, they have prepared certain buffer times and inventories for those companies to overcome a weak delay or disruption. However, they cannot tolerate extra loss or cargo damage in the delayed shipment, as they might not have a large enough buffer that exceeds their contingency plans. Or an increase in damage rate would cause additional loss; as a result, the company with contingency plans would care more about the damage rate than other attributes.

7.3.4.3 The Influence of JIT Policy on Shippers' WTPs

The SURE results indicate that whether applying JIT policy or not in their transport decisions would have no influence on shippers' WTPs for maritime service attributes under normal operations. This is a slight unconformity with previous studies, such as Bagchi, Raghunathan and Bardi (1987) who investigated the influence of JIT on the attributes for carrier selection through rating important attributes in an questionnaire. They found that firms in the JIT group give significantly higher emphasis to rate, customer service, claims handling/follow-up, and equipment availability/service flexibility; and Danielis, Marcucci and Rotaris (2005) identified that firms with JIT in its procurements are more sensitive to the reliability attribute than firms purchasing transport services on order or on demand and they are also slightly more sensitive to the safety attribute, but there is no difference as regards door-to-door transit time. These unconformity findings of this research disclose that shippers' preference for containerised maritime transport services are discrepant compared with other transport modes.

However, if there is a disruption, shippers applying JIT policy in their transportation will have a stronger tendency to pay to reduce a one day in delay caused by a disruption. This is because firms with JIT have less safety stocks and they are confronted with higher risk of stock-out in a disruption. As a result, firms with JIT policy greatly value a one day reduction in delay. Correspondingly, shippers purchasing containerised maritime transport service on order or on demand present a stronger preference for a maritime service with a lower damage rate when facing a disruption.

7.3.5 The Influence of Shipment Specific Characteristics

7.3.5.1 The Influence of Shipment Payment Term CIF on Shippers' WTPs

Investigating how shipment payment terms of CIF and FOB affect shippers' preference for maritime service attributes, it can be observed that shippers' WTP values would not be influenced by their shipments payment terms under normal operations. However, under a disruption scenario, shippers' WTP values for the reliability and damage rate attributes for shipments paid by CIF will be lower than that of shippers whose shipments were paid by FOB, all else being equal. This is understandable as CIF shipments contain insurance for cargo loss, in contrast, shippers for FOB shipments are more likely to pay higher to reduce a one percent damage rate and increase a one percent on-time reliability during a disruption. On the other hand, in practice, importers normally would make a payment within 30–60 days after receiving their cargoes in international trade through maritime transportation. Apparently, any delay or damage caused by the shipping lines should not be the shippers' responsibility since shippers who paid by FOB do not manage the transportation after a port. However, shipping damage/loss and uncertainty under a disruption might affect or defer shippers' accounts receivable. As such, compared with shippers whose shipments were paid by CIF, shippers paid by FOB term are willing to pay to improve the damage rate and on-time reliability attributes.

7.3.5.2 The Influence of Shipment Transit Time on Shippers' WTPs

With respect to the impacts of travel distance or transit time on shippers' preference, it is found that the length of shipments transit time has an insignificant influence on shippers' WTP values for all maritime service attributes under a disruption. However, under normal operations, it does significantly impact shippers' WTP values for all maritime attributes if shippers' shipment transit time is less than 22 days. That is, under normal operations, shippers whose shipments transit time is longer than 22 days would have equivalent WTPs for surveyed maritime attributes. Inversely, shippers whose shipments transit time is less than 22 days are willing to pay less to improve maritime service quality than those whose shipments transit time is longer than 22 days. In other words, under normal operations shippers for intermediate and longer travel distance shipments (transit time not less than 22 days) are willing to pay more than the shippers for short distance shipments to improve the damage rate, frequency, transit time, and on-time reliability attributes in maritime transportation.

Compared with other previous studies related to travel time or distance in transport decisions, Danielis, Marcucci and Rotaris (2005) reveal that the shorter the travel time the more important time and reliability become relative to cost in road transport, and Beuthe and Bouffioux (2008) identify that the importance of transport service attributes varies according to the length of travel distance. The findings in this study further confirm that shipment transit time or distance have a significant impact on shippers' preference during their maritime transport decisions, and the importance of each transport service attribute is adaptable to the change of shipment transit time/distance. Moreover, travel time in short distance road transportation plays a significant role in transport decisions, whereas, the transit time attribute in maritime distribution is significantly less valued than the damage rate and frequency attributes. Thus, for short distance containerised maritime transportation, shippers are more cost oriented and willing to pay less to improve maritime service than shippers for medium and long transit time shipments. However, if shipments' transit time is longer than 22 days, shippers become more quality oriented, and are willing to pay more to improve maritime service quality.

7.3.6 The Influence of Potential Security Issues and Related Risks on Shippers' WTPs

Little attention in transportation choice research has been given to security issues, but Voss et al. (2006) and Meixell and Norbis (2008) pointed to preparedness and security as new criteria for carrier selection. This study adds a point in maritime transportation security.

7.3.6.1 The Influence of Strategies/ Regulations for Potential Terrorist Attacks and Risks on Shippers' WTPs

The SURE model results indicate that shippers no matter whether considering potential terrorist attacks/risks or not during their transport decisions would pay equivalent values of WTP for all maritime service attributes when facing a SCD. In contrast, under normal operations, shippers' WTP values for maritime service attributes are significantly affected by their management strategies for potential terrorist attacks and risks. Shippers taking potential terrorist attacks/risks into consideration and preparing for such attacks/risks during their transport decisions would remarkably pay more to improve all maritime service attributes than those not preparing for potential terrorist attacks and risks. Particularly, shippers considering potential terrorist attacks/risks would intensify the importance of the damage/loss attribute, followed by the frequency, transit time, and reliability attributes when making their transport decision. In other words, cargo damage or loss is shippers' primary concern whenever they think of a potential terrorist incident or risk. Shippers concerned about a potential terrorist attack are willing to pay above USD $110 more to mitigate/avoid cargo loss/damage caused by the terrorist attack than those shippers not concerned about a potential terrorist attacks.

7.4 Industry Implications of the Findings

In summary, the analysis results of this study identify the importance of each maritime transport service attribute, and quantify the value of time, reliability, damage, and frequency in containerised maritime service under normal operations, as well as the value of mitigating delay and security threats to shippers, and improving on-time reliability under a disruption. In choosing containerised maritime transportation, freight rates are no longer the only primary determinant but frequency and damage rate have become the key factors influencing shippers' transport decisions. As indicated in the LCM results, shippers' preferences are heterogeneous, and the importance of each maritime service attribute varies with individual shipper's products characteristics, shipment specific characteristics, company characteristics, and SC characteristics. In addition, when a disruption takes place, the value of each maritime service attribute would be changed. In the early section of this chapter, the preference intensity of each maritime service attribute for different subsamples was discussed. The following section will further discuss its industrial implications for different actors.

7.4.1 Shippers

From the point of view of shippers, the findings of this study could be helpful for shippers to make better transport decisions under normal operations: first, shippers could easily select a suitable service provider who could best fit in their transport strategy based on their production characteristics, shipment specific characteristics, and company, as well as SC characteristics. Second, the findings of this study could provide shippers with precise information to negotiate with their transport service provider/carrier about pricing and detailed service levels or enhance certain service quality factors. Third, shippers could prepare better contingency plans for their transportation according to the precise information of these analysis results.

Under a disrupted operating condition, according to the value of delay, reliability, damage/security threat attributes, and based on shippers' production and shipments characteristics, as well as company/SC characteristics, shippers could undertake a cost benefit analysis to decide whether to pay extra costs to avoid or mitigate the impacts of a disruption. Moreover, shippers could find an appropriate solution to decrease the loss or influence of their shipment delay based on their production characteristics, company, and SC characteristics.

7.4.2 Carriers and Shipping Lines

For carriers and shipping lines, given the heavy weight of frequency, damage rate, and reliability attributes in shippers' maritime transport decisions, carriers and shipping lines should emphasize actions that could improve maritime service quality, such as increasing frequency, reliability, and decreasing damage rate of maritime service. Improvement of frequency and reliability in maritime services would also conquer the capacity shortage and unreliability challenges in contemporary logistics industry. The findings of this study provide valuable quantitative information of precise and detailed customer demands. With comprehensive understandings of customer demands and a shipper's WTP for a specific service attribute, carriers and shipping lines could subdivide market segments and focus on their strength market segment providing customization services, in turn consolidating their competitiveness. Besides, this could help carriers and shipping lines better streamline their pricing strategy and reshape their business strategy to further improve customer service.

Furthermore, the quantitative value of delay, reliability, and damage under a disruption would provide carriers and shipping lines useful data for an input-output analysis to examine the costs and benefits of a new measure/service or investment in new equipment to mitigate delays and the impact of disruptions.

7.4.3 Ports Operators and Investors

Under normal operation, to improve the use and competitiveness of ports, ports operators and investors should put more effort into improving service frequency and reliability, and decreasing damage/loss of containers during loading/unloading. Further, according to customers' detailed requirements of transportation, they could also ameliorate their management process or strategies to improve port efficiency and mitigate port congestions. Besides, return on investment (ROI) could be estimated based on the value of maritime service attributes to investigate the costs and benefits of investment in new equipment or service to intensify ports efficiency and safety. All investments should be directed to the infrastructures and equipment that can enhance better port services to maximize customers' satisfaction and ports security.

Under a disruption operation, these findings could provide ports operators and investors with pinpoint information on customers' needs to manage and alleviate the stress of ports congestions. In addition, by referring to the value of delay, reliability, and damage under a disruption, ROI analysis could be done to investigate the worth of new product developments or new investments for ports congestions or ports disruptions.

7.4.4 Insurers

Insurers could better identify what matters to their customers in containerised maritime transportation and could classify their customers' segmentations accurately for their specific transportation concerns.

In addition, based on the quantitative findings of this study, as well as the WTP value variation relative to shippers' production characteristics, shipment characteristics, and company/SC characteristics, insurers could design and promote more customer-oriented insurance products. Moreover, the identification of disruption costs in terms of value of delay, reliability, and damage could contribute to security premiums level design under disruptions, wars, or terrorisms.

7.4.5 Governments and Policy Makers

In general, governments and policy makers pay close attention to the macro-level of business. With these quantitative findings, governments could acquire more comprehensive data and information to regulate and coordinate the relationship between all parties and create better conditions for tackling the problems caused by disruptions in the course of transportation. Through quantifying the benefits of transportation infrastructure improvements, governments and policy makers could attract more private and public sectors to invest in maritime transportation facilities and infrastructures to improve efficiency and safety, as well as to reduce congestion. With government and policy maker intervention and rational planning, overall social efficiency could be improved, overall social resources could be rationally used, and total social costs could be reduced.

These findings of shippers' demands could also provide policy makers quantitative information to establish and modify policies to improve maritime transportation efficiency and security that fully considers shippers' benefits and needs. Meanwhile, more measures and regulations could be taken to ensure the efficient and secure handling processes of containers, in turn, greatly alleviating the congestions problems in maritime transportation.

7.5 Conclusion

This chapter discusses the results of the models and their industrial implications that vary with individual shipper's production characteristics, shipment characteristics, as well as company and SC characteristics. Furthermore, the industrial implications for each related parties are discussed.

CHAPTER EIGHT

8 CONCLUSIONS

8.1 Contributions

The foregoing chapters have identified and quantified the important containerised maritime service attributes under conditions with and without a SCD. Using a discrete choice experiment and MNL and LCM choice models, this thesis examines the changes to the importance of these maritime service attributes in making transportation decisions and how these vary by individual shippers' production characteristics, shipment characteristics, and company, as well as SC characteristic. These are done via the use of SURE models. This chapter summaries the major findings of this thesis and highlights the significant contributions that have been made.

8.1.1 Identifying Important Service Attributes in Containerised Maritime Transportation

The existing literature on identification of the importance service attributes in freight transportation has primarily concentrated in the past on carrier selection criterion in load transportation or transport modes choice. Very few studies have focused on and identified the importance of service attributes in international containerised maritime transportation. This research fills this gap. The use of a discrete choice experiment allowed respondents to trade-off attributes under various hypothetical scenarios which allowed for a determination of which attributes a salient in the SC decision process involving maritime transport under both normal and disrupted operational conditions. Using MNL and LCM discrete choice models, allowed for the estimation and parameterisation of shippers' preferences in international containerised maritime freight transportation and a determination of preference heterogeneity amongst individual shippers.

8.1.2 Quantifying the Value of Quality Attributes in Containerised Maritime Transportation

A majority of the existing literature on the evaluation of the value of freight service attributes has focused on the value of time and reliability in road trucking and train transportation. The current research not only quantifies the value of time and reliability but also addresses the gap in the value of damage/loss and frequency in international containerised maritime transportation service sector. Quantifying the value of containerised maritime transportation attributes is unique to the literature and represents a starting point for later future in-depth analysis.

8.1.3 Quantifying the Disruption Costs in International Containerised Maritime Transportation Chains

A vast amount of research has focused on the identification of the risks/sources of SCDs, whilst only a small number of studies have investigated the impacts of a SCD. To the best of the author's knowledge, this thesis represents the first research effort to study and quantify SCD costs through evaluating the value of transport service attributes under scenarios with and without a disruption within international containerised maritime transportation chains. Indeed, both the relative and the absolute importance that shippers assign to the international containerised maritime transportation attributes under a disruption are initially identified and quantified. This research also adds to the work on security issues in the international containerised maritime transportation choices.

8.1.4 Identifying the Importance of Service Attributes Varying with Individual Shipper's Production, Shipment, Company and SC Characteristics, and Includes SC Integration in Maritime Transportation Choices

An abundance of research has in the past identified the important service attributes within the freight transportation sector across various segments. Nevertheless, only a handful of studies have examined variations in the importance of transportation service attributes related to different shippers' characteristics. This research offers an original and significant contribution to this gap by investigating the influences of different product categories, shipment specific information, and company/SC characteristics on shippers' preferences for the international containerised maritime transportation choices. Further, this study also represents the first known research to include SC integration, such as contingency planning, JIT inventory policies, and prevention of maritime security threats, into maritime transportation choice decisions.

8.1.5 Summary of Hypotheses

The above mentioned contributions are embodied in a series of research hypotheses which were confirmed in Chapters 6 and 7. Table 8-1 summaries the results of the eight hypotheses tested in this study. Ticks show that the hypothesis could not be rejected for a specific attribute under normal operational and adverse operational conditions. The freight rate attribute under normal operation or surcharge/rebate under a disruption operation is not presented in Table 8-1, as it is the monetary/cost attribute in this study used to quantify shippers' WTP to acquire better maritime service (including reliability, frequency and time) or to prevent potential time or damage loss.

Table 8-1: The Hypotheses Tests Results Summary

		Normal Operation				Disruption		
Hypo.		**Transit Time**	**Reliability**	**Damage**	**Frequency**	**Transit Time (Delay)**	**Reliability**	**Damage**
H_1		√	√	√	√	√	√	√
H_2		√	√	√		√	√	√
H_3	Shenzhen	√	√	√	√	√	√	√
	Sydney					√		√
H_4	Goods Value						√	√
	Cargoes Type	√	√	√	√	√	√	√
H_5	Exporter	√	√	√	√	√	√	
	Small Firm					√	√	√
	Medium Firm					√	√	
H_6	Not Assess Carriers' Reputation	√	√	√	√			
	With Contingency Plans						√	√
	Not JIT in Firm					√		√
H_7	CIF Payment						√	√
	Short Transit Time	√	√	√	√			
	Medium Transit Time							
H_8	No Preparedness for Potential Terrorist Attacks and Risks	√	√	√	√			

Hypothesis H_1 was confirmed, indicating that under normal operations, shippers' preference for an international containerised maritime transport service is influenced by sailing frequency, damage rate, reliability, transit time, and freight rate. Hence, to strengthen competitiveness and enhance efficiency, maritime industrial parties should emphasize on investments or measurements that could improve its maritime transportation service qualities in terms of sailing frequency, damage/loss, reliability, and transit time. Moreover, the results from the LCM reveal that shippers' preferences for maritime service are heterogeneous and vary with individual shipper's characteristics. As such, customization and differentiation of maritime services should be distinguished and subdivided to satisfy diversified markets/customers demands.

