MARITIME DISRUPTIONS IN THE AUSTRALIAN-INDONESIAN WHEAT SUPPLY CHAIN: AN ANALYSIS OF RISK ASSESSMENT AND MITIGATION STRATEGIES

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DECLARATION OF ORIGINALITY

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ABSTRACT

Maritime operations perform a global interface function connecting international, regional and domestic supply chain networks within a transportation and distribution platform. Due to the pivotal role of trade, maritime operations have the potential to generate wide-scale disruptive effects along supply chains. Basically, various unwanted internal and external factors that create uncertainty and severe negative consequences in the maritime leg can be defined as maritime disruptions. This includes risks associated with safety and security, the environment, infrastructure, markets, organisation, and leadership factors. However, the short and long-term effects of maritime disruptions do not appear to be widely understood or in some cases even considered by supply chain entities. By exploring and understanding the causes and effects of maritime disruptions, supply chain entities may be better prepared to manage the challenges presented by maritime disruptions and recognising the benefits of developing disruption management strategies.

Due to the globalisation of wheat supply chains, the increased risk of maritime disruption has become a major limiting factor in the efficient movement of wheat from producers (wheat farmers) to global end consumers. This is also evident in the wheat supply chain between Australia and Indonesia, which is the context of this research. Despite wheat being one of the dominant seaborne trade commodities between the two countries, the wheat supply chain is complex because it utilises international shipping (ports in Australia to Indonesia) and the domestic maritime chain (via inter-island shipping in Indonesia). This thesis argues that the maritime leg of the wheat supply chain creates increased operational risks among entities in the wheat supply chain between the two countries. Therefore, the thesis focuses on one major research question: Does the maritime leg contribute to disruptions in the wheat supply chain between Australia and Indonesia?

To further examine this research question three sub-research questions are explored:
(i) Are shippers and consignees aware of the disruptions that may occur in the maritime leg of the Australian-Indonesian wheat supply chain?

(ii) Are shippers and consignees in the Australian-Indonesian wheat supply chain implementing supply risk assessments or mitigation strategies to minimise the maritime disruption events?

(iii) Are current risk mitigation and detection processes in maritime operations effective in the Australian-Indonesian wheat supply chain systems?

To address the above research questions, the study uses both quantitative and qualitative research approaches. These combined methods analyse the stages of disruptive events in maritime operations and identifies direct and indirect driving factors. The sample for the study consists of senior managers in the wheat supply chain from both Australia and Indonesia because of their key involvement in the decision making process after disruptions occur and when disruption management strategies are developed. The senior managers were interviewed via telephone using a structured questionnaire to obtain information on their perceptions of the risk of disruption, detailed processes of disruption discovery and recovery, and the probability levels of various disruption management scenario assessments. An overall response rate of 68 per cent (34 respondents) was achieved with each in-depth telephone interview averaging 32 minutes with a range of 15 to 90 minutes.

Data analysis is conducted in two stages. The first stage analyses the time and financial costs along the wheat supply chain of maritime disruptions in terms of probability, consequences, frequency rate and propagation effects both in Australia and Indonesia, including the role of third and fourth party logistics in both creating and managing maritime disruptions. In this stage, previous disruption management strategies during the three stages of maritime disruption: pre-, during and post-disruption are explored. The study finds the existence of 40 different disruptions in the wheat supply chain of which 17 disruptive events dominantly occur in the Australian-Indonesian wheat supply chain. The study also reveals that mitigation, adaptation, coordination and intervention are supply chain risk management strategies that are normally
implemented by entities in managing maritime disruptions along the wheat supply chain.

In the second stage, the Markov chain process was used as the prime means to evaluate the disruption management strategies based on four major business scenarios such as contingency plan, flexible inventory strategy, business continuity management, and recovery planning. Compared to other statistical methods, the Markov process enables the prediction of future consequences of maritime disruptions given a previous probability level that involves constantly changing occurrences of maritime disruptive events. In addition, the Markov decision process (MDP) combines. As a result of the MDP analysis, multi-disruption management scenarios are recommended to optimise financial and time costs of strategies implemented when maritime disruptions occur. The study also finds that farmers and final consumers are entities that are highly likely to experience maritime disruptions along the wheat supply chain, as the consequences of disruptions in the chain are passed on to them.
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GLOSSARY

AWB  Australian Wheat Board
ABARE  Australian Bureau of Agricultural and Resource Economics
APTINDO  Asosiasi Pengusaha Tepung Terigu Indonesia
APW  Australian Premium White
AQIS  Australian Quarantine and Inspection Service
ASW  Australian Standard White
BPS  Badan Pusat Statistik
BMG  Badan Meterologi, Klimatologi dan Geofisika
BULOG  Badan Urusan Logistik
CIF  Cost Insurance Freight
DEPDAG  Departemen Perdagangan
DFAT  Department of Foreign Affairs and Trade
FOB  Free On Board
HUBLA  Perhubungan Laut
ITS  Institut Teknologi Sepuluh Nopember Surabaya
MT  Million-Tonnes
SME  Small and Medium Enterprise
TEU  Twenty equivalent units
WEA  Wheat Export Authority
3 P/L  Third Party Logistics
4 P/L  Fourth Party Logistics
SWN  Standard wheat noodle
WEA  Wheat Exports Australia
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CHAPTER ONE