Hypothesis H_2 was confirmed, suggesting that a disruption event is likely to affect shippers' preferences for maritime transport service, and lead to a shift in the importance for each of the maritime service attributes. The implications of this are three-fold: 1) Under a disruption event, shortening the days given over to delay become a shipper's top priority, followed with increasing on-time reliability and decreasing damage/loss in transit. As such, shippers aspire to measurements that could reduce delay and damage/loss, as well as secure and improve on-time reliability during transport disruptions. Further, shippers may be willing to pay a premium to expedite their shipments. 2) Surveyed managers nominated disruption costs within their businesses as having a number of different impacts including, but not limited to a potential loss of sales, other intangibles such as loss of reputation, additional expediting costs, increased administration costs (communications, documentation, etc.), and a deferral to their financial cash flows. Whilst many of these disruption costs are difficult to quantify, this thesis quantifies the transportation disruption costs through evaluating and contrasting the value of service attributes under scenarios with and without a disruption to the international containerised maritime transportation chains. The results herein reveal that, on average, the value of time under a transportation disruption could be more than a fourfold increase over that held during normal operating conditions whilst the value of reliability increase almost doubles, and the value to avoid damage increases approximately by 20 percent. This finding implies that transportation disruption costs may be severely underestimated when calculated using traditional average values of freight travel time in situations where disruptions are infrequent. Industrial parties have the ability to apply the quantitative differences identified herein when calculating transportation disruption costs within their contingency strategies to mitigate the impacts of a transportation disruption. 3) Heterogeneity of shippers' preferences increases when a disruption takes place. The results from the LCM indicate that three latent classes are identified under a disruption. That is, the importance of maritime service attributes is obviously affected by a disruption, and varies with individual shipper's characteristics, such as industry categories, shipment information, and company/SC characteristics. Therefore, the contingency strategies to handle a transportation disruption could diverge from firm to firm.

Hypothesis H_3 was also confirmed, suggesting that companies located in different geographical locations will vary in their preference for transport service attributes under operational conditions with or without a disruption event. Firms should consider not only integrating this knowledge into their transportation decisions but also SCM strategies, such as its facility location decisions.

Hypothesis H_4 was confirmed, indicating that shippers' preferences for maritime transport service attributes are influenced by the value of their shipping goods and the goods industry categories, both with and without a disruption event. This finding indicates the importance of maritime service attributes under normal and abnormal operations vary with a shipper's cargo category and value. Therefore, shippers' transport decisions are based on what is being shipped. A generalized assessment of shippers' preferences could cause biased understanding for all industrial parties.

Hypothesis H_5 was confirmed. Significant differences between exporters and importers, and large and small enterprises were found to be indicators of differences between shippers' preferences for maritime transport service attributes. This suggests that shippers design their transportation strategies differently according to organization sizes and their business nature of importer or exporter roles when dealing with international trade. Practically, carriers may use this finding to customization their services and strengthen their competitiveness in appropriate market segments.

Hypothesis H_6 was confirmed, suggesting that companies/SCs differing in how they assess carrier reputation, design and implement contingency plans, or whether they apply a JIT inventory strategy or not, have different WTP for the various maritime service attributes explored within this thesis under normal or disrupted operations. This finding implies that firms with different SCM strategies might wish to consider the implementation of different transportation strategies when collaborating with their SC partners.

Hypothesis H_7 was confirmed. The specific characteristics of a shipment, such as shipment payment terms being CIF or FOB, and the length of shipment travel time have significant influence on shippers' preferences for an international containerised maritime transportation service. This confirms that shippers' transportation decisions vary with according to the characteristics of what is being shipped, how is payment paid, and how long is the transit time, etc. From a practical perspective, this suggests that carriers might be able to provide customized services tailored to meet the specific needs of shippers' based on their transport decision processes, as well as focus on their market strengths in terms of service offerings.

Finally, hypothesis H_8 was also confirmed. This thesis for the first time identified the influences of the preparedness of potential terrorist attacks on shippers' transport decisions. It was found that shippers, concerning about possible terrorist attacks, are willing to pay higher premiums to avoid these. Specifically, loss or damage to cargo represents the primary concern in relation to potential terrorist incidences. This thesis demonstrated how it is possible to quantify the cost of disruption to those working within SCs, which may provide insurance companies and policy makers a possible benchmark for evaluation of investment choices related to strategies to avoid or mitigate risks of maritime related terrorist incidences.

8.2 Limitations and Further Research

Although the analysis and discussion in the preceding chapters contribute to the literature in several aspects, it is important to address the limitations of this research to identify possible future research directions.

The primary limitation for related to the current research is one of limited sample size particularly in relation to important subsamples. For example, shipments under consolidation are supposed to be sensitive to damage rate, however the WTPs for all maritime service attributes were found to be statistically insignificant for both disruption and normal operation scenarios. Although state of the art experimental designs were employed, specifically designed to work with small samples, it is hypothesised that the sample size for this segment of respondents was too small. As such, it is recommended that future research employ larger sample sizes within each industry category to improve the predictive power of the models. Secondly, the sampled firms were mostly small to medium-sized importers or exporters. Future research should attempt to sample larger size firms which may have an influence upon the findings. The over sampling of small and medium sized firms in this current research may make the sample less representative than it should be, which limits any conclusions drawn to be specific to the particular sampled population of firms. Therefore, a larger sample size in different industries with different shipment characteristics crossing small and large company sizes is recommended for future research.

Further, slow streaming has been one of the dominant trends in container shipping over the past five years, and is expected to escalate in future. Building on the findings of this research, one area that could be examined further is to extend transit time and change frequency, reliability, damage rate and freight rate attributes to investigate the impacts of slow streaming on shippers' transport choice decisions.

Third, in aiming to identify any possible sources influencing shippers' maritime transport decisions, this research applied SURE regression models based on the results obtained from LCMs. That is, a sequential estimation process was employed. The use of results from one model as inputs into another model, whilst common practice, is inefficient and may induce issues of model error. Future research should look to more advanced econometric models in which a simultaneous estimation process is employed.

In addition, future efforts on this topic should be carried out from a practical industry perspective, for example, using these results in the development of new maritime transportation services and related industries. That is, there exists a need to test the findings from this thesis in practice.

8.3 Conclusions

Little research exists in the area of international containerised maritime freight transportation related to shipper preferences. This thesis develops and applies advanced discrete choice models to estimate the importance and derive the values of reliability, transit time, damage, and frequency in maritime transportation, offering a bridge to more advanced and in-depth techniques. In doing so, this thesis fills a significant gap within the literature.

Further, the quantification of the impacts a disruption to SC operations has also been scantly addressed within the literature. This thesis not only addresses this specific issue by identifying shippers' preferences within the international containerised maritime transportation sector, but also quantifies the transport related disruption costs by deriving the values of time, reliability, and damage for both normal and disrupted operational scenarios.

Furthermore, little of the transport literature has addressed shipper preferences and how they vary from one transport mode to another or from one industry to another. This research also addresses and adds to the literature on this topic by finding that shippers' preferences in the international containerised maritime transportation sector vary by geographical location, transport shipment characteristic, production characteristic, company/SCM strategy, and industry security preparedness. These differences also vary according to whether one is operating in normal conditions or experiencing some sort of disruption event. These findings should be of interest to academics and practitioners alike.

REFERENCES

Aberdeen Group 2006, Global Supply Chain Benchmark Report, Industry Priorities for Visibility, B2B Collaboration, Trade Compliance, and Risk Management. Boston, Massachusetts, USA: Aberdeen Group, Inc. .

Appleton, D. 2005, Counting the Cost of Congestion. *Presentation held at the TOC2005 Europe Conference.* Antwerp,14 June 2005.

Australian Government Department of Foreign Affairs and Trade 2009, Trade and Economic Data and Publications. *In:* Australian Government Department of Foreign Affairs and Trade (ed.). retrived on 2nd Feb, 2011 from http://www.dfat.gov.au/publications/stats.html.

Bagchi, P. K., Raghunathan, T. S. and Bardi, E. J. 1987, 'The Implications of Just-In-Time Inventory Policies on Carrier Selection', *Logistics and Transportation Review* Vol. 23, No. 4**,** pg. 373-384.

Bates, J. 1988, 'Econometric Issues in Stated Preference Analysis', *Journal of Transport Economics and Policy*, Vol. 22, No.1**,** pg.59-68.

Becker, G. S. 1965, 'A Theory of the Allocation of Time', *Economic Journal*, vol. 75**,** pp. 493–517.

Bennett, J. and Adamowicz, V. 2001, 'Some Fundamentals of Environmental Choice Modelling'. *In:* Bennett, J. and Blamey, R. (eds.) *The Choice Modelling Approach to Environmental Valuation.* Northampton, MA, USA: E. Elgar: Cheltenham, UK ; c2001.

Bentham, J., 1781, *Introduction to the Principles of Morals and Legislation*, 1948 edition, New York: Hafner.

Bergantino, A. and Bolis, S. 2005, 'An Adaptive Conjoint Analysis of Freight Service Alternatives: Evaluating the Maritime Option '. *In:* Reggiani, A. and Schintler, L. A. (eds.) *Methods and Models in Transport and Telecommunications: Cross Atlantic Perspectives.* Germany: Springer.

Beuthe, M. and Bouffioux, C. 2008, 'Analysing Qualitative Attributes of Freight Transport from Stated Orders of Preference Experiment', *Journal of Transport Economics and Policy* Volume 42, Part 1**,** pg. 105-128.

Bhat, C. R. and Castelar, S. 2002, 'A Unified Mixed Logit Framework for Modeling Revealed and Stated Preferences: Formulation and Application to Congestion Pricing Analysis in the San Francisco Bay Area', *Transportation Research Part B: Methodological,* Volume 36, Issue 7, August 2002**,** Pages 593-616.

Bhatnagar, A. and Ghose, S. 2004, 'A Latent Class Segmentation Analysis of e-shoppers', *Journal of Business Research,* vol. 57**,** pg. 758-767.

Bichou, K., 2008, Security and Risk-Based Models in Shipping and Ports: Review and Critical Analysis. Available: http://www.internationaltransportforum.org/jtrc/discussionpapers/DP200820.pdf [Accessed 8 Feb 2010].

Bliemer, M. C. and Rose, J. M. 2009, 'Designing Stated Choice Experiments: State-of-the-Art'. *In:* Kitamura, R., Yoshii, T. and Yamamoto, T. (eds.) *The Expanding Sphere of Travel Behaviour Research: Selected Papers from the 11th International Conference on Travel Behaviour Research.* Bingley, United Kingdom: Emerald Group Publishing Limited.

Bliemer, M. C. J., Rose, J. M. and Hensher, D. A. 2007, 'Efficient Stated Choice Experiments Allowing for Differences in Error Variances Across Subsets of Alternatives', *Submitted for publication to Transportation Research B.*

Boile, M., Theofanis, S., Golias, M. and Mittal, N. 2006, Empty Marine Container Management: Addressing Locally a Global Problem. *TRB Annual Meeting 2006.* Washington, DC. Paper # 06-2147.

Bolgar, C. 2011, Avoiding the Pitfalls of Supply Chain Disruptions. *In:* ZURICH (ed.) *Insights-Supply Chain Risk Issue 2011.*

Bolis, S. and Maggi, R. 1998, Adaptive Stated Preference Analysis of Shippers' Transport and Logistics Choice. *the 38th ERSA Conference.* Vienna, 1998.

Bolis, S. and Maggi, R. 2003, 'Logistics Strategy and Transport Service Choices: An Adaptive Stated Preference Experiment', *Growth and Change* vol. 34, Iss: 4**,** pg. 490-504.

Bolton, J. M. and Wei, Y. 2003, 'Distribution and Logistics in Today's China', *The China Business Review*, vol. 30, No. 5**,** pg. 8.

Bonney, J. and Leach, P. T., 2010, *Slow boat from China* [Online]. The Journal of Commerce Online. Available: http://www.joc.com/maritime/slow-boat-china [Accessed 9th Dec 2013].

Boughton, R. F. 2003, 'Addressing the Escalating Cost of Road Transport', *Logistics andTransport Focus*, Vol. 5 No. 3**,** pp. 36-43.

Braathens, N.-A., 2010, *Globalisation, Transport and the Environment*, OECD Publishing (February 10, 2010).

Bram, J., Orr, J. and Rapaport, C. 2002, ' Measuring the Effects of the September 11 Attack on New York City ', *Economic Policy Review*, vol. 8, Iss: 2**,** pg.5.

Brindley, C., 2004, *Supply Chain Risk*, England, Ashgate Publishing Limited.

Brooks, M. R. 1984, 'An Alternative Theoretical Approach to the Evaluation of Liner Shipping: Part I. Situational Factors', *Maritime Policy and Management*, vol. 11**,** pg. 35-43.

Brooks, M. R. 1985, 'An Alternative Theoretical Approach to the Evaluation of Liner Shipping: Part II. Choice Criteria', *Maritime Policy and Management*, vol. 12, Iss: 2**,** pg. 145-155.

Bureau of Transport and Regional Economics 2002, Australia's Seaborne Containerised Freight (Forecasts to 2010-11). *In:* Bureau of Transport and Regional Economics (ed.). Canberra, August 2002: the Department of Transport and Regional Services.

Business Monitor International (BMI), 2011, *China Freight Transport Report (Includes 5 Year Forecasts to 2015), Q1, 2011* [Online]. BMI, December 2010, Pages: 32. Available: http://www.researchandmarkets.com/research/e51248/china_freight_tran [Accessed 13 Feb 2012].

Cavinato, J. L. 2004, 'Supply Chain Logistics Risks: From the Back Room to the Board Room', *International Journal of Physical Distribution & Logistics Management*, vol. 35, Iss: 4**,** pp. 383-387.

Chalk, P. 2009, Maritime Piracy-Reasons, Dangers and Solutions. *The RAND Corporation Testimony Series.* Santa Monica: The RAND Corporation,.

Chapman, P., Christopher, M., Juttner, U., Peck, H. and Wilding, R. 2002, 'Identifying and Managing Supply-Chain Vulnerability', *Logistics and Transport Focus*, vol. 4, Iss:4**,** pp. 59.

China Second in Line 2010, *The Economist* [Online], Aug 16th 2010, by R.A. | Washington Available: http://www.economist.com/blogs/freeexchange/2010/08/china_0 [Accessed retrived on 1 st Oct, 2010].

Chiou, J.-S., Wu, L.-Y. and Hsu, J. C. 2002, 'The Adoption of Form Postponement Strategy in a Global Logistics System: The Case of Taiwanese Information Technology Industry', *Journal of Business Logistics*, Vol. 23, No. 1**,** pg. 107-124.

Chiu, R.-H. 1996, *'Logistics Performance of Liner Shipping in Taiwan'*, Ph. D. Dissertation, University of Wales, College of Cardiff.

Chopra, S. and Sodhi, M. S. 2004, 'Managing Risk To Avoid Supply-Chain Breakdown', *MIT Sloan Management Review*, vol. 46, Iss: 1**,** pp. 53-62.

Christopher, M., 1992, *Logistics and Supply Chain Management: Strategies for Reducing Costs and Improving Services*, London, Pitman Publishing.

Christopher, M., 2005, *Logistics and Supply Chain Management: Creating Value-Adding Networks*, Great Britain, Prentice Hall/Financial Times.

Christopher, M. and Peck, H. 2004, 'Building the Resilient Supply Chain', *International Journal of Logistics Management,* vol.15, Iss: 2**,** pp. 1-13.

Clarkson Research Services 2009, Shipping Review and Outlook, Spring 2009 and Container Intelligence Monthly. Clarkson Research Services,September, 2009.

Closs, D. J., Keller, S. B. and Mollenkopf, D. A. 2003, 'Chemical Rail Transport: the Benefits of Reliability', *Transportation Journal,* Vol. 42 No. 3**,** pp. 17-30.

Congressional Research Service (CRS) 2005, Port and Maritime Security: Background and Issues for Congress. *In:* Frittelli, J. F. (ed.) *CRS Report for Congress.*

Cooper, M. C. and Ellram, L. M. 1993, 'Characteristics of Supply Chain Management and Implication for Purchasing and Logistics Strategy', *The International Journal of Logistics Management*, vol. 4, Iss: 2**,** pp. 13-24.

Cordner, L. 2008, 'Globalisation, Geography and Governance: Why the Maritime Case Is Vital to Defending Australia's Interests', *Maritime Studies,* Issue 160, May-June, 2008**,** pg. 1-14.

Council of Supply Chain Management Professionals (CSCMP), 2010a, *Supply Chain* [Online]. Available: http://cscmp.org/digital/glossary/glossary.asp [Accessed 1st June 2010].

Council of Supply Chain Management Professionals (CSCMP), 2010b, *Supply Chain Management* [Online]. Available: http://cscmp.org/digital/glossary/glossary.asp. [Accessed 2nd June 2010].

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J. and Handfield, R. B. 2007, 'The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities', *Decision Sciences,* vol. 38, no. 1**,** pp.131-156.

Crum, M. R. and Allen, B. J. 1997, 'A Longitudinal Assessment of Motor Carrier: Shipper Relationship Trends, 1990 vs 1996', *Transportation Journal*, Vol. 37, No. 1**,** pg. 5-17.

Cucchiella, F. and Gastaldi, M. 2006, 'Risk Management in Supply Chain: A Real Option Approach', *Journal of Manufacturing Technology Management,* vol.17, Iss: 6**,** pp. 700.

Dahlman, O., Mackby, J., Sitt, B., Poucet, A., Meerburg, A., Massinon, B., Ifft, E., Asada, M. and Alewine, R. 2005, Container Security: A Proposal for a Comprehensive Code of Conduct. *National Defense University Fort McNair Washington, DC 20319.*

Danielis, R. and Marcucci, E. 2007, 'Attribute Cut-Offs in Freight Service Selection', *Transportation Research Part E,* vol 43**,** page 506–515.

Danielis, R., Marcucci, E. and Rotaris, L. 2005, 'Logistics Managers' Stated Preferences for Freight Service Attributes', *Transportation Research Part E: Logistics and Transportation Review,* Vol. 41 No. 3**,** pp. 201-215.

Danielis, R. and Rotaris, L. 1999, 'Analysing Freight Transport Demand Using Stated Preference Data: A Survey and A Research Project for the Friuli-Venezia Giulia Region', *Trasporti Europei (European Transport)* vol. 13**,** pg. 1-15.

Davier, M. v. 2009, 'Mixture Distribution Item Response Theory, Latent Class Analysis, and Diagnostic Mixture Models'. *In:* Embretson, S. E. (ed.) *Measuring Psychological Constructs: Advances in Model-based Approaches, 1st Edition.* Washington, D.C.: American Psychological Association.

Davis, T. 1993, 'Effective Supply Chain Management', *Sloan Management Review, Summer***,** pp.35-46.

Dawes, T. 2004, 'Crisis Planning', *The British Journal of Administrative Management***,** pp. 26.

Dekker, T. 2012, The Limits of Flexibility in Controlling for Heterogeneity in Mixed Multinomial Logit Models: An Argument for Using Latent Class Models. *IATBR 2012, July 15-20, 2012.* Toronto, Ontario • Canada.

Diop, A., Hartman, D. and Rexrode, D. 2007, C-TPAT Partners Cost/Benefit Survey, Report of Results 2007. CBP:Washington DC: Center for Survey Research, University of Virginia; Weldon Cooper Center for Public Service, University of Virginia.

Donnelly, W. A. 1982, 'The Regional Demand for Petrol in Australia', *Economic Record*, vol. 58**,** pg. 317-327.

Drewry Maritime Research, 2013, *Slow steaming to escalate* [Online]. Available: http://www.cnss.com.cn/html/2013/updates_0521/103068.html [Accessed 15 Dec 2013].

Drewry Shipping Consultants 2006a, The Drewry Annual Container Market Review and Forecast 2006/07. *Drewry Shipping Consultants.* London.

Drewry Shipping Consultants 2006b, The Drewry Container Shipper Insight – Fourth Quarter 2006. *Drewry Shipping Consultants.* London.

Estache, A. and Rus, G. d., 2000, *Privatization and Regulation of Transport Infrastructure: Guidelines for Policymakers and Regulators,* Washington, D.C., World Bank Institute.

Evenson, R. E. 1999, Global and Local Implications of Biotechnology and Climate Change for Future Food Supplies. *This paper was presented at the National Academy of Sciences Colloquium "Plants and Population: Is There Time?" held December 5–6, 1998, at the Arnold and Mabel Beckman Center in Irvine, CA. vol. 96, Iss:11, pp.5921-5928.*

Feo-Valero, M., García-Menéndez, L., Sáez-Carramolino, L. and Furió-Pruñonosa, S. 2011, 'The Importance of the Inland Leg of Containerised Maritime Shipments: An Analysis of Modal Choice Determinants in Spain', *Transportation Research Part E,* Volume 47 , Issue 4**,** pg. 446–460.

Figliozzia, M. A. 2010, 'The Impacts of Congestion on Commercial Vehicle Tour Characteristics and Costs ', *Transportation Research Part E: Logistics and Transportation Review,* vol. 46, Iss: 44**,** Pages 496-506.

Fowkes, A. S., Firmin, P. E., Tweddle, G. and Whiteing, A. E. 2004, 'How Highly Does the Freight Transport Industry Value Journey Time Reliability and for What Reasons?', *InternationalJournal of Logistics: Research and Applications, ,* Vol. 7 No. 1**,** pp. 33-43.

Fowkes, A. S. and Tweddle, G. 1997, Validation of Stated Preference Forecasting: A case Study Involving Anglo-Continental Freight. *Transportation planning methods Volume 11. Proceedings of seminar F held at PTRC European Transport Forum, Brunel University, England, 1-5 September 1997. Volume P415.* Publisched by PTRC Education and Research Service Ltd, London, pp.173-189.

Fridstrom, L. and Madslien, A. 1994, Own Account or Hire Freight. *the International Conference on Travel Behaviour.* Valle Nevado, Santiago de Chile, 12–16 June 1994.

Frosdick, M. 1997, 'The Techniques of Risk Management are Insufficient in Themselves ', *Disaster Prevention and Management,* vol. 6, Iss: 3**,** pp. 165-177.

Gihson, B. J., Mentzer, J. T. and Cook, R. L. 2005, 'Supply Chain Management: The Pursuit of a Consensus Definition', *Journal of Business Logistics,* vol. 26, Iss: 2**,** pp.17-25.

Giles, D. E. A. and Hampton, P. 1984, 'Regional Production Relationships During the Industrialization of New Zealand, 1935-1948', *Journal of Regional Science,* Nov 1984, vol. 24, Iss: 4 pg. 519-533.

Giles, D. E. A. and Hampton, P. 1987, 'A Regional Consumer Demand Model for New Zealand', *Journal of Regional Science,* vol. 27, Issue 1**,** pp. 103-118.

Greenberg, M. D., Chalk, P., Willis, H. H., Khilko, I. and Ortiz, D. S. 2006, Maritime Terrorism Risk and Liability. Santa Monica: RAND.

Greene, W. H. and Hensher, D. A. 2003, 'A Latent Class Model for Discrete Choice Analysis: Contrasts with Mixed Logit', *Transportation Research Part B* vol. 37, Iss: 8**,** pg. 681-698.

Grisolía, J. M. and Willis, K. G. 2012, 'A Latent Class Model of Theatre Demand', *Journal of Cultural Economics*, vol. 36, No. 2**,** pg. 113-139.

Gulyani, S. 2001, 'Effects of Poor Transportation on Lean Production and Industrial Clustering: Evidence from the Indian Auto Industry', *World Development*, vol. 29, No. 7**,** pg. 1157-1177.

Hale, T. and Moberg, C. R. 2005, 'Improving Supply Chain Disaster Preparedness: A Decision Process for Secure Site Location', *International Journal of Physical Distribution & Logistics Management,* vol. 35, Iss: 3/4**,** pp. 195.

Handfield, R. and McCormack, K. P., 2007*, Supply Chain Risk Management: Minimizing Disruptions in Global Sourcing,* Boca Raton, Auberbach Publications.

Harel, O. and Miglioretti, D. 2007, 'Missing Information as a Diagnostic Tool for Latent Class Analysis', *Journal of Data Science,* vol. 5**,** pg. 269-288.

Harland, C., Brenchley, R. and Walker, H. 2003, 'Risk in Supply Networks', *Journal of Purchasing and Supply Management,* vol. 9, Iss: 2**,** pp. 51-62.

Hendricks, K. B. and Singhal, V. R. 2003, 'The Effect of Supply Chain Glitches on Shareholder Wealth', *Journal of Operations Management,* vol. 21, Iss: 5**,** pp. 501.

Hendricks, K. B. and Singhal, V. R. 2005, 'An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm', *Production & Operations Management,* vol. 14, Iss: 1**,** pp. 35-52.

Hensher, D., Louviere, J. and Swait, J. 1999, 'Combining Sources of Preference Data', *Journal of Econometrics* vol. 89**,** pg. 197-221.

Hensher, D. and Puckett, S., 2004, *Freight Distribution in Urban Areas: The Role of Supply Chain Alliances in Addressing the Challenge of Traffic Congestion for City Logistics,* Sydney, Australia, Institute of Transport and Logistics Studies (ITLS), University of Sydney.

Hensher, D. A. and Greene, W. H. 2003, 'The Mixed Logit model: The state of practice', *Transportation,* May 2003; 30, 2, pg. 133.

Hensher, D. A., Rose, J. M. and Greene, W. H., 2005, *Applied Choice Analysis: A Primer*, Cambridge, Cambridge University Press

Hess, S., Ben-Akiva, M., Gopinath, D. and Walker, J., 2011, Advantages of Latent Class Over Continuous Mixture of Logit Models. Available: http://www.stephanehess.me.uk/papers/Hess_Ben-Akiva_Gopinath_Walker_May_2011.pdf [Accessed 12 Mar 2012].

Hole, A. R. 2008, 'Modelling Heterogeneity in Patients' Preferences for the Attributes of a General Practitioner Appointment', *Journal of Health Economics*, vol. 27, Iss: 4**,** pp.1078-1094.

International Maritime Bureau's (IMB) Piracy Reporting Centre 2010, Report on Piracy and Armed Robbery against Ships. 14 January 2010, Kuala Lumpur, IMB.

International Maritime Organization (IMO) 2005, International Shipping, Carrier of the World Trade. *World Maritime Day 2005, IMO.* United Nations, New York, NY.

International Maritime Organization (IMO) 2009, International Shipping and World Trade Facts and Figures. Maritime Knowledge Centre of the IMO.

Jamaluddin, T. and Shah, T. M. 1995, *'Marketing of Freight Liner Shipping Services with Reference to the Far East-Europe Trade: A Malaysian Perspective'*, Ph.D. Dissertation, University of Wales, College of Cardiff.

Johnson, J. C. 2007, 'China: A Sleeping Giant Arises', *Journal of Transportation Law, Logistics, and Policy*, vol. 74, No. 1**,** pg. 11-48.

Jong, G. d. 2000, 'Value of Freight Travel-Time Savings'. *In:* Hensher, D. A. and Button, K. J. (eds.) *Handbook of Transport Modelling, 1st Edition.* New York : Pergamon, 2000.

Judge, G. G., Griffiths, W. E., Hill, R. C., Lütkepohl, H. and lee, T.-C., 1985, *The Theory and Practice of Econometrics, 2nd Edition*, New York, Wiley, c1985.

Jüttner, U., Peck, H. and Christopher, M. 2003, 'Supply Chain Risk Management: Outlining an Agenda for Future Research ', *International Journal of Logistics: Research and Applications*, vol. 6, No. 4**,** pp. 197-210.

Karemera, D. and Koo, W. W. 1994, 'Trade Creation and Diversion Effects of the U.S.-Canadian Free Trade Agreement', *Contemporary Economic Policy*, Jan 1994; vol. 12, Iss: 1**,** pg. 12-23.

Kawamura, K. 2000, 'Perceived Value of Time for Truck Operators', *Transportation Research Record: Journal of the Transportation Research Board*, volume 1725 / 2000**,** pg. 31-36.

Kendall, l. C. and Buckley, J. J., 2001, *The Business of Shipping*, Centrevill, Maryland, Cornell Maritime Press.

Kent, J. L. and Parker, R. S. 1999, 'International Containership Carrier Selection Criteria: Shippers/Carriers Differences', *International Journal of Physical Distribution & Logistics Management*, Vol. 29 No. 6, pp. 398-408.

Khan, O. and Burnes, B. 2007, 'Risk and Supply Chain Management: Creating a Research Agenda', *The International Journal of Logistics Management*, Vol. 18 No. 2**,** pp. 197-216.

Kleindorfer, P. R. and Saad, G. H. 2005, 'Managing Disruption Risks in Supply Chains', *Production & Operations Management*, Vol. 14, Iss:1**,** pg.53-68.

Klie, L., 2006, *Disaster-Proofing the Supply Chain* [Online]. Food Logistics. Available: http://www.foodlogistics.com [Accessed 6 March 2009].

Kmenta, J. and Gilbert, R. F. 1968, ' Small Sample Properties of Alternative Estimators of Seemingly Unrelated Regressions', *Journal of the American Statistical Association* vol. 63, Iss: 324 pp. 1180–1200.

KPMG 2011, Supply Chain Complexity: Managing Constant Change- A Study of Supply Chain Maturity. UK: KPMG LLP

Kurri, J., Sirkiä, A. and Mikola, J. 2000, 'Value of Time in Freight Transport in Finland', *Transportation Research Record: Journal of the Transportation Research Board*, Volume 1725 / 2000**,** pg. 26-30.

Lado, N., Martinez-Ros, E. and Valenzuela, A. 2004, 'Identifying Successful Marketing Strategies by Export Regional Destination', *International Marketing Review,* vol. 21, Iss: 6**,** pg.573.

Lambert, D. M., Lewis, M. C. and Stock, J. R. 1993, 'How Shippers Select and Evaluate General Commodities LTL Motor Carriers', *Journal of Business Logistics,* Vol. 14 No. 1**,** pg. 131-143.

Lambert, D. M., Stock, J. R. and Ellram, L. M., 1998, *Fundamentals of Logistics Managment,* Boston MA: Irwin/McGraw-Hill.

Lancaster, K. J. 1966, 'A New Approach to Consumer Theory', *Journal of Political Economy,* vol. 74**,** pg. 132-157.

Lazarsfeld, P. F. and Henry, N. W., 1968, *Latent Structure Analysis,* Boston, Houghton Mill.

Lee, E.-S. and Song, D.-W. 2010, 'Knowledge Management for Maritime Logistics Value: Discussing Conceptual Issues', *Maritime Policy & Management*, vol. 37, Iss: 6 pp. 563 — 583.

LockamyIII, A. and McCormack, K. 2010, 'Analysing Risks in Supply Networks to Facilitate Outsourcing Decisions', *International Journal of Production Research*, Vol. 48, No. 2**,** pp. 593–611.

Londe, B. J. L. and Masters, J. M. 1994, 'Emerging Logistics Strategies: Blueprints for the Next Century', *International Journal of Physical Distribution & Logistics Management*, vol. 24, Iss: 7**,** pp. 35-47.

Louviere, J. J. 2001, 'Choice Experiments: An Overview of Concepts and Issues'. *In:* Bennett, J. and Blamey, R. (eds.) *The Choice Modelling Approach to Environmental Valuation.* Northampton: Cheltenham, UK, c2001. .

Louviere, J. J. and Hensher, D. A. 1983, 'Using Discrete Choice Models with Experimental Design Data to Forecast Consumer Demand for a Unique Cultural Event', *The Journal of Consumer Research*, vol. 10, Iss: 3 (Dec., 1983)**,** pg.348-361.

Louviere, J. J., Hensher, D. A. and Swait, J. D., 2000, *Stated Choice Methods: Analysis and Applications*, Cambridge, UK, Cambridge University Press.

Louviere, J. J. and Woodworth, G. 1983, 'Design and Analysis of Simulated Consumer Choice or Allocation Experiments: An Approach Based on Aggregate Data', *Journal of Marketing Research (pre-1986)*, Nov 1983; vol. 20**,** pg. 350.

Magala, M. and Sammons, A. 2008, 'A New Approach to Port Choice Modelling', *Maritime Economics & Logistics,* vol. 10**,** pg. 9-34.

Maloni, M., Paul, J. A. and Gligor, D. M. 2013, 'Slow steaming impacts on ocean carriers and shippers', *Maritime Economics & Logistics,* 15, 2**,** pp.151-171.

Manuj, I. and Mentzer, J. T. 2008, 'Global Supply Chain Risk Management', *Journal of Business Logistics,* Vol. 29, No. 1 pp. 133-155.

Marcucci, E. and Danielis, R. 2008, 'The Potential Demand for a Urban Freight Consolidation Centre', *Transportation* vol. 35**,** page 269–284.

Marschak, J. 1960, 'Binary Choice Constraints on Random Utility Indicators'. *In:* Kenneth, A. (ed.) *Stanford Symposium on: Mathematical Methods in the Social Sciences.* Stanford,CA: Stanford University Press, 1960, pp. 312-329.