INTRODUCTION
1.1 Background

Supply chain operators are facing a variety of uncertainties on their particular leg of the supply chain due to various internal and external factors disrupting the shipment of goods from the source to the planned destinations. For example, Gaonkar and Viswanadham (2007), Robert et al. (2008), and Rodrigues et al. (2008) argue that global outsourcing strategies implemented by dominant international supply chain operators create uncontrollable deviations from their original plans when disruptions occur during many stages of the chain flow. These disruptions also include the maritime related processes, which are transportation cluster services in the downstream operations of the supply chain. Maritime disruptions include the risks associated with the transport of cargo in shipping-related industries such as the shortage of ship fleets for one particular route or cargo at a certain period of time; natural hazard conditions at sea such as severe wave height; or a supply/demand imbalance of containers (Song et al. 2005; Jula & Ioannou 2006; Lin & Tseng 2007).

Further possible uncertainties in port and shipping-related services creating disruption in the supply chain include congestion (Cullinane & Song 1998; Pettitt 2007), strikes of stevedores or port workers (Peter 2000; Ruscoe 2004; Nathan 2005; Pettitt 2007), and security related incidents at the port (Li & Wonham 1999; Organisation for Economic Co-operation and Development 2003; Van de Voort et al. 2003; Barnes 2004; Ruscoe 2004; Barnes & Oloruntoba 2005; Carafano 2007). These disruptions may subsequently generate chaotic conditions along the chain which may result in four categories of outcomes: delays, deviations, stoppages, and loss of service platform due to disaster. In general, these four operational outcomes are disruptions that may produce unwanted changes from the original plans of supply chain operations. A delay occurs when there are variances in supply chain performance without any changes to the original supply chain plans (Craighead et al. 2007; Wagner & Bode 2008). When there is a fundamental alteration in the supply chain network, due to the non-availability of services in supply chain operations through problems in areas such as production, warehousing, distribution or transportation services, this is classified as a deviation (Gaonkar & Viswanadham 2007; Parmar 2007). A stoppage however, is determined to have occurred as a result of an interim discontinuation in the supply chain network...
created by changes in environmental systems such as severe weather (Yu & Qi 2004; Gaonkar & Viswanadham 2007). Finally, if a spontaneous and unpredictable event or disaster such as an earthquake demolishes supply chain infrastructures, it is defined as a loss of service platform (Barnes 2004; Gaonkar & Viswanadham 2007; Paul & Maloni 2010).

If uncertainties in port and shipping-related services are not responded to appropriately and in a timely fashion, they may severely affect the availability of specific cargoes and the impact on the supply chain operators’ functions in terms of financial performance, market position and the competitive level of entities in a supply chain (Akaha 1986; Bearing-Point & Hewlett-Packard 2005; Lewis et al. 2006; Loannis 2006; Pinto & Wayne 2006; Homan 2007). As a consequence, maritime operations in particular may be categorised as critical nodes if specific disruption events occur in a port area, shipping operations or forwarding services. Furthermore, due to global services linking supply chain networks, the effects of maritime disruptions presumably may propagate to other stages either upstream or downstream along a supply chain (Blackhurst et al. 2004; Craighead et al. 2007; Wu et al. 2007). An example of propagation effects of maritime disruptions can be found in Indonesia where the transport of agricultural grain-based products in 2006-2007 resulted in higher food prices for wheat-based products. In another example, Quigley (2007) reports on the changing trend of wheat commodities transported by containerised shipment rather than bulk due to the shortage of dry-bulk ships in the market, especially from North and South America in 2006. This changing trend is also identified by Gurning and Grewal’s (2007) study of increasing containerised wheat transport from Australia to Indonesia during 2005-2006 as an efficient business continuity strategy in responding to higher total supply chain costs, lead times, and low availability of dry bulk ships (as also recommended by William 2002; Gibb & Buchanan 2006; Skelton 2007).

The complexity of a wheat supply chain can be found between Australian and Indonesia, which has both international shipping (ports in Australia to Indonesia) and the domestic maritime chain (via inter-island shipping in Indonesia). In essence, the operational performance of ports, shipping, and forwarding services for wheat-based
commodities has an effect on the supply chain process in terms of ship type selected, the consignment category, intermodal transport flow, storage operation, and the type of terminal used at ports (Bohme 1992; Mercier 1999). Further, if maritime risk factors disrupt a wheat supply chain, then each stage of inventory, distribution, and the inland transportation process of wheat from point to point is consequently affected. The effective continuity of maritime services is essential for carrying food, including wheat-related products world-wide, particularly in Asian countries due to a diversification and change in consumption behaviour from traditional foods such as rice to wheat and its derivative products (Rae 1997; Mercier 1999; Dorjee et al. 2003). This consequently may generate higher volumes of wheat cargo being transferred from the main traditional wheat sources in North America, Canada, Australia, and East Europe to consumers in the Asian regions, Africa and the European continent. As a result, this would presumably increase ship traffic and throughput of terminal operations, and result in more complex forwarding services both in dry-bulk cluster and container shipping.