Mason, R. J. and Lalwani, C. 2004, Integrating Transport into the Supply Chain to Improve Supply Chain Performance. *Proceedings of the 9th Logistics Research Network Conference,* . Dublin, Ireland, 9-10 September, 2004, pp. 565-578.

Mason, S. J., Ribera, P. M., Farris, J. A. and Kirk, R. G. 2003, 'Integrating the Warehousing and Transport Functions of the Supply Chain', *Transportation Research Part E: Logistics andTransportation Review,* Vol. 39, No. 2**,** pp. 565-578.

Mason-Jones, R. and Towill, D. R. 1998, 'Shrinking the Supply Chain Uncertainty Circle', *Control,* September, 1998**,** pg. 17-22.

Massachu-setts Institute of Technology (MIT) Center for Transportation & Logistics 2008, Development of a Statewide Freight System Resiliency Plan-Final Research Report. *Freight System Resiliency.* Cambridge, MA: MIT Center for Transportation & Logistics.

Massiani, J. 2003, Can We Use Hedonic Pricing to Estimate Freight Value of Time. *the 10th International Conference on Travel Behaviour Research.* Lucerne, Switzerland, 2003.

McFadden, D. 2001, 'Economic Choices', *The American Economic Review* vol. 91, Iss: 3**,** pg. 351-378.

McGinnis, M. A. 1990, 'The Relative Importance of Cost and Service in Freight Transportation Choice: Before and After Deregulation', *Transportation Journal,* Vol. 30, No. 1**,** pg. 12-19.

Mckinnon, A. 1999, 'The Effect of Traffic Congestion on the Efficiency of Logistical Operations', *International Journal of Logistics: Research and Applications,* vol. 2**,** pg. 111-129.

McKinnon, A. and Ge, Y. 2004, 'Use of a Synchronised Vehicle Audit to Determine Opportunitiesfor Improving Transport Efficiency in a Supply Chain', *International Journal of Logistics: Research and Applications,* Vol. 7 No. 3**,** pp. 219-238.

Meixell, M. J. and Norbis, M. 2008, 'A Review of the Transportation Mode Choice and Carrier Selection Literature', *The International Journal of Logistics Management,* Vol.19, No.2**,** pp. 183-211.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D. and Zacharia, Z. G. 2001, 'Defining Supply Chain Management', *Journal of Business Logistics,* vol. 22, Iss: 2**,** pp. 1-25.

Mentzer, J. T., Stank, T. P. and Esper, T. L. 2008, 'Supply Chain Management and its Relationship to Logistics, Marketing, Production, and Operations Management', *Journal of Business Logistics,* vol. 29, Iss: 1**,** pp. 31-46.

Moore, P. G., 1983, *The Business of Risk,* Cambridge University Press, Cambridge.

Naik-Panvelkar, P., Armour, C., Rose, J. M. and Saini, B. 2012, 'Patient Preferences for Community Pharmacy Asthma Services: A Discrete Choice Experiment', *pharmacoeconomics,* vol. 30, Iss: 10**,** pg. 961-976.

Neiger, D., Rotaru, K. and Churilov, L. 2009, 'Supply Chain Risk Identification with Value-Focused Process Engineering', *Journal of Operations Management,* vol. 27**,** pp. 154–168.

Norrman, A. and Jansson, U. 2004, 'Ericsson's Proactive Supply Chain Risk Management Approach After a Serious Sub-supplier Accident', *International Journal of Physical Distribution & Logistics Management*, vol. 34, Iss: 5**,** pp.434 - 456.

Notteboom, T. and Gue, J.-P. R. 2008, 'Containerisation, Box Logistics and Global Supply Chains: The Integration of Ports and Liner Shipping Networks', *Maritime Economics & Logistics,* vol. 10**,** pg. 152-174.

Ocean Shipping Consultants 2006, The European and Mediterranean Container Port Markets to 2015. *Ocean Shipping Consultants.* Chertsey.

Olson, D. L. and Wu, D. D. 2010, 'A Review of Enterprise Risk Management in Supply Chain', *Kybernetes,* Vol. 39, No. 5**,** pp. 694-706.

Organisation for Economic Co-operation and Development (OECD) 2003, Security in Maritime Transportation: Risk Factors and Economic Impact. Maritime Transport Committee.

Organisation for Economic Co-operation and Development (OECD) 2005, Container Transport Security Across Modes European Conference of Ministers of Transport (ECMT).

Page, P., 2011, *Time, money* [Online]. The Journal of Commerce Online. Available: http://www.joc.com/commentary/time-money [Accessed 8th Dec 2013].

Panayides, P. M. 2006, 'Maritime Logistics and Global Supply Chains: Towards a Research Agenda', *Maritime Economics and Logistics,* vol. 8, Iss: 1**,** pp. 3–18.

Peck, H. 2005, 'Drivers of Supply Chain Vulnerability: An Integrated Framework', *International Journal of Physical Distribution & Logistics Management,* vol. 35, Iss: 3/4**,** pp. 210-232.

Peck, H. 2006, 'Reconciling Supply Chain Vulnerability, Risk and Supply Chain Management', *International Journal of Logistics: Research and Applications,* vol.9, Iss: 2**,** pp.127-142.

Peck, H., Abley, J., Christopher, M., Haywood, M., Saw, R., Rutherford, C. and Strathen, M. 2003, Creating Resilient Supply Chains: A Practical Guide. Cranfield University, Cranfield.

Prentice, B. E. 2008, 'Tangible and Intangible Benefits of Transportation Security Measures ', *Journal of Transportation Security,* vol. 1, Iss: 1**,** pg. 3–14.

Rao, S. and Goldsby, T. J. 2009, 'Supply Chain Risks: A Review and Typology', *The International Journal of Logistics Management,* Vol. 20, No. 1**,** pp. 97-123.

Riley, J. 2004, Terrorism and Rail Security. *In:* RAND (ed.). Santa Monica.

Rodrigues, V. S., Potter, A. and Naim, M. M. 2010, 'The Impact of Logistics Uncertainty on Sustainable Transport Operations', *International Journal of Physical Distribution & Logistics Management,* Vol. 40 No. 1/2**,** pp. 61-83.

Rodrigues, V. S., Stantchev, D., Potter, A., Naim, M. and Whiteing, A. 2008, 'Establishing a Transport Operation Focused Uncertainty Model for the Supply Chain', *International Journal of Physical Distribution & Logistics Management,* Vol. 38 No. 5**,** pp. 388-411.

Roeder, K., Lynch, K. and Nagin, D. 1999, 'Modeling Uncertainty in Latent Class Membership: A Case Study in Criminology', *Journal of the American Statistical Association,* vol. 94**,** pg. 766–776.

Rose, J. M. 2011, Advanced Discrete Choice Models: State of the Art Sydney: Faculty of Economics and Business, Institute of Transport and Logistics,The University of Sydney, Sydney, NSW, Australia

Rose, J. M. and Bliemer, M. 2006, Designing Efficient Data for Stated Choice Experiments. *11th International Conference on Travel Behaviour Research.* Kyoto, Japan, 20th August 2006

Rose, J. M. and Bliemer, M. C. J., 2005, *Constructing Efficient Choice Experiments,* Sydney, Institute of Transport and Logistics Studies, University of Sydney.

Rose, J. M., Bliemer, M. C. J., Hensher, D. A. and Collins, A. C. 2008, 'Designing Efficient Stated Choice Experiments in the Presence of Reference Alternatives', *Transportation Research Part B* vol. 42**,** pg. 395–406.

Rose, J. M., Scarpa, R. and Bliemer, M. C. J. 2009, Incorporating Model Uncertainty into the Generation of Efficient Stated Choice Experiments: A Model Averaging Approach. *International Choice Modelling Conference 2009.* Yorkshire, United Kingdom, 1st April 2009.

Royal Society 1992, Risk: Analysis, Perception and Management. Report of a Royal Society Study Group. *Royal Society.* London.

Runhaar, H. and van der Heijden, R. 2005, 'Public Policy Intervention in Freight Transport Costs: Effects on Printed Media Logistics in The Netherlands', *Transport Policy,* Vol. 12 No. 1**,** pp. 35-46.

Saldanha, J. P., Russell, D. M. and Tyworth, J. E. 2006, 'A Disaggregate Analysis of Ocean Carriers' Transit Time Performance ', *Transportation Journal*, Vol. 45 No. 2**,** pp. 39-60.

Saldanha, J. P., Tyworth, J. E., Swan, P. F. and Russell, D. M. 2009, 'Cutting logistics costs with ocean carrier selection', *Journal of Business Logistics*, 30, 2**,** pp. 175-195.

Sándor, Z. and Wedel, M. 2002, 'Profile Construction in Experimental Choice Designs for Mixed Logit Models', *Marketing Science,* vol. 21**,** pg. 455-475.

Sarathy, R. 2006, 'Security and the Global Supply Chain', *Transportation Journal*, Fall 2006; vol. 45, Iss: 4**,** pg. 28-51.

Sheffi, Y., 2005, *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*, Cambridge, MA, MIT Press (October 2005).

Sheffi, Y., James B. Rice, J., Fleck, J. M. and Caniato, F. 2003, Supply Chain Response to Global Terrorism: A Situation Scan. *EurOMA POMS Joint International Conference.* Cernobbio, June 17, 2003.

Shen, J., Sakata, Y. and Hashimoto, Y. 2009, 'Latent Class Model or Mixed Logit Model? A Comparison by Transport Mode Choice Data', *Applied Economics* vol. 41, Iss: 22**,** pg. 2915-2924.

Shinghal, N. and Fowkes, T. 2002, 'Freight Mode Choice and Adaptive Stated Preferences', *Transportation Research Part E: Logistics and Transportation Review*, vol. 38, Iss: 5**,** pg. 367-378.

Sinha, P. R., Whitman, L. E. and Malzahn, D. 2004, 'Methodology to Mitigate Supplier Risk in an Aerospace Supply Chain', *Supply Chain Management*, vol. 9, Iss: 2**,** pp.154–168.

Srivastava, V. K. and Giles, D. E. A., 1987, *Seemingly Unrelated Regression Equations Models: Estimation and Inference*, New York, Dekker, c1987.

Stank, T. P. and Goldsby, T. J. 2000, 'A Framework for Transportation Decision Making in An Integrated Supply Chain', *Supply Chain Management: An International Journal*, Vol. 5 No. 2**,** pg. 71-77.

Stecke, K. E. and Kumar, S. 2009, 'Sources of Supply Chain Disruptions, Factors That Breed Vulnerability, and Mitigating Strategies', *Journal of Marketing Channels*, vol.16, Iss: 3**,** pp.193-226.

Svensson, G. 2000, 'A Conceptual Framework for the Analysis of Vulnerability in Supply Chains', *International Journal of Physical Distribution & Logistics Management,* vol. 30**,** pp. 731-749.

Svensson, G. 2001, 'The Impact of Outsourcing on Inbound Logistics Flows', *International Journal of Logistics Management,* vol. 12, Iss: 1**,** pp. 21.

Swait, J., Louviere, J. J. and Williams, M. 1994, 'A Sequential Approach to Exploiting the Combined Strengths of SP and RP Data: Application to Freight Shipper Choice', *Transportation,* vol. 21, Iss: 2**,** pg. 135-152.

Tang, C. S. 2006a, 'Perspectives in Supply Chain Risk Management ', *International Journal of Production Economics,* vol.103, Iss: 2**,** pp. 451-488.

Tang, C. S. 2006b, 'Robust Strategies for Mitigating Supply Chain Disruptions', *International Journal of Logistics: Research and Applications,* vol. 9, Iss: 1 pp. 33–45.

Thai, V. V. 2007, 'Impacts of Security Improvements on Service Quality in Maritime Transport: An Empirical Study of Vietnam', *Maritime Economics & Logistics,* vol. 9**,** pg. 335-356.

Thibault, M., Brooks, M. R. and Button, K. J. 2006, 'The Response of the U.S. Maritime Industry to the New Container Security Initiatives', *Transportation Journal,* vol. 45, Iss: 1**,** pg. 5-15.

Thurstone, L. L. 1927, 'A Law of Comparative Judgment', *Psychological Review*, vol. 34**,** pg. 273-286.

Tiwari, P., Itoh, H. and Doi, M. 2003, 'Shippers' Port and Carrier Selection Behaviour in China: A Discrete Choice Analysis', *Maritime Economics & Logistics*, vol. 5, Iss: 1**,** pg. 23-39.

Train, K., 2003, *Discrete Choice Methods with Simulation*, Cambridge, Cambridge University Press.

Tzannatos, E. S. 2003, 'A Decision Support System for the Promotion of Security in Shipping', *Disaster Prevention and management*, vol. 12, Iss: 3**,** pg. 222-229.

U.S. Department of Homeland Security (DHS), 2007, Budget-in-Brief: Fiscal Year 2008. Available: http://www.dhs.gov/xlibrary/assets/budget_bib-fy2008.pdf [Accessed 6 January, 2011].

United Nations Conference on Trade and Development (UNCTAD) 2007, Maritime Security: ISPS Implementation, Costs and Related Financing. Geneva: UNCTAD.

United Nations Conference on Trade and Development (UNCTAD) 2009, Review of Maritime Transport. United Nations New York and Geneva, 2009: UNCTAD.

United States Customs and Border Protection (CBP), 2007, *C-TPAT Overview* [Online]. Washington, DC. Available: http://www.cbp.gov/xp/cgov/trade/cargo_security/ctpat/what_ctpat/ctpat_overview.xml [Accessed 6 Jan 2011].

United States General Accounting Office (GAO) 2002, Port Security: Nation Faces Formidable Challenges in Making New Initiativs Successful. GAO.

Upton, D. M. 1994, 'The Management of Manufacturing Flexibility', *California Management Review*, Vol. 36, No. 2**,** pg. 72-89.

Vernimmen, B., Dullaert, W. and Engelen, S. 2007, 'Schedule Unreliability in Liner Shipping: Origins and Consequences for the Hinterland Supply Chain', *Maritime Economics & Logistics,* vol. 9**,** pg. 193-213.

Vorst, J. G. A. J. v. d. and Beulens, A. J. M. 2002, 'Identifying Sources of Uncertainty to Generate Supply Chain Redesign Strategies', *International Journal of Physical Distribution & Logistics Management,* Vol.32, No. 6**,** pp.409-430.

Voss, M. D., Page, T. J., Keller, S. B. and Ozment, J. 2006, 'Determining Important Carrier Attributes: A Fresh Perspective Using the Theory of Reasoned Action', *Transportation Journal,* Vol. 45 No. 3**,** pp. 7.

Wagner, S. M. and Bode, C. 2006, 'An Empirical Investigation into Supply Chain Vulnerability', *Journal of Purchasing & Supply Management,* vol. 12 pp. 301–312.

Wagner, S. M. and Neshat, N. 2010, 'Assessing the Vulnerability of Supply Chains Using Graph Theory', *International Journal of Production Economics,* vol. 126**,** pp. 121–129.

Wang, Q., Zantow, K., Lai, F. and Wang, X. 2006, 'Strategic Postures of Third-party Logistics Providers in Mainland China', *International Journal of Physical Distribution & Logistics Management,* vol. 36**,** pg. 793.

Waters, D., 2007, *Global Logistics: New Directions in Supply Chain Management,* Great Britain, Kogan Page Limited.

Wen, C.-H. and Lai, S.-C. 2010, 'Latent Class Models of International Air Carrier Choice', *Transportation Research Part E,* Vol. 46, Iss: 2**,** pg. 211-221.

White, E. N. and Hewings, G. J. D. 1982, 'Space-time Employment Modelling: Some Results Using Seemingly Unrelated Regression Estimators', *Journal of Regional Science,* vol. 22**,** pg. 283-302.

Wigan, M., Rockliffe, N., Thoresen, T. and Tsolakis, D. 2000, 'Valuing Long-haul and Metropolitan Freight Travel Time and Reliability ', *Journal of Transportation and Statistics*, vol. 3**,** pg. 83-90.

Wikipedia, 2009, *List of the Largest Trading Partners of the People's Republic of China* [Online]. Available: http://en.wikipedia.org/wiki/List_of_the_largest_trading_partners_of_the_People%27s_Republic_of_China [Accessed 2nd Feb 2011].

Wikipedia, 2012, *Seemingly Unrelated Regressions* [Online]. Available: http://en.wikipedia.org/wiki/Seemingly_unrelated_regressions [Accessed 6th Jun 2012].