There appears to be only limited recent research on disruptions in the transportation stages of supply chains, most of which focus on air transport and inland transport operations with little attention on the maritime leg (Howick & Eden 2001; Yu & Qi 2004; Kleindorfer & Saad 2005; Yang et al. 2005; Christensen 2006; Friedman et al. 2006; Rundmo & Moen 2006; Tang 2006; Parmar 2007; Wilson 2007). The available research on disruptions in maritime operations tends to be focused on exploratory studies and building awareness of the range of disruptions (for example Barnes 2004; Bearing-Point & Hewlett-Packard 2005; Michelle & Terry 2005; Arnold et al. 2006; Lewis et al. 2006; Pinto & Wayne 2006). In essence, the impact of maritime disruptions and strategies on managing disruptions in the maritime leg of wheat supply chains is at best limited.

The overall paucity of research and interest in supply chain risk management strategies in response to disruption in maritime sectors provides the motivation to undertake this current study. Given the growing importance of wheat as a global food source, the goal
of this research is to investigate maritime-related disruption characteristics on the wheat supply chain.

1.2 The wheat supply chain as a multifaceted chain structure

The concept of the wheat supply chain has essentially evolved through the development of a generic food supply chain model connecting farm suppliers to farmers, marketers, processors, wholesalers, distributors, retailers and final consumers. Traditionally, the wheat chain structure was on a relatively small scale and fragmented in terms of the operation area which was also primarily regional and localised (Saltmarsh & Wakeman 2004; Bilgen & Ozkarahan 2007). However, due to the trend of global sourcing, the wheat market consequently expanded operationally to become a multifaceted chain structure affected by the ‘consolidation and commoditisation’ of wheat products (Roth et al. 2008, p. 23).

The type of entities involved in supplying wheat from the farming source to the end user of a wheat based product (consumers) is shown in Figure 1-1. The involvement of maritime entities such as shipping, ports, forwarders, shippers, and consignees increases the complexity due to a wheat supply chains being international and involving a number of players within each type of entity. Detailed discussion of this structure is provided in Chapter Two.

Figure 1-1: Entities in a wheat supply chain
Source: Author
1.3 Australian-Indonesian wheat supply chain

Arns et al. (2002) and Blackhurst et al. (2004; 2005) suggest that the extent of uncertainties in a supply chain is determined by the inherent complexity of the supply chain. An example of a complex supply chain is the wheat supply chain between Australia and Indonesia. This supply chain structure contains a complete supply chain flow both nationally (domestic) and internationally in terms of the number of interactions between wheat farmers, handlers, processors, distribution centres, logistics agents/representatives, wholesalers, and customers (Newman & Kopras 1999; Bogasari 2007; Badan Urusan Logistik 2007). In addition, the modes of transport used in transporting wheat from Australia to Indonesia are relatively varied, utilising trucking and rail systems (for land modes) and maritime transport for both domestic and international shipment. Supply chain entities in Indonesia also tend to use maritime transport services for distributing wheat products to various domestic islands when compared to Australian entities that transport wheat by rail.

In addition, the Australian-Indonesian wheat supply chain is further complicated by the different structures, interactions, and problems that the two countries’ players face in the wheat trade. These include the significant disparities of supply chain practices, rules, level of technology used, human resource skills, logistical and maritime infrastructures, and the mode of transport including rail, road, shipping and ferries that may increase uncertainties and maritime disruptive events within the wheat chain (INSTATE 1995; DFTA 2000).

The Australian-Indonesian wheat supply chain is also of interest due to significant natural factors that create further interruptions. As highlighted by Edijatmiko (Edijatmiko 2007), APTINDO (2008), Gurning (2008), and Syamsudin (2008), climatic conditions such as drought and severe wave height are impacting on the effectiveness of the wheat supply chain. Droughts in Australia are the fundamental supply issue that affect the production capacity of Australian wheat to Indonesian markets. The issues differ in Indonesia in that the major challenge for shipping service availability is the
severe wave heights that disturb ship and port operations. The distribution processes to inter-island destinations are also affected by similar natural disruptions.

Regardless of improvements being made to minimise the interrupting factors, maritime disruptions will nonetheless still exist in the Australian-Indonesian wheat supply chain due to the high levels of complexity. In other words, maritime disruptions cannot be completely removed but instead can only be minimised. Therefore, entities in the wheat supply chain need to understand the extent of maritime disruptions and, how they are instigated and managed in order to prepare, plan and maintain the acceptable performance of the wheat supply chain.

1.4 Research questions and research objectives

In general, the principal focus of the current research is to examine the maritime leg as a major source of disruption sources in the wheat supply chain particularly in relation to shipping and port operations, inland transport and distribution, and propose risk mitigation and other supply chain risk management strategies.

1.4.1 Research questions

The fundamental purpose of this research is to examine the extent to which the operational mechanism of maritime disruption impacts on supply chain processes in general and on the Australian-Indonesian wheat supply chain in particular. The following primary research question (PRQ) has been structured to elaborate this aim.

**PRQ**  
*Does the maritime leg contribute to disruptions in the wheat supply chain between Australia and Indonesia?*

To explore PRQ, the three following subsidiary questions (SRQ) are investigated:
SRQ 1  Are shippers and consignees aware of the disruptions that may occur in the maritime leg of the Australian-Indonesian wheat supply chain?

SRQ 2  Are shippers and consignees in the Australian-Indonesian wheat supply chain implementing supply risk assessments or mitigation strategies to minimise the maritime disruption events?

SRQ 3  Are current risk mitigation and detection processes in maritime operations effective in the Australian-Indonesian wheat supply chain system?

1.4.2  Research objectives

Overall, the major objective of this research is aimed at examining a proposition that the maritime industry makes a significant contribution to providing and responding to uncertainty factors in supply chain management in general and the wheat chain in particular. Therefore, in order to comprehensively map the potential uncertainty and disruption events in the maritime process, this research develops a network based approach to supply chain risk management within three main phases of occurrences.

The proposed phases in the maritime leg of a wheat supply chain are (1) pre-disruption, (2) during the disruption phase, and (3) the post disruption phase. The theory building process of maritime disruptions will be generically determined through a set of qualitative disruption categories and measurable parameters such as probability and consequence levels from the Australian-Indonesian wheat supply chain. The second objective is to establish a new risk assessment technique for the maritime stages, including the development of fundamental strategies for responding to the disruptions that are consequently taken by shippers and service providers in a particular period of disruption events in the shipping industry and port networks. Further, this risk assessment technique will be applied in the case of the Australian-Indonesian wheat supply chain in order to determine an effective mitigation plan for responding to any potential disruptions occurring in the wheat supply chain.
1.5 Organisation of the thesis

This introductory chapter explored the broad research problem and underlined the background to problem formulation. The chapter identified reasons why the Australian-Indonesia wheat supply chain is an interesting and complex area of research that enables the investigation of many disruption-related variables and potential mitigations.

Chapter Two discusses the general flow of the Australian-Indonesian wheat chain in much more depth. In addition, the functions and behaviours of each entity in the chain and its existing problems regarding the shortage of wheat supplies from Australia to Indonesia are discussed, as is the dry bulk and containerised shipping impact on wheat trade between the two countries.

Chapter Three identifies the previous and existing research on uncertainty and disruptive event characteristics and their impact on supply chains. This chapter explores the progress of supply chain and transport operations concepts and strategies longitudinally as a key risk management model. Essentially, the chapter discusses the various reasons and effects of maritime disruptions and also offers a theoretical framework of how supply chain players decide appropriate approaches and responses in their quest for managing supply chain disruptions.

Chapter Four explains the methodological approach of the research in this thesis including the process for collecting primary data via telephone interviews from Australian and Indonesian senior managers in the wheat supply chain. The chapter also presents the use of qualitative and quantitative approaches in exploring disruption risk perceptions and responses in the wheat supply chain.

Chapter Five discusses the results of the telephone interviews to establish the statistical significance of the senior managers’ perceptions of maritime disruptions and impact on supply chain process operations. Various instigating, interdependent, leadership and
progressive factors of disruptive events are extensively discussed. The chapter also
develops a mitigation framework of maritime disruptions in the wheat supply chain.

Chapter Six uses the analysis of potential disruption and supply chain parameters
(collected from Chapter Five) to develop management scenario assessments in general
maritime operations of the wheat chain between Australia and Indonesia. This chapter
then develops multi-disruption strategies based on the Markov decision process. The
purpose of this is to enable effective decision making and explores the complex
patterns in the Australian-Indonesian wheat supply chain by assessing the disruption
management strategies discovered through the case of bulk shipping shortages during
the period 2007-2009. The arrangement of disruption management scenarios are
established in order to recommend appropriate responses to maritime disruptions in the
wheat supply chain.

Chapter Seven, the concluding chapter, argues the importance of the study within the
confines of its limitations and reports the main findings, the implications of the results
for disruption management strategy and practice, and suggests directions for future
research.
CHAPTER TWO

THE AUSTRALIAN-INDONESIAN WHEAT SUPPLY CHAIN
2.1 Introduction

This chapter focuses on the trade structure, categories of wheat traded, and the business process of the wheat supply chain between Australia and Indonesia. This includes an analysis of the structure of entities in the wheat supply chain that forms a basis for further discussion and background in later chapters. The case for higher food prices occurring due to maritime disruptions is also discussed as being an influential factor in Indonesia, reflecting the evidence of the existing impact of maritime disruptions in the wheat supply chain. The shortage of dry bulk ships in the period 2006-2008 provides evidence that the wheat supply chain performance, including the wheat price from farmers to final customers, is affected by maritime disruptions. This chapter focuses specifically on providing an overview of the complexity of the Australian-Indonesian wheat supply chain by assessing the structures, categories and business process of the chain.