Wikipedia, 2013, *Slow steaming* [Online]. Available: http://en.wikipedia.org/wiki/Slow_steaming [Accessed 10th Dec 2013].

William, C. and Thompson, J. 2002, One Year Later-The Fiscal Impact of 9/11 on New York city. Comptroller of the city of New York, NEW YORK, N.Y.

Willis, H. H. and Ortiz, D. S. 2004, Evaluating the Security of the Global Containerised Supply Chain. Santa Monica: RAND Corporation.

Wilson, M. C. 2007, 'The Impact of Transportation Disruptions on Supply Chain Performance', *Transportation Research Part E*, vol. 43**,** pp. 295–320.

Womack, J. P. and Jones, D. T., 2005, *Lean Solutions: How Companies and Customers Can Create Value and Wealth Together*, New York, Simon & Schuster.

Wu, T., Blackhurst, J. and O'grady, P. 2007, 'Methodology for Supply Chain Disruption Analysis', *International Journal of Production Research*, vol. 45, Iss: 7**,** pp. 1665-1682.

Zamparini, L. and Reggiani, A. 2007, 'Freight Transport and the Value of Travel Time Savings: A Meta-analysis of Empirical Studies', *Transport Reviews*, Vol. 27, No. 5**,** pg. 621-636.

Zellner, A. 1962, 'An Efficient Method of Estimating Seemingly Unrelated Regression Equations and Tests for Aggregation Bias', *Journal of the American Statistical Association,* vol. 57**,** pp. 348-368.

Zhang, N. L. 2004a, 'Hierarchical Latent Class Models for Cluster Analysis', *Journal of Machine Learning Research,* vol. 5**,** pg. 697-723.

Zhang, S. 2004b, An Update on China's Maritime Policies. *OECD workshop on Maritime transport.* Paris, 4-5 November 2004.

Zhang, Z. and Figliozzi, M. A. 2010, 'A Survey of China's Logistics Industry and the Impacts of Transport Delays on Importers and Exporters', *Transport Reviews,* vol. 30, Iss: 2**,** pg. 179-194.

Zsidisin, G. A. 2003, 'Managerial Perceptions of Risk', *Journal of Supply Chain Management,* Vol. 39, No. 1**,** pp. 14-25.

Zsidisin, G. A., Ellram, L. M., Carter, J. R. and Cavinato, X. 2004, 'An Analysis of Supply Risk Assessment Techniques', *International Journal of Physical Distribution & Logistics Management,* vol. 34, Iss:5**,** pp. 397-413.

Zsidisin, G. A., Ragatz, G. L. and Melnyk, S. A. 2005, 'The Dark Side of Supply Chain Management', *Supply Chain Management Review,* vol. 9, Iss: 2**,** pp. 46-52.

GLOSSARY OF ABBREVIATIONS

SCs	Supply chains
IMO	International Maritime Organization
OECD	Organisation for Economic Co-operation and Development
SCD	Supply chain disruption
WMD	Weapons of mass destruction
C-TPAT	The Customs-Trade Partnership Against Terrorism
ISPS	The International Ship and Port Security Code
CSI	The Container Security Initiative
CBP	The US Customs and Border Protection
AMR	The Advanced Manifest Rule (also called the 24-hour Rule)
SPP	The Security and Prosperity Partnership
SAFE	The Security and Accountability for Every (SAFE) Port Act
SFI	The Secure Freight Initiative
9/11 Act 1701	Implementing Recommendations of the 9/11 Commission Act of 2007 – Section
UNCTAD	The United Nations Conference on Trade and Development
GAO	United States General Accounting Office
SCM	Supply chain management
SP	Stated preference
RP	Revealed preference
JIT	Just in Time
WTP	Willingness to pay

CSCMP	Council of Supply Chain Management Professionals
IT	Information technology
VMI	Vendor Managed Inventory
SCR	Supply chain risk
SCV	Supply chain vulnerability
ICT	Information and communication technology
WTC	The World Trade Centre
GCP	Gross City Product
FMD	Foot and mouth disease
DA_NET	Disruption Analysis Network model
SCRM	Supply chain risk management
DDLT	Demand during lead time
CLM	The Council of Logistics Management
DC	Documentary Credit
CRS	Congressional Research Service
SME	Small and Medium sized Enterprises
EU	The European Union
ETA	Estimated time of arrival
GDP	Gross Domestic Product
IMB	International Maritime Bureau
NUMMI	The New United Motor Manufacturing Inc.
DHS	U.S. Department of Homeland Security

96 hour rule The initiative requires a four-day (96 hour) advance notice of arrival of any vessel be submitted to the U.S. government

24 hour rule This rule requires that maritime carriers and NVOCCs provide a cargo declaration 24 hours before cargo is laden aboard a vessel at a foreign port outside the U.S.

NVOCCs	Non-vessel operating common carriers
MTSA	The Maritime Transportation Security Act of 2002
OSC	Operation Safe Commerce
BMI	Business Monitor International
SURE	Seemingly unrelated regression equations
LCM	The Latent Class Model
VTTS	The value of travel time savings
VFTTS	The value of travel time saving within the freight transport sector
VOT	The freight transport value of time
VOR	The freight transport value of reliability
FOB	Free on board
CIF	Cost Insurance Freight
CM	Choice modelling
RUM	The Random Utility Maximization
EV1	Distributed extreme value type 1
IID	Independently and identically distributed
MNL	The multinomial logit model
IIA	The independence of irrelevant alternatives assumption
BIC	The Bayesian information criterion

AIC	The Akaike Information Criterion
CAIC	Consistent Akaike Information Criterion
ML	The Mixed Logit Model
FGLS	The feasible generalized least squares method
IGLS	The iterative generalized least squares
IOLS	The iterative ordinary lease squares
AVC	The asymptotic variance-covariance
FR	Freight Rate
SUR	Surcharge/Rebate
TT	Transit Time
DL	Delay
RL	Reliability
DM	Damage
FRQ	Frequency
CAPI	Computer-aided personal interview
VOD	The value of damage rate
VOF	The value of frequency
DRL	Reliability under a disruption
DDM	Damage under a disruption
ROI	Return on investment

APPENDIX A: THE INDEPENDENT VARIABLES OPERATIONALIZATION AND ABBREVIATIONS

Independent Variables	**Abb**	**Definition**
Exporter	EP	1 if firm is exporter, 0 is importer
Assess Reputation	AR	1 if firm not assess carriers reputation, 0 otherwise
Just In Time	JIT	1 if firm not apply JIT management policy, 0 otherwise
Transhipment	TRS	1 if a trip involves a transhipment, 0 otherwise
Free On Board	FOB	1 if a shipment paid by CIF, 0 paid by FOB
Reconsolidation	RC	1 if shipment is under a reconsolidation, 0 otherwise
Contingency Plan	CP	1 if firm with contingency plans to handle disruptions, 0 otherwise
Terrorist attack affecting transport decisions	TER	1 if firm not consider terrorist attack would affect its transport decisions, 0 otherwise
Shenzhen	L1	1 if firm locates in Shenzhen, 0 otherwise
Shanghai	L2	1 if firm locates in Shanghai, 0 otherwise
Sydney	L3	1 if firm locates in Sydney, 0 otherwise
Organization annual sales	OS1	1 if firm annual sales no more than USD $10 million, 0 otherwise
	OS2	1 if firm annual sales between USD $10 million and $100 million, 0 otherwise
	OS3	1 if firm annual sales more than USD $100 million, 0 otherwise
Travel time	TD1	1 if shipment overall travel days less than 22 days, 0 otherwise
	TD2	1 if shipment overall travel days between 22 and 32 days, 0 otherwise
	TD3	1 if shipment overall travel days more than 32 days, 0 otherwise
Goods value	GV1	1 if shipment cargo value less than USD $30,000 per TEU, 0 otherwise
	GV2	1 if shipment cargo value between USD $30,000 and $70,000 per TEU, 0 otherwise
	GV3	1 if shipment cargo value more than USD $30,000 per TEU, 0 otherwise
Recent delay shipment	RD1	1 if recent shipment experienced delay less than 4 days, 0 otherwise
Electronic	I1	1 if shipment commodity belongs to electronic, 0 otherwise
Construction	I2	1 if shipment commodity belongs to constructions, 0 otherwise
Garments	I3	1 if shipment commodity belongs to garments, 0 otherwise
Chemical	I4	1 if shipment commodity belongs to chemical, 0 otherwise
Machinery	I5	1 if shipment commodity belongs to machinery, 0 otherwise
Food	I6	1 if shipment commodity belongs to food, 0 otherwise
Consumer goods	I7	1 if shipment commodity belongs to consumer goods, 0 otherwise

APPENDIX B: SURVEY COVER LETTER

To: Respondent
At: Company
From: Dr. Miguel Figliozzi –
University of Sydney

INSTITUTE of TRANSPORT and LOGISTICS STUDIES

Sydney, 07-Sep.-2006

Survey Subject: value of delays, reliability, and security threats for importers/exporters

Thank you for your cooperation with this survey on behalf of ITLS and the University of Sydney. This letter is to inform you about the purpose and methodology of this survey.

How long will the interview take? 25-30 minutes

Are any sensitive or detailed data needed? No, the survey only requires your judgement based on your experience as a manager concerned with logistics matters.

What do I need to do? You will be asked some general questions about your company and maritime/container transportation. You will be presented with a set of shipping alternatives with different rates and service levels and asked to choose the alternative that you prefer.

Are all responses confidential? Absolutely, all responses will be aggregated and processed mathematically so that individual responses will no longer be distinguishable.

Why is this survey needed? This study tries to determine how shippers perceive the value of time of shipment delays. Specifically, it examines the impact of recent global security threats on shippers' costs and delays.

How does this survey help my firm? The results of this survey will reveal the costs of security threats and unreliability for importers and exporters. In addition, the results will be useful to quantify the benefits of transportation infrastructure improvements.

Can I see the final result? Yes, all respondents will receive a electronic and hardcopy versions of the final report and survey summary results.

I hope to have informed you sufficiently with this letter. If you have any further questions before or after the interview, please do not hesitate to contact us.

Thank you again for your assistance,

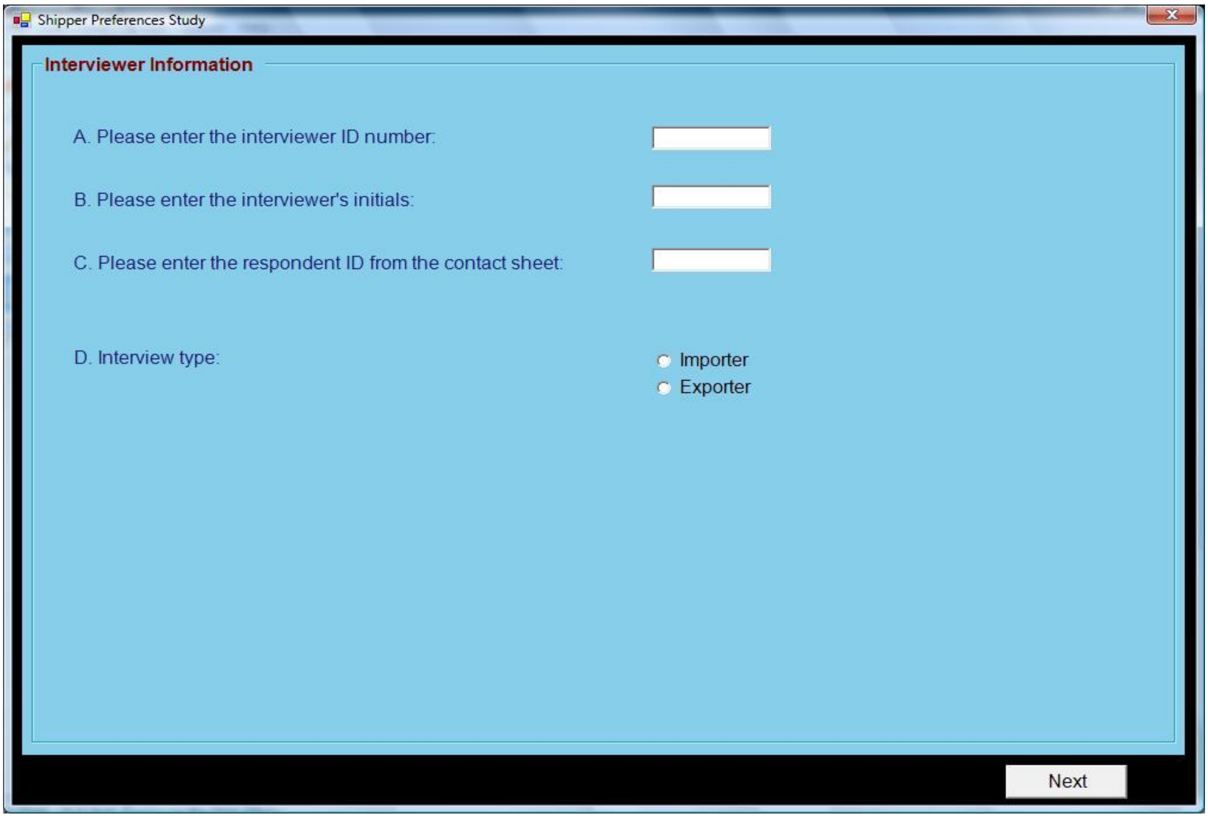
Faculty of Economics and Business
C37, The University of Sydney
NSW 2006 Australia