2.2 A generic wheat supply chain

Taking Figure 2-1 as an example of a generic wheat supply chain, farmers are the original source of wheat as shown in Stage 1 of the wheat supply chain. The quantity of wheat transported in this stage may be dependent on the scale of the wheat farming group including their use of farming and harvesting technology (Anderson & Garlinge 2000; Abbas & Aly 2004). The farming area may be clustered by the scale of the farm for wheat such as in the Southern-Belt wheat areas in Australia which provide comparative advantages from climatic characteristics that favour growing wheat. Similar farming areas can be found in Saskatchewan in Canada, North Dakota in the United States, Nairobi in Kenya, Henan province in China, and Groningen in the Netherlands (Quiggin & Fisher 1994; Park & Koo 2001; Nyangito et al. 2002; CWB 2007; Pol 2007; WEA 2008).

In Stage 2, wheat handlers in the supply chain procure wheat goods from farmers. Fundamentally these are primary buyers of wheat who generate the next flow of wheat in the wheat supply chain. The wheat handlers include marketing bodies such as wheat pools, farmer associations and groups of collectors (Bilgen & Ozkarahan 2007; Bushell
& MacAulay 2007). After Stage 2 in the chain are the wheat processors such as animal feed processing industries, human food processors including oilseed industries and processors for beverages and bio-fuel industries such as ethanol products (Duval & Biere 1998; William et al. 2004).

![Figure 2-1. The functions of various entities in a wheat supply chain](source: Adapted from Rubzen et al. (2005))

The processors in Stage 3 can be classified as upstream entities in the wheat supply chain. Transferring the wheat products from the upstream chain to downstream sequences is the role of distributors in Stage 4 who integrate with various export and domestic markets and could be an agent-based entity or marketing body such as Wheat Export Australia (WEA) in Australia or the Indonesian national logistics agency known as BULOG. The other main function of distributors in Stage 4 is to provide wheat transportation services including the storing, handling, and forwarding of wheat-based goods from one premise to others. The distributors transfer the wheat to downstream intermediaries such as wholesalers, sub-wholesalers and retailers who in turn make the wheat available to consumers.
Wholesalers, in Stage 5, have an important function in the process of wheat allocation either on an international or domestic scale of wheat trading compared to sub-wholesalers (Stage 6) who focus on a smaller local domestic market (Duval & Biere 1998; Bushell & MacAulay 2007). Stage 7 of the wheat supply chain relates to retailers that provide the outlets to consumers. Wheat retailers in general have commercial units such as food retail services, shops, or third party suppliers.

In relation to consumers in the wheat supply chain in Stage 8, the Indonesian flour millers association known as APTINDO and others divide consumers into two categories: industrial consumers and primary industry non-industrial consumers that include small-medium enterprises, restaurants, shops, and end consumers (1998; APTINDO 2001; Reichert & Vachal 2003; William et al. 2004; Bushell & MacAulay 2007).

The multifaceted structure of the global wheat chain represents the complexity of a supply chain which not only relies on the entities along the chain but also depends on transport characteristics and processes, the size of trading volumes, and the market power of supply chain members in the wheat industry (Abbas & Aly 2004; Maloni & Brown 2006). Therefore, if particular uncertainties, including maritime disruptions, occur in a wheat supply chain, the dynamic performance of one specific wheat product is affected mainly due to the vertical linkages of the chain, including the sharing of information and the value of supplying wheat between the points of the original source of wheat to consumers (McMullen 1989; Young & Hobbs 2002). With regard to these factors, a wheat supply chain is taken as the empirical case for this study because the end to end chain may show a significant complexity in which various uncertainties and maritime disruptive events probably exist.

2.3 The trade structure between Australia and Indonesia

The total volume of bulk cargo of bilateral trade between Australia and Indonesia during 2001 to 2009 exceeds containerised manufactured products. In 2006, as reported by Indonesian Statistics Bureau (BPS), Department of Trade of Indonesia (DEPDAG),
and Australian Department of Foreign Affairs and Trade (DFAT), the traffic volume of cargo flowing between the two countries totalled 6.8 million tonnes consisting of 3.8 million tonnes of dry (90 per cent) and liquid bulk cargo (10 per cent), 2.8 million tonnes in containers and 0.2 million tonnes in break-bulk form (BPS 2007; DEPDAG 2007; DFAT 2007). During 2001-2009 (see Figure 2-2), the trade pattern between each country has been fluctuating with dry bulk cargo dominating. DEPDAG and BPS report that for 2007-2010 commodities exported from Indonesia to Australia in the form of dry bulk cargo were predominantly nickel ore concentrate, uncoated papers, and chemical products. Products and commodities imported by Indonesia from Australia were mainly dominated by agricultural commodities (such as wheat and flour, artificial corundum, cane or beet sugar, and cotton) followed by mining commodities (such as iron-ores, mineral and chemical fertilisers, and unwrought aluminium).