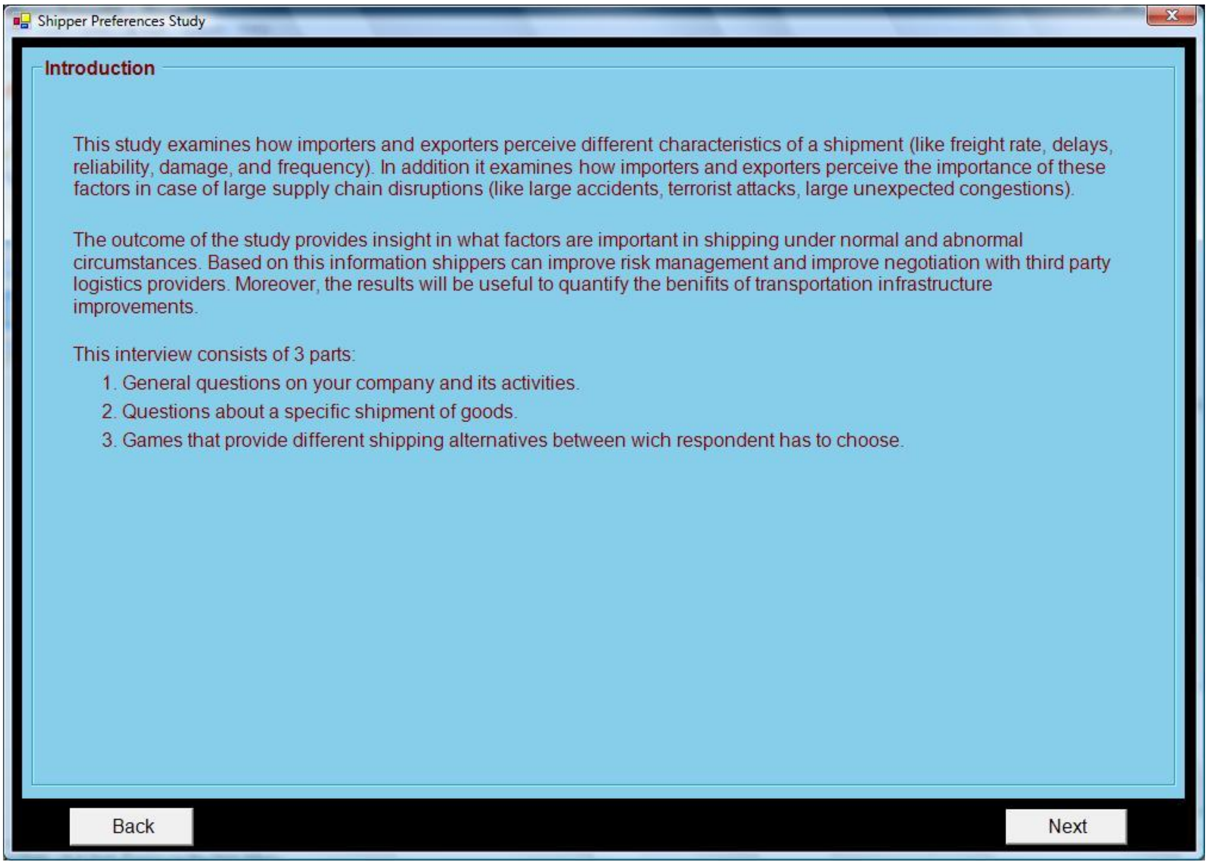
www.itls.usyd.edu.au

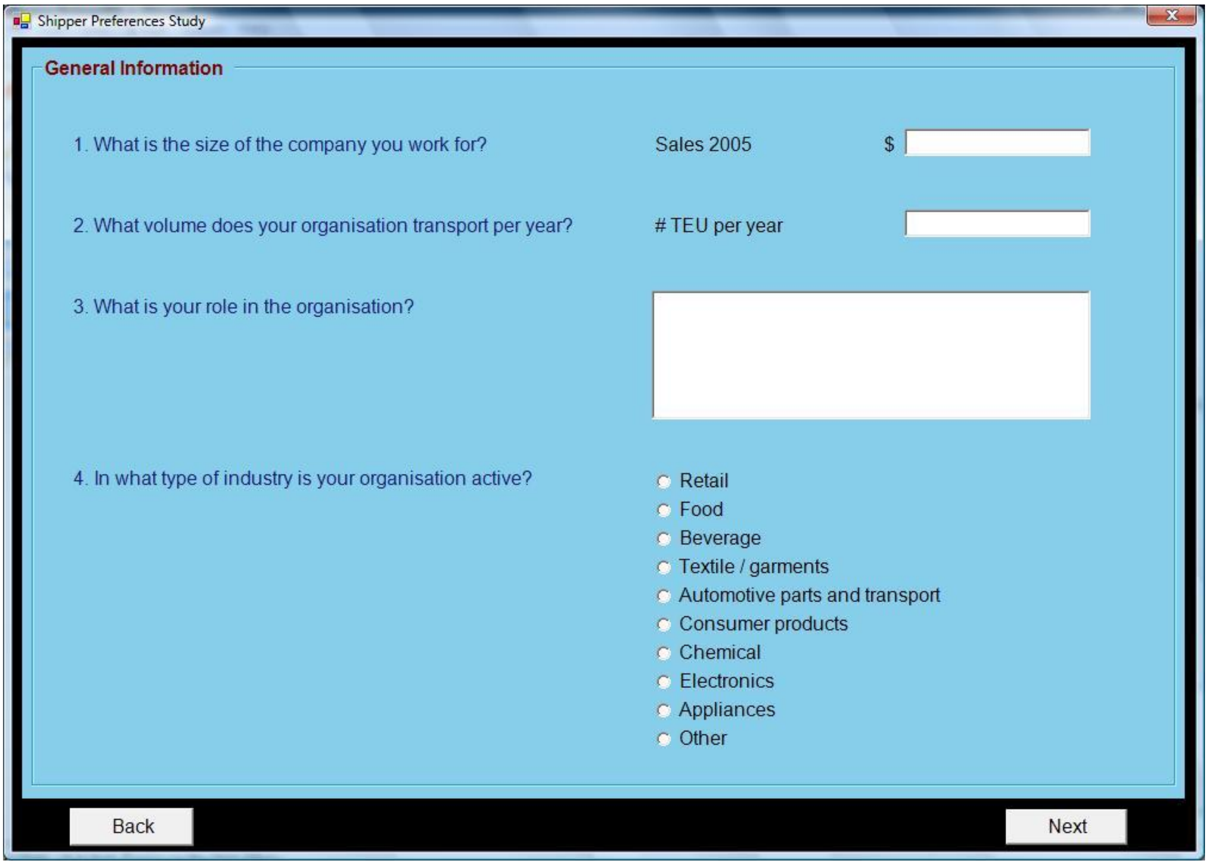
An Australian Key Centre

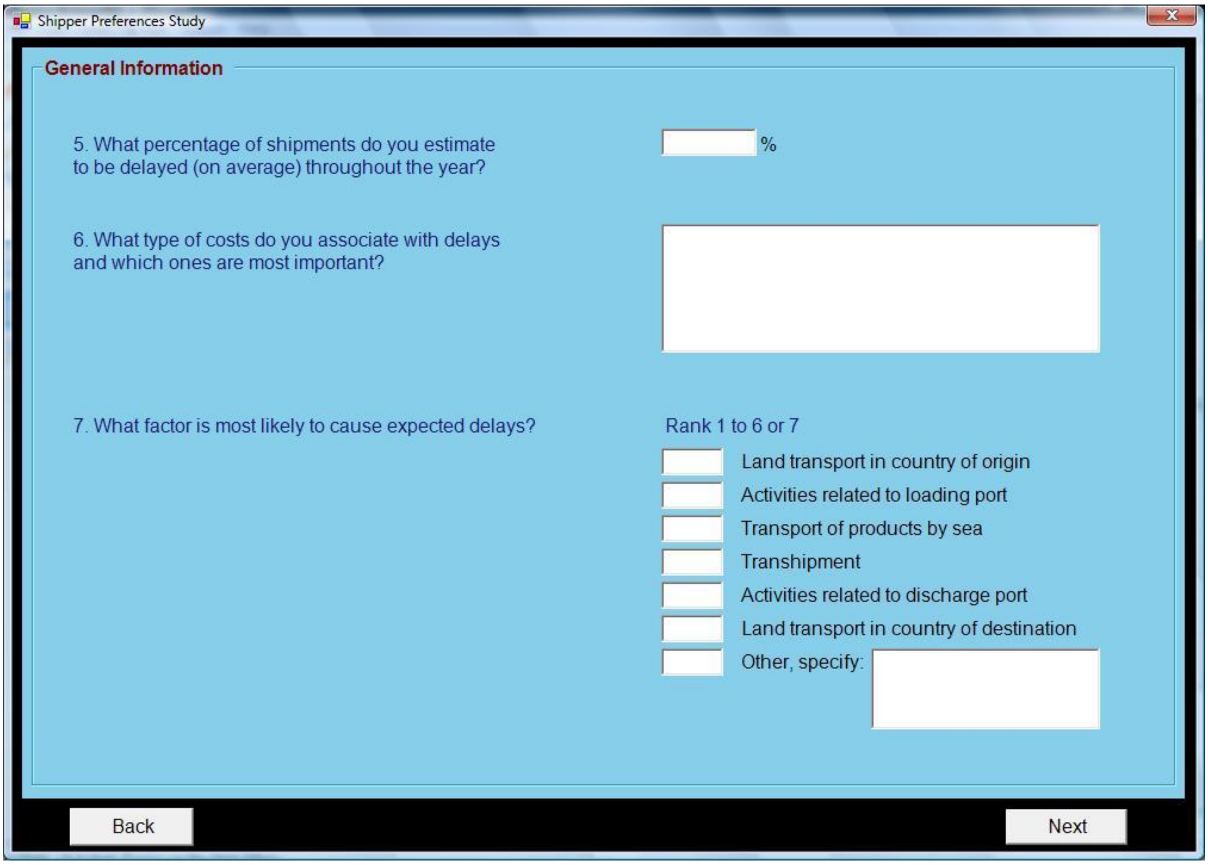
Dr. Miguel Figliozzi
Ph: (02)9351 0071-95 -- miguel@itls.usyd.edu.au

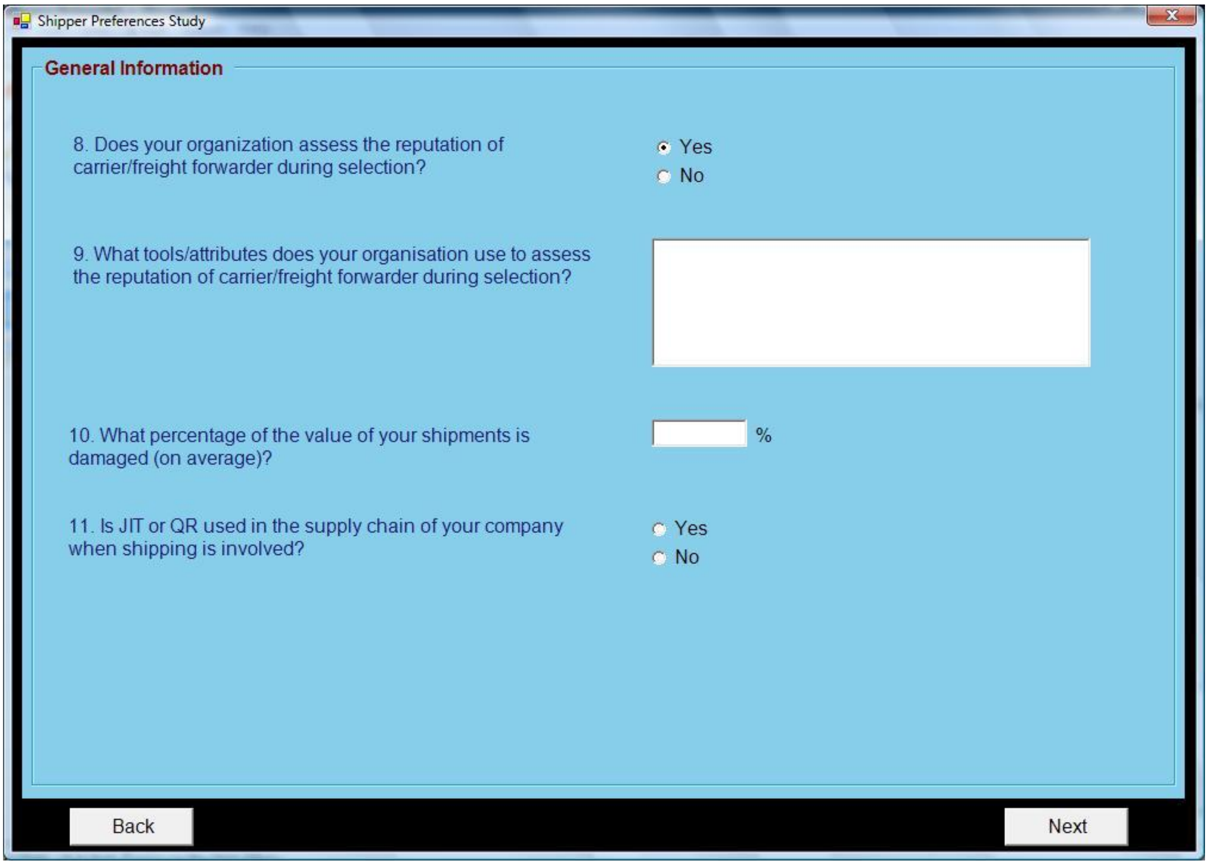
APPENDIX C: SURVEY QUESTIONNAIRE IN CAPI (ENGLISH)

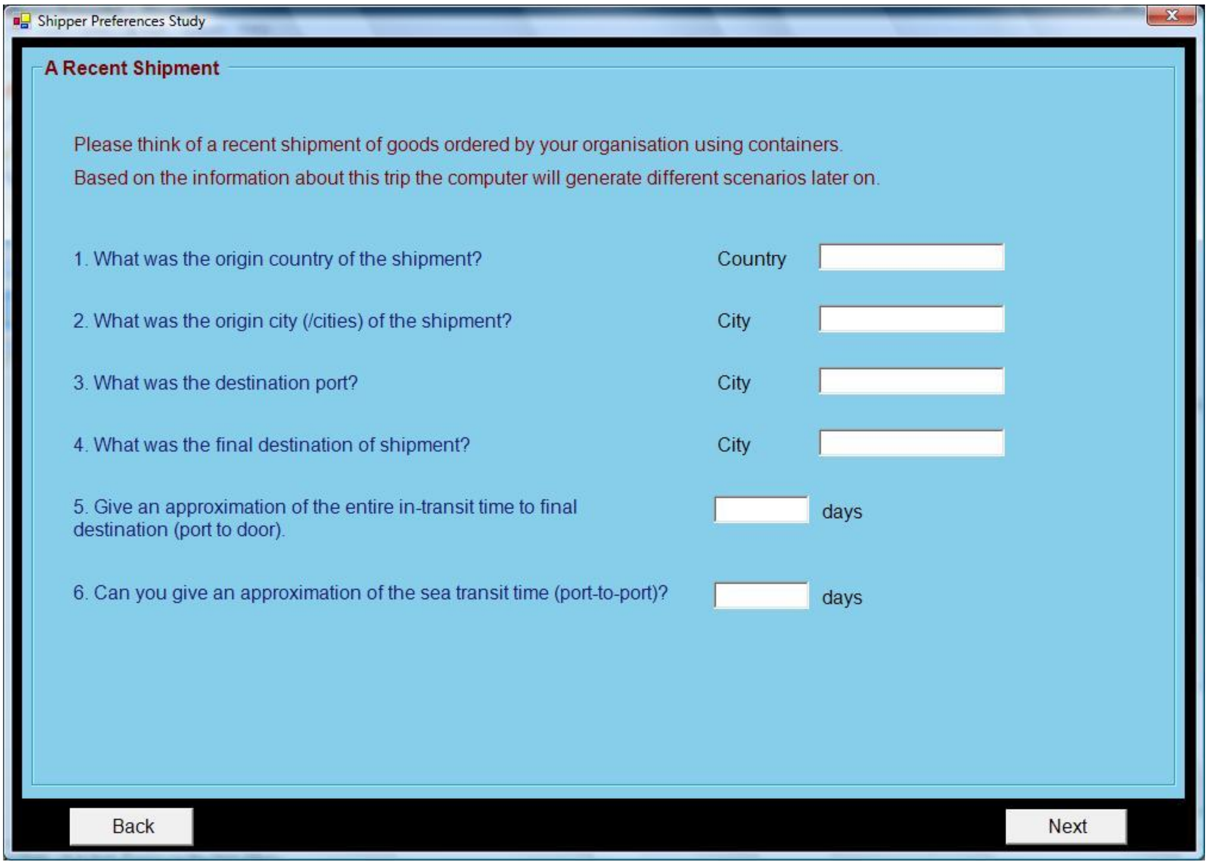


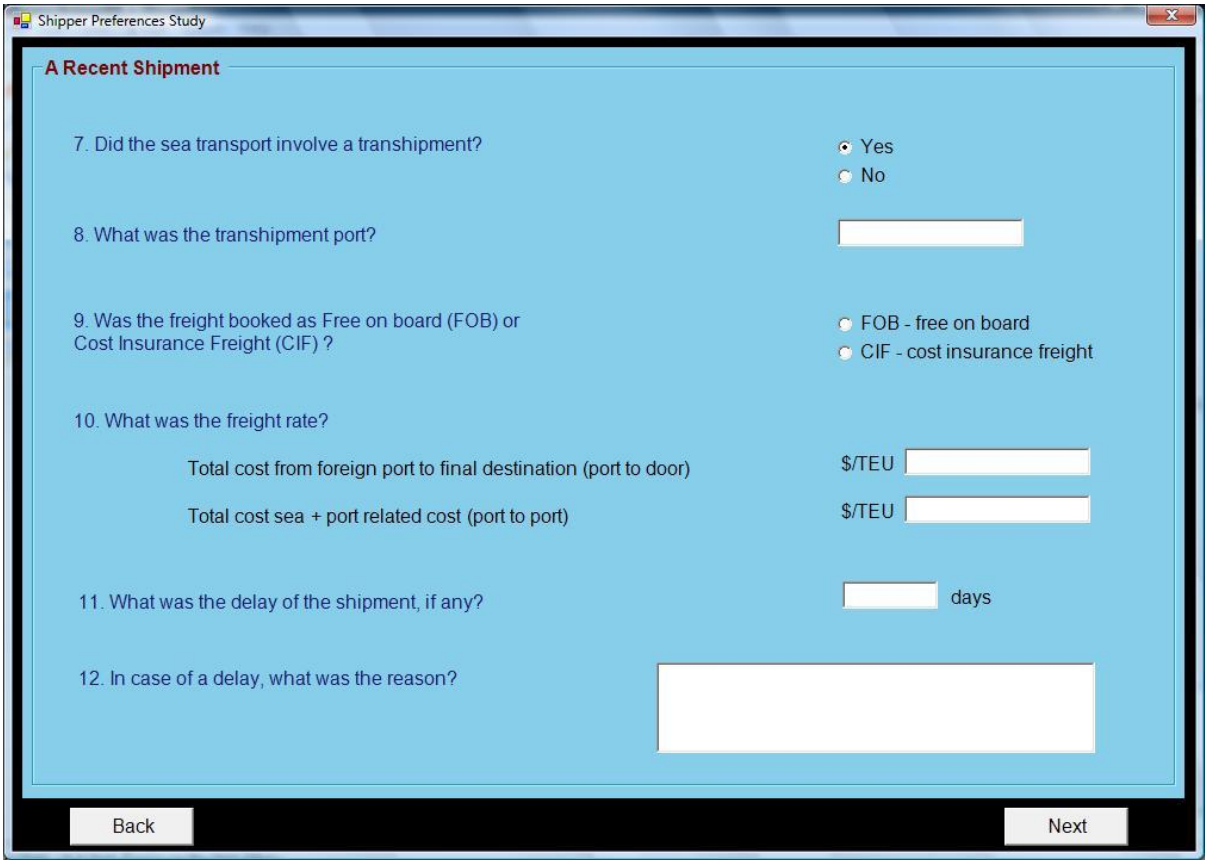

Shipper Preferences Study
Introduction
This study examines how importers and exporters perceive different characteristics of a shipment (like freight rate, delays, reliability, damage, and frequency). In addition it examines how importers and exporters perceive the importance of these factors in case of large supply chain disruptions (like large accidents, terrorist attacks, large unexpected congestions).
The outcome of the study provides insight in what factors are important in shipping under normal and abnormal circumstances. Based on this information shippers can improve risk management and improve negotiation with third party logistics providers. Moreover, the results will be useful to quantify the benifits of transportation infrastructure improvements.
This interview consists of 3 parts:
1. General questions on your company and its activities.
2. Questions about a specific shipment of goods.
3. Games that provide different shipping alternatives between wich respondent has to choose.
Back
Next