![Figure 2-2. Top ten commodities of Australian products to Indonesia (2001-2009).](image)
Source: BPS (2007); DEPDAG (2010)

For agricultural commodities, wheat is the leading product by volume traded between the two countries. Figure 2-3 indicates that since 2001 Australia has been the major exporter of wheat to Indonesia compared to other countries (DEPDAG 2007, 2008).
Further, DEPDAG reports that over a six year period, Australia contributed on average approximately 60 per cent of Indonesia’s raw wheat market, which is more than the combined total of other countries such as Canada, Argentina, Ukraine, and USA.

![Figure 2-3. The importing trend of wheat sources to Indonesia in the 2001-2009](image)

Source: DEPDAG (2007, 2008)

Indonesia’s total annual imported wheat market averages between 4.3 to 4.5 million tonnes (Rittgers 2004; Widiyanti 2007). Wheat based food, such as noodles, has become an important basic food of Indonesian house-holds due to a significant trend away from the consumption of rice (Fabiosa 2006). In addition, the International Trade Centre (ITC 2006, p.4) reports that noodles and baked goods have emerged as important alternative staples due to these wheat-based products being ‘affordable, versatile and convenient’ for Indonesian consumers. Indonesia has always been highly self sufficient in rice, but for wheat-based commodities Indonesia relies on imports of wheat and meslin (raw-wheat) from Australia (Newman & Kopras 1999). There appears to be three major reasons why Australia has become the top supplier of wheat to Indonesia: proximity, reliable and consistent supply, and taste preference. The first reason is due to the geographical advantage in terms of a shorter distance between the
two countries when compared to other wheat resources such as India, Europe, North and South America (Byrnes & Nirang 2000; ITS-Global 2006). The benefit to Indonesian consumers of the geographical proximity is that the price of wheat or flour based commodities are quite competitive compared to rice.

Reliability and consistency of the wheat supply is the second reason for Australia’s dominance and is a necessary condition to ensure Indonesia has guaranteed availability of wheat for its markets (ITS-Global 2006; Purnama 2006; Bogasari 2007). Based on a report of the Canadian Wheat Board (2007), in 2005 Australia produced about four per cent of the global production of wheat or 24.36 million tonnes (MT). Further, as reported by the Wheat Export Authority (WEA) in 2007, the export of wheat from Australia was between 40 to 60 per cent of the annual international total market imported by Indonesia (WEA 2008). As reported by the Food and Agriculture Organisation (FAO) (FAO 2008), this quantity is higher than other countries such India, China, and Europe which predominantly use production for domestic consumption. The third reason for Australia being the major supplier of wheat is due to Indonesia’s customer preference for Australian wheat quality, taste and colour (Wijaya et al. 2005; Bogasari 2007). All three reasons are important factors why Australian wheat products are the significant choice of most of Indonesian consumers.

### 2.3.1 Categories of wheat

As a basic food in Asia, Africa and Europe, wheat products are imported from major wheat global exporters such as Canada, USA, China, Argentina, Australia, India, and Ukraine (Wijaya et al. 2005; ABARE 2007; FAO 2008). Of the wheat exported from Australia to Indonesia, there are seven main grades of wheat based on a particle size index and protein content. The seven main grades, as shown in Figure 2-4, are standard noodle (ASWN), soft wheat (ASOFT), premium white (APW), standard white (ASW), standard hard (APH), extra hard (AH), and durum wheat (Coombs 1994; AWB 1998; Williams 1998).

In addition, the seven common wheat commodities are clustered into five main uses, (i) starch and industrial wheat, (ii) durum wheat for pasta, (iii) novelty wheat (purple
wheat) for beverages, (iv) wheat for ethanol production, and (v) fodder wheat for hay, chaff, and grazing (Anderson & Garlinge 2000).

**Figure 2-4. Wheat classification in trade based on grain hardness**
*Source: Chang (2003)*

Wheat in Australia is grown in geographical wheat belt areas (see Figure 2-5) which are located within five regions that extend across five States; Western Australia, South Australia, New South Wales, Victoria, and Queensland. The Australian Bureau of Agricultural and Resource Economics (ABARE) explains that the wheat belt mainly produces two types of wheat, Australian premium white wheat and Australian hard wheat (ABARE 2008). In the wheat belt regions, drought has become a critical factor due to global climate changes that impact on Australia’s wheat harvest capacity, as occurred during 2004-2007 (WEA 2008).

The decreasing trend of harvest quantity from 2002-2008 has resulted in the Australian wheat industry having difficulty maintaining its stock capacity for international trading. Hence, the drought and its impact on the availability of wheat for the international
market created a situation where Indonesia had been unable to import a guaranteed quantity from Australian wheat suppliers during 2005-2007 (CSIRO 2007).

Figure 2-5. Australian wheat growing regions
Source: ABARE (2008); WEA (2008)

2.3.2 The major wheat handlers in Australia and Indonesia

Whereas the previous sub-section explained the types of wheat and the impact of drought on wheat supply, this section discusses the activities of the international wheat trade between Australia and Indonesia as a complex network. This network includes the processes of ordering, purchasing, delivering and distributing wheat products both for domestic and international supply chain links. These factors may be influential reasons for maritime disruptions occurring. The international trade of wheat between Australia and Indonesia appears to follow two main processes in which maritime services play a significant role. The trading flow begins when Indonesian consignees order or deal the agreed quantity to be transported from Australia as shown in stage 2 of Figure 2-1, and then actions in the pre-shipment procedures are taken to prepare movements of wheat commodities for domestic and international transportation (Blankfeld & Fritz 2001). Similarly, in Australia, wheat owners who may also be exporters usually perform two
essential phases equally, the pre-shipment of cargoes, and the movement arrangement of cargoes for domestic and international destinations.

The supply chain structure for wheat commodities, as shown in Figure 2-1, can also be found in the domestic market of Australian grain products in the area of the South-Belt in Australia. In the early stage of a supply chain process, farmers continuously do business with their direct customers who are grain handlers. Subsequently, these grain handlers have their own downstream customers such as grain processors for either human food or animal food purposes. The important grain handlers in Australia are the Australian Wheat Board (AWB) Limited, Grain-Pool or Agra Corporation, Premium Grain-Handlers, Brooks Grain and ABB Grain Limited. The downstream customers are the vital groups which control the movement of wheat commodities either for the domestic or international market. The domestic market for grain on average reaches about six million tonnes annually or about 25 per cent of regular crop production (Chang 2003). This means that approximately 75 per cent of Australian’s wheat products have been dedicated to the international market under the control of the AWB (ITS-Global 2006). The end customers of wheat derivative products in Australia are household and individual consumers through various primary and smaller channels by wholesalers and retailers.

There are three options for purchasing Australian wheat on both the domestic and the international market (Wilkinson & Henderson 2000). The first is direct purchase by processors from wheat farmers for which a cash price usually applies, with the potential for on-farm storage and deferred delivery. The second is by domestic buyers or merchants who will source packages of wheat for processors or handlers. Through this, forward contracts can be utilised and specific qualities can be specified including the logistics of storing, handling, and transporting the wheat that can be organized on behalf of the processor. The other alternative is to sell or buy the wheat through the AWB which provides similar services to other buyers or traders for specific quality traits.

Wholesale distribution of wheat is complex and changing less rapidly than in the retail sector as shown in Figure 2-1. This is also the case in the Australian-Indonesian route.
There are relatively few distributors with national reach in Indonesia. Direct importing has not taken off as rapidly as some analysts have predicted (Ariani 2003; Wijaya et al. 2005; Nadia 2006; Hemphill 2007). Some large users of imported products outsource both the import function and logistics. Although household and small to medium businesses tend to dominate the sector in numerical terms, there are also national processors. These are typically vertically integrated, owning primary production, processing and distribution facilities. Other users in Indonesia include a large number of small-scale food processors and national processors, both of which are focused on their target markets overseas and their local market.

Figure 2-6 shows that Bogasari Flour Mills (FM), Eastern Pearl FM, Sriboga Raturaya FM, and Panganmas Inti Persada FM are the major suppliers of Indonesia’s wheat commodity imports from Australia (APTINDO 2007, 2009). These four major millers are becoming increasingly significant as wheat market controllers in Indonesia. Of the 5.4 to 5.5 million tonnes of flour consumed annually in Indonesia, 86 per cent is supplied by these four major millers and the other 14 per cent is imported from overseas (APTINDO 2000, 2004; Siagian 2007).

The distribution chain of Indonesian flour products to consumers is divided into direct and indirect channels (APTINDO 2003). Direct consumers are primary industry companies that represent about 32 per cent of Indonesian flour consumers. The biggest consumers of flour based products in Indonesia are small and medium enterprises (SME) which purchase about 63 per cent (APTINDO 2004). The traditional Indonesian flour consumer is the house-hold which purchases about five per cent annually. As reported by International Strategic Team (INSTATE) and United States Department of Agriculture (USDA), the distribution channel for these indirect consumers commonly involves regional and local distributors, depots in each local districts, wholesalers, and retailers (INSTATE 1995; USDA 2001).

In terms of the end product of flour-based commodities in Indonesia, they are mostly classified into three major end products such wet noodles (30 per cent), bread (25 per cent) and instant noodles (20 per cent) (APTINDO 2003, 2004). Wheat handlers in both
countries are important entities when considering who are affected when maritime disruptive events occur in the wheat supply chain.