Shipper Preferences Study
General Information
1. What is the size of the company you work for?
Sales 2005
$
2. What volume does your organisation transport per year?
TEU per year
3. What is your role in the organisation?
4. In what type of industry is your organisation active?
Retail
Food
Beverage
Textile / garments
Automotive parts and transport
Consumer products
Chemical
Electronics
Appliances
Other
Back
Next


Shipper Preferences Study
General Information
5. What percentage of shipments do you estimate to be delayed (on average) throughout the year?
%
6. What type of costs do you associate with delays and which ones are most important?
7. What factor is most likely to cause expected delays?
Rank 1 to 6 or 7
Land transport in country of origin
Activities related to loading port
Transport of products by sea
Transhipment
Activities related to discharge port
Land transport in country of destination
Other, specify:
Back
Next


Shipper Preferences Study
General Information
8. Does your organization assess the reputation of carrier/freight forwarder during selection?
Yes
No
9. What tools/attributes does your organisation use to assess the reputation of carrier/freight forwarder during selection?
10. What percentage of the value of your shipments is damaged (on average)?
%
11. Is JIT or QR used in the supply chain of your company when shipping is involved?
Yes
No
Back
Next


Shipper Preferences Study
A Recent Shipment
Please think of a recent shipment of goods ordered by your organisation using containers.
Based on the information about this trip the computer will generate different scenarios later on.
1. What was the origin country of the shipment?
Country
2. What was the origin city (/cities) of the shipment?
City
3. What was the destination port?
City
4. What was the final destination of shipment?
City
5. Give an approximation of the entire in-transit time to final destination (port to door).
days
6. Can you give an approximation of the sea transit time (port-to-port)?
days
Back
Next


Shipper Preferences Study
A Recent Shipment
7. Did the sea transport involve a transhipment?
Yes
No
8. What was the transhipment port?
9. Was the freight booked as Free on board (FOB) or Cost Insurance Freight (CIF) ?
FOB - free on board
CIF - cost insurance freight
10. What was the freight rate?
Total cost from foreign port to final destination (port to door)
$/TEU
Total cost sea + port related cost (port to port)
$/TEU
11. What was the delay of the shipment, if any?
days
12. In case of a delay, what was the reason?
Back
Next

Shipper Preferences Study

A Recent Shipment

13. What was the size of the shipment? # TEU

14. What was the value of goods per container for this shipment? $ / TEU

15. What was the type of commodity?

16. Was the shipment based on a consolidation (multiple shippers using the same container)?
- Yes
- No

17. How was the freight booked?
- Forwarder / NVO
- Carrier

Back Next

Shipper Preferences Study

Practice Scenario

Scenario: Assume you have 4 different service levels or options to arrange the transportation of your containers. You have to choose which option suits your personal preferences best based on the given attributes.

The attributes that might influence your choice are:

Freight rate	The rate per container (TEU/FEU as appropriate). The levels are similar to your stated freight rate of $2,500.00
Transit time	Door to door time. The levels are similar to your stated transit time of 25 days
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.
Frequency of service	The number of services per week. (a frequency of 0.5 is equivalent to 1 service every 2 weeks)

	Option 1	Option 2	Option 3	Option 4
Freight rate (FR)	$2,210.00	$2,790.00	$2,600.00	$2,210.00
Transit time (TT)	26 days	22 days	26 days	24 days
Reliability	78%	90%	84%	96%
Damage	0.5%	0.5%	1.5%	2%
Frequency	0.5	2	1	1.5
What is your preferred option?	Option 1	Option 2	Option 3	Option 4

Back Next

Shipper Preferences Study

模拟练习

情节: 假设你有 4种不同的选项来安排你的集装箱运输，其中每个选项包括四到五个不同程度的服务属性。
基于给定的属性变量，请选择一个你认为最适合你的选项来安排你的集装箱运输。

可能影响你选择的服务属性是

运输费用	指每个集装箱的运费率 (20 FCL或40 FCL的) 在本实验中所设计的运费与你前面给定的 ¥2,500.00 类似。
在途时间	指门对门（客户到客户的运输时间） 在本实验中设计的在途时间与你前面所给定的 25天相类似。
可信度	指该船运将不遭受延迟的百分比 该数据与不同的船运公司/不同运输路线的历史记录相一致。
损坏率	指货物在运输途中的损坏率 该数据与不同的船运公司/不同运输路线的历史记录相一致。
航班的频率	指每星期的船运航班的次数。 例如，0.5的航班服务频率就是指每2周有1个航班。

	选项 1	选项 2	选项 3	选项 4
运输费用	¥2,420.00	¥2,420.00	¥2,420.00	¥2,750.00
在途时间	23 天	31 天	27 天	19 天
可信度	78%	90%	96%	84%
损坏率	0.25%	1%	0.75%	1%
航班频率/每周	0.5	1	2	1
你的最优选项是什么?	○ 选项 1	○ 选项 2	○ 选项 3	○ 选项 4

Back Next

Shipper Preferences Study

Scenario 1

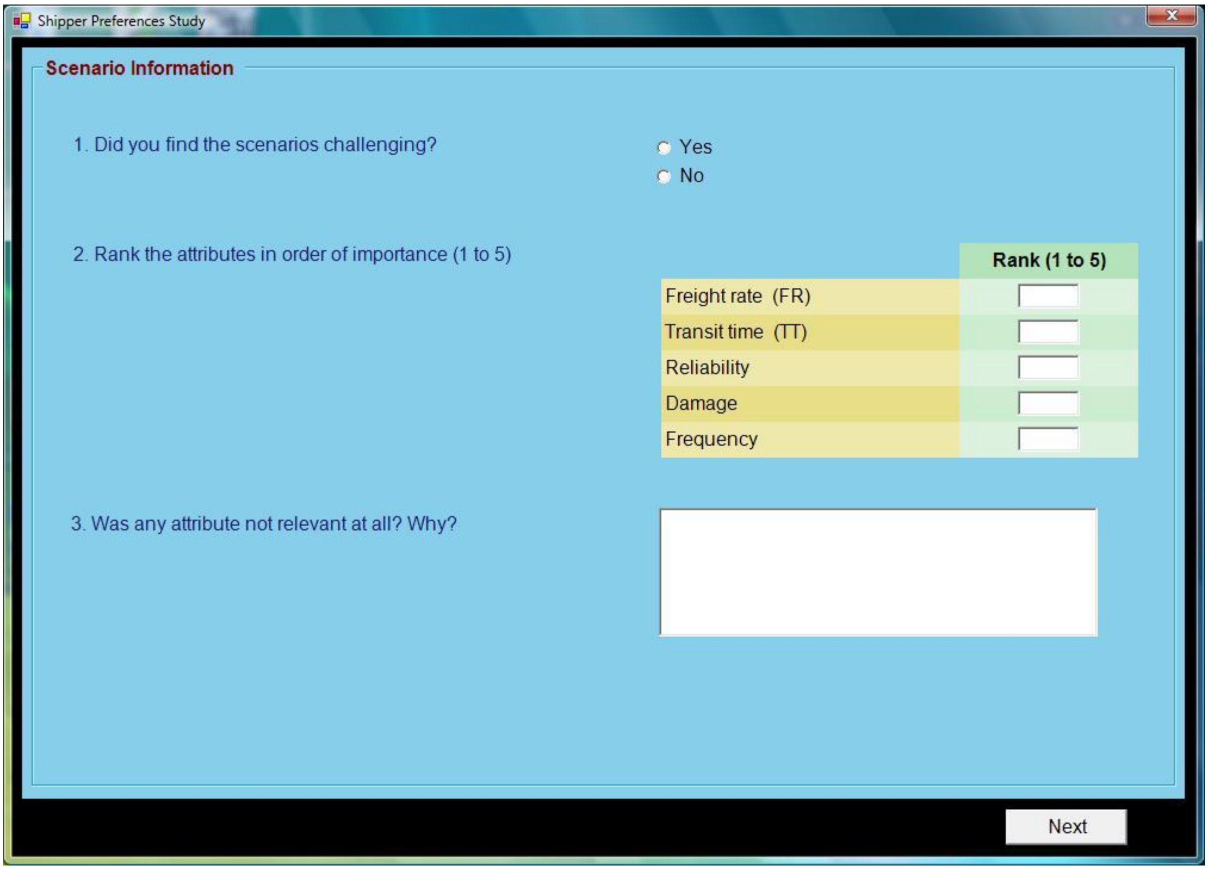
Scenario: Assume you have 4 different service levels or options to arrange the transportation of your containers.
You have to choose which option suits your personal preferences best based on the given attributes.

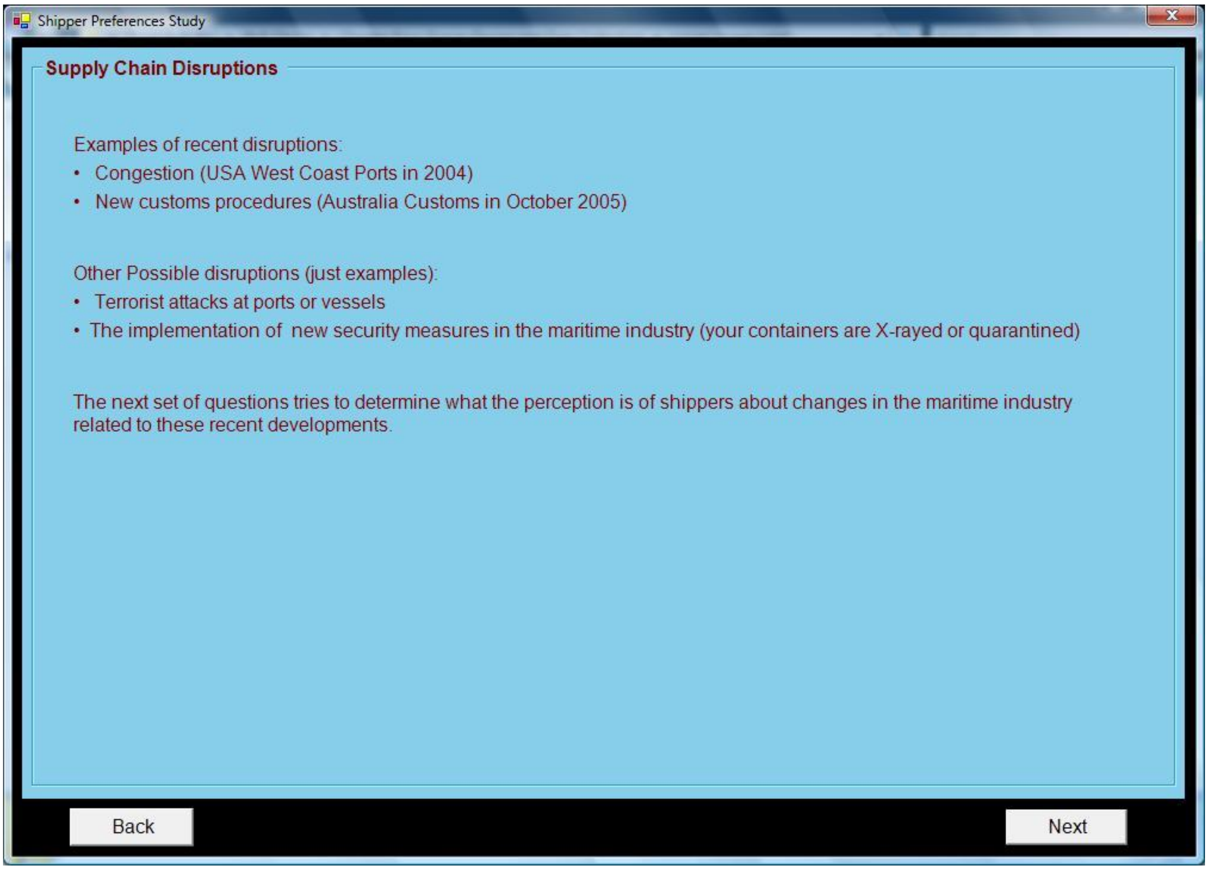
The attributes that might influence your choice are:

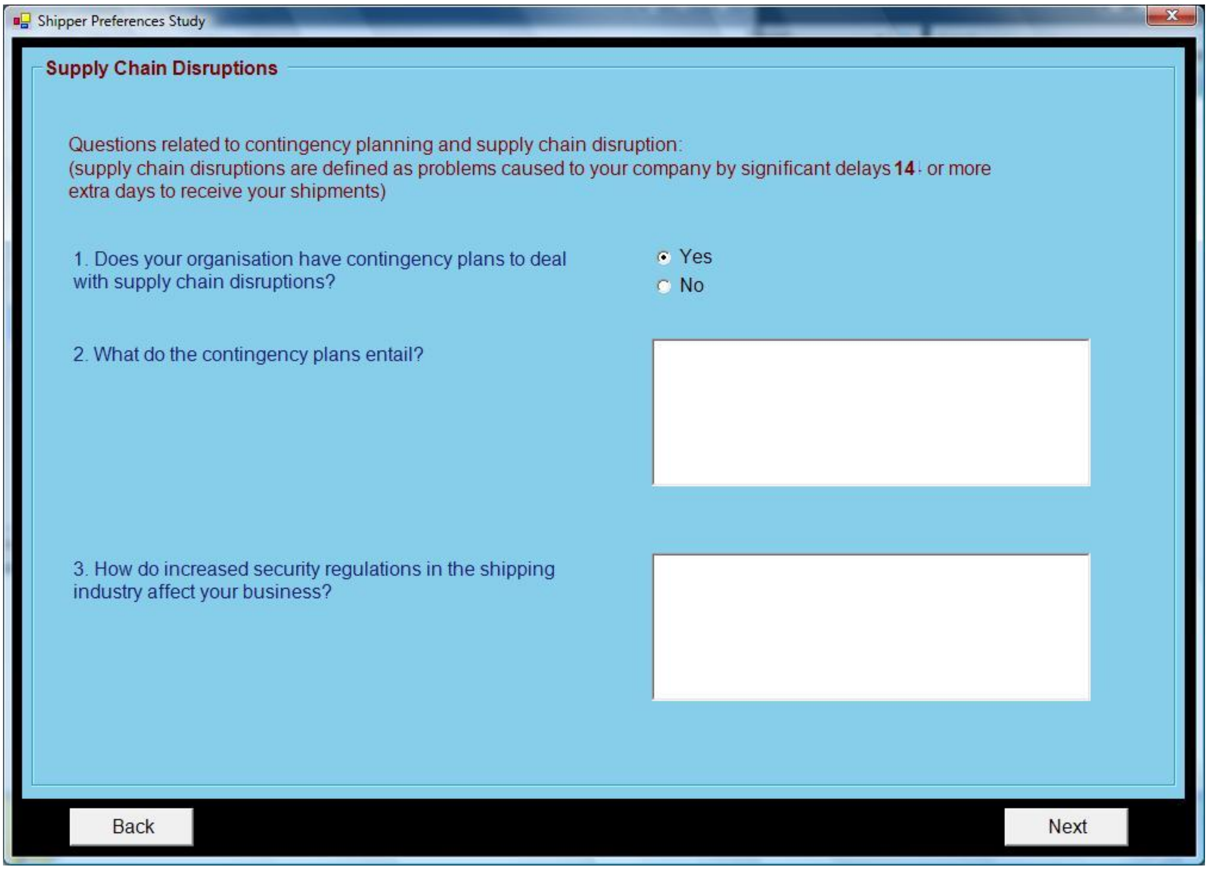
Freight rate	The rate per container (TEU/FEU as appropriate). The levels are similar to your stated freight rate of $2,500.00
Transit time	Door to door time. The levels are similar to your stated transit time of 25 days
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.
Frequency of service	The number of services per week. (a frequency of 0.5 is equivalent to 1 service every 2 weeks)

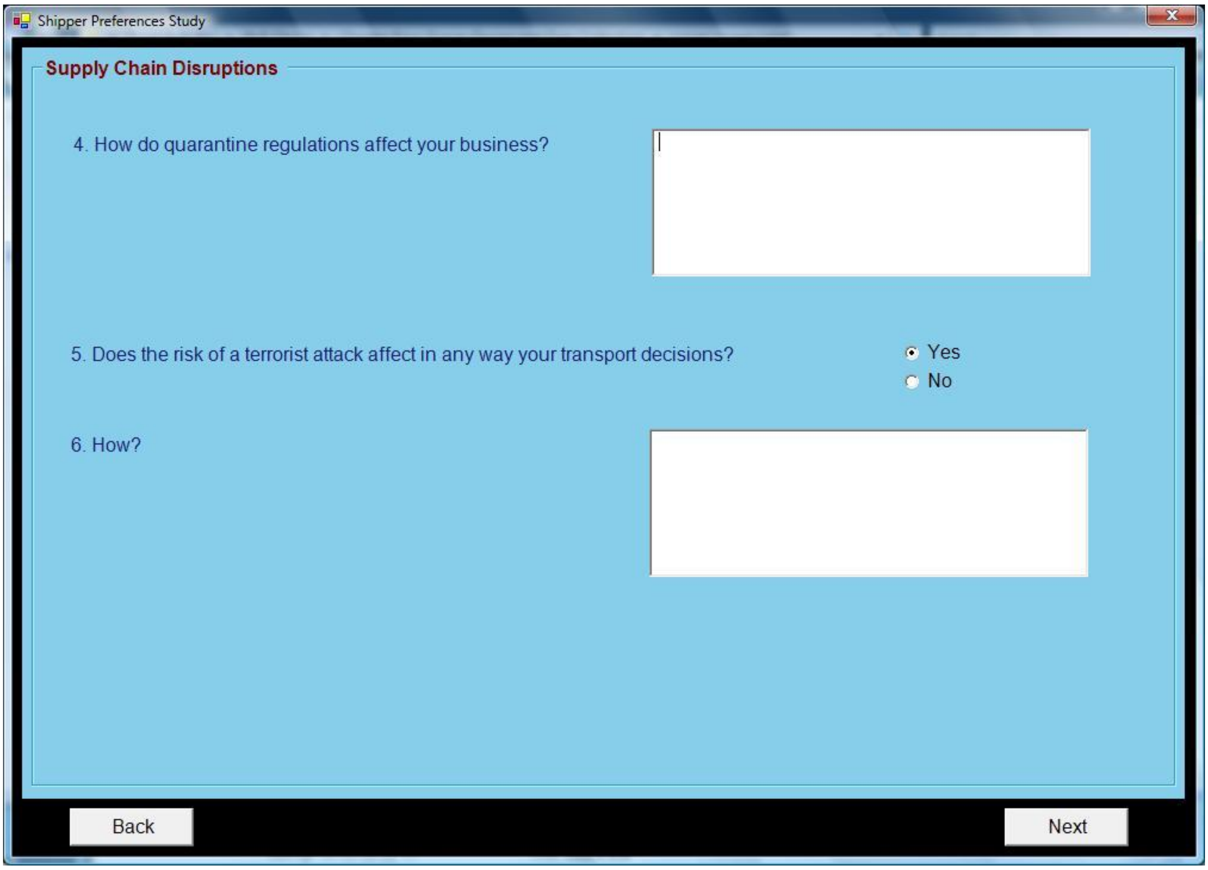
	Option 1	Option 2	Option 3	Option 4
Freight rate (FR)	$2,400.00	$2,600.00	$2,400.00	$2,400.00
Transit time (TT)	28 days	26 days	24 days	22 days
Reliability	90%	90%	96%	78%
Damage	1%	1%	0.5%	2%
Frequency	1.5	1	0.5	2
What is your preferred option?	○ Option 1	○ Option 2	○ Option 3	○ Option 4

Next


Shipper Preferences Study
Scenario Information
1. Did you find the scenarios challenging?
Yes
No
2. Rank the attributes in order of importance (1 to 5)
Rank (1 to 5)
Freight rate (FR)
Transit time (TT)
Reliability
Damage
Frequency
3. Was any attribute not relevant at all? Why?
Next


Shipper Preferences Study
Supply Chain Disruptions
Examples of recent disruptions:
• Congestion (USA West Coast Ports in 2004)
• New customs procedures (Australia Customs in October 2005)
Other Possible disruptions (just examples):
• Terrorist attacks at ports or vessels
• The implementation of new security measures in the maritime industry (your containers are X-rayed or quarantined)
The next set of questions tries to determine what the perception is of shippers about changes in the maritime industry related to these recent developments.
Back
Next


Shipper Preferences Study
Supply Chain Disruptions
Questions related to contingency planning and supply chain disruption:
(supply chain disruptions are defined as problems caused to your company by significant delays 14 or more extra days to receive your shipments)
1. Does your organisation have contingency plans to deal with supply chain disruptions?
Yes
No
2. What do the contingency plans entail?
3. How do increased security regulations in the shipping industry affect your business?
Back
Next


Shipper Preferences Study
Supply Chain Disruptions
4. How do quarantine regulations affect your business?
5. Does the risk of a terrorist attack affect in any way your transport decisions?
Yes
No
6. How?
Back
Next

Shipper Preferences Study

Practice Scenario

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	-	$290.00	-	$290.00
Rebate	$290.00	-	$100.00	-
Delay	15 days	11 days	17 days	13 days
Reliability	78%	78%	96%	96%
Damage	1%	0.75%	0.5%	0.25%
What is your preferred option?	○ Option 1	○ Option 2	○ Option 3	○ Option 4

Back Next

Shipper Preferences Study

Scenario 1

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	$290.00	-	-	$100.00
Rebate	-	$100.00	$290.00	-
Delay	11 days	17 days	15 days	11 days
Reliability	96%	78%	96%	78%
Damage	0.5%	0.25%	1%	0.5%
What is your preferred option?	○ Option 1	○ Option 2	○ Option 3	○ Option 4

Next

Shipper Preferences Study

Scenario 2

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	-	$290.00	$100.00	$290.00
Rebate	$290.00	-	-	-
Delay	17 days	13 days	11 days	11 days
Reliability	96%	84%	84%	90%
Damage	1%	0.5%	1%	0.75%
What is your preferred option?	○ Option 1	○ Option 2	○ Option 3	◉ Option 4

Next

Shipper Preferences Study

Scenario 3

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	-	$100.00	$290.00	-
Rebate	$100.00	-	-	$100.00
Delay	17 days	11 days	13 days	15 days
Reliability	84%	96%	84%	78%
Damage	0.25%	1%	0.75%	0.25%
What is your preferred option?	○ Option 1	◉ Option 2	○ Option 3	○ Option 4

Next

Shipper Preferences Study

Scenario 7

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	-	$290.00	-	$290.00
Rebate	$290.00	-	$100.00	-
Delay	15 days	11 days	17 days	13 days
Reliability	78%	78%	96%	96%
Damage	1%	0.75%	0.5%	0.25%
What is your preferred option?	Option 1	Option 2	Option 3	Option 4

Next

Shipper Preferences Study

Scenario 8

Think of the same shipment of goods as we used in the previous games.

Scenario: Your freight forwarder or carrier has just called you and is informing you that there is **extra transit time** serious delay in your shipment delivery due to a terrorist attack at a transhipment port. Expected extra transit time of 14 days.

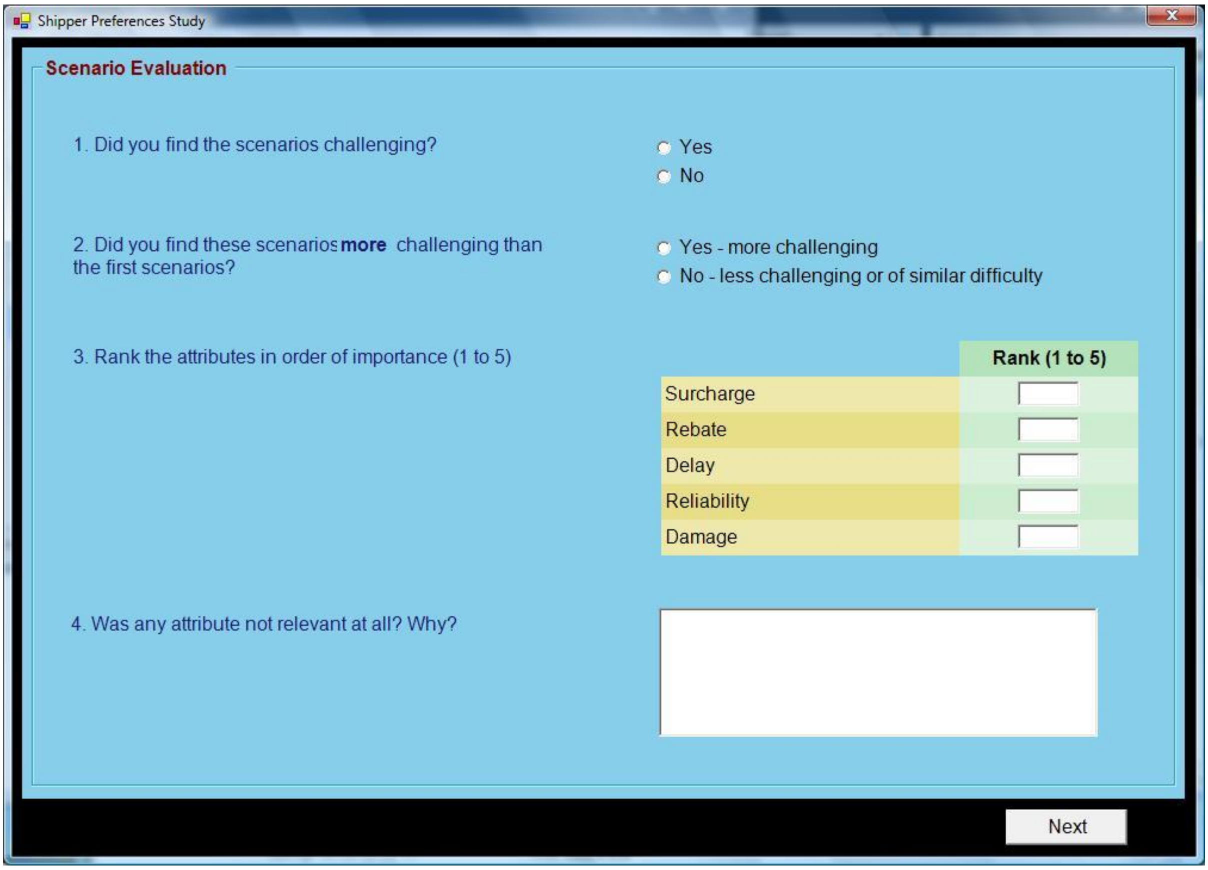
Your freight forwarder offers you 4 different services to expedite your shipment.
In the slow options you may get a rebate, in the fast options you will pay a surcharge.

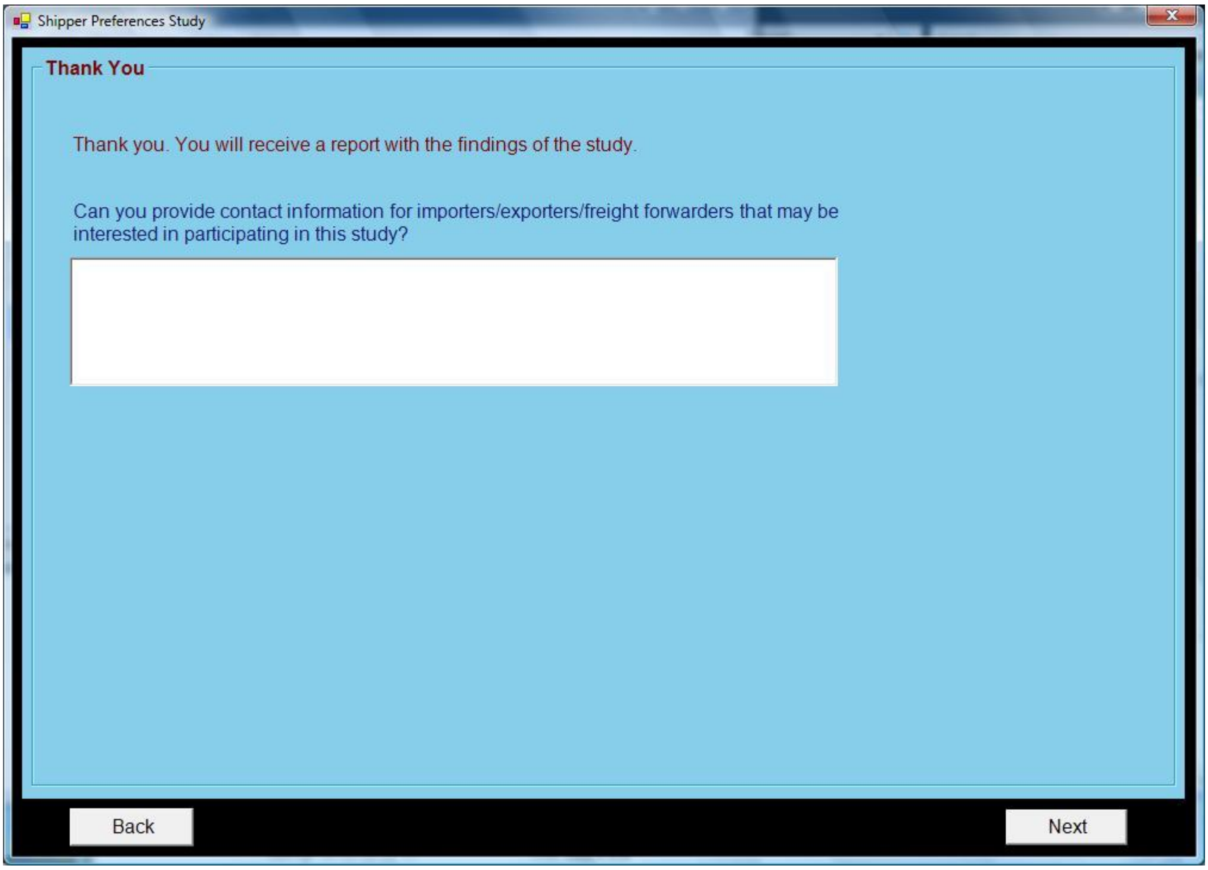
The attributes that might influence your choice are:

Surcharge	Charge per container (TEU/FEU as appropriate) to expedite delivery.
Rebate	Charge per container (TEU/FEU as appropriate) to compensate for delays.
Delay	Time exceeding originally expected delivery time (door to door).
Reliability	Percentage of the shipments that won't suffer delays. Corresponds to the historical records of the different carriers/routes.
Damage	Percentage of goods damaged while in transit. Corresponds to the historical records of the different carriers/routes.

	Option 1	Option 2	Option 3	Option 4
Surcharge	$290.00	$100.00	-	-
Rebate	-	-	$100.00	$100.00
Delay	13 days	11 days	17 days	17 days
Reliability	78%	90%	78%	96%
Damage	0.75%	0.25%	0.25%	1%
What is your preferred option?	Option 1	Option 2	Option 3	Option 4

Next


Shipper Preferences Study
Scenario Evaluation
1. Did you find the scenarios challenging?
Yes
No
2. Did you find these scenarios **more** challenging than the first scenarios?
Yes - more challenging
No - less challenging or of similar difficulty
3. Rank the attributes in order of importance (1 to 5)
Rank (1 to 5)
Surcharge
Rebate
Delay
Reliability
Damage
4. Was any attribute not relevant at all? Why?
Next


Shipper Preferences Study
Thank You
Thank you. You will receive a report with the findings of the study.
Can you provide contact information for importers/exporters/freight forwarders that may be interested in participating in this study?
Back
Next