2.3.3 Functionality and behaviour of wheat marketing bodies

As the exclusive marketers of Australian wheat for export and domestic human and animal consumption, the Australian Wheat Board (AWB) and Wheat Exports Australia (WEA) play a pivotal role in the movement of grain from farmers, mainly in the South-belt zone, to primary handlers and then on to domestic buyers or for export. Their role as marketing authorities is determined by government regulation. The function of these wheat authorities, as the Australian farmers' marketing partner, is to capture the maximum return for the grain through the AWB (Laskie 1999).

Before 2009, the AWB worked with grain companies as the main consumers and Australia's Pacific International Railways to secure adequate capacity to execute AWB sales contracts and ensure the wheat is delivered on time and within the quality and
quantity parameters demanded by global buyers (Chang 2003). The AWB has earned an international reputation by offering its global customers a consistent and continuous supply of high-quality wheat. The AWB strives to provide customers with an agreed reliable and consistent time and cost of delivering wheat products (AWB 1998). Similar to the AWB, in Indonesia a similar marketing entity was established titled the Indonesia Logistics Agency (known as Badan Urusan Logistik or BULOG in Indonesian). BULOG has the right to control any logistics issue of various important food commodities for public consumption in relation to rice, wheat/flour, sugar, and soybeans (BULOG 2003). BULOG in general has two important roles, firstly to stabilise commodity prices and secondly to ensure the availability for public consumers (BULOG 2003). These two policy instruments are implemented by market interventions to provide sufficient buffer stocks for their storage facilities across the nation. In pursuing its roles, BULOG has agents as strategic partners in all local regions in Indonesia to engage in logistical functions such as distribution, handling, and transporting various food commodities, including wheat and its derivative products.

In general, both the AWB and BULOG have similar functions as the marketing and controlling wheat bodies in their respective countries. Regarding these functions, there are about six primary tasks carried out by these agencies such as delivery of the selling-buying contract, handling the agreements, paying the farmers for the wheat sold, moving wheat to ports or domestic buyers, acting as the selling authority, and selecting appropriate or accredited trading partners (exporters or importers) for international markets or sources (BULOG 2003; ACIL-Tasman 2006; Bogasari 2007; Bushell & MacAulay 2007; Robert & Sylvain 2007; WEA 2007).

In Australia, the wheat and grain industry in general has continuously been changing its structure in order to adapt and respond to expansion and opportunities in the wheat industry, including the establishment of WEA as a new governmental counterpart for the AWB. Since 1985, wheat based entities in Australia have been consolidated dynamically (Bushell & MacAulay 2007). Prior to the establishment of WEA, the AWB was a regulated regime for the wheat community based on state and grain commodities in order to optimise the benefits for Australian farmers (WEA 2007).
2.4 Maritime service providers and wheat trading terms

As wheat cargo consignments are classified into bulk and containerised cargoes. Shipping wheat by containers is a more complex and lengthy procedure when compared to bulk shipping (Bertrand 1996; Prentice 1998; WEA 2007). However, due to the shortage of dry bulk ships in 2006-2007, the freight rates for containerised wheat shipment was more competitive than dry bulk despite the container flow of wheat commodities having to transit through both international and regional transhipment terminals.

In both markets (Australia and Indonesia), entities dealing with the direct receiving and delivering of wheat usually have a wide-ranging logistics platform at international terminals as the interface points before wheat is distributed by various modes of transport (DFAT 2000). Shipping, port operations, forwarding activities, and the shippers and consignees are the major maritime service providers dealing with the handling and distributing of wheat commodities in the chain.

Shipping companies as fleet operators and shipping brokers, play a substantial role in transporting wheat globally (as seen in Figure 2-7). Wheat commodities carried in bulk ships represent the largest segment of the international wheat shipping task which is about 84 per cent of the total volume of the global wheat trade compared to container services at 16 per cent (Gurning & Grewal 2007). Institutions such as quarantine and the customs office are two crucial components in the process of wheat handling at ports in the loading and unloading process. The other principal transportation providers in the wheat chain are the operators of ferries (called pelayaran rakyat in Indonesian) that provide primarily freight services for inter-island transports in Indonesia (BULOG 2003). In Australia, the domestic wheat transport is predominantly provided by truck operators and rail services providers (BULOG 2003; ACIL 2006; 2007; Bushell & MacAulay 2007; WEA 2007).

Another significant operation of the Australian-Indonesian wheat shipping market is the handling of wheat at ports. In general, operators providing services such as loading or unloading elevators in this zone are terminal, silo, and pool operators (RIRDC 2005;
DFAT 2007). Terminal operators provide handling services for all users regardless of the ownership of wheat. In contrast to terminal operators, silo operators exclusively handle their own wheat cargoes due to a specific type of wheat commodity being handled. Similarly, pool operators in the wheat chain provide storage and handling services for several dedicated groups of several wheat traders or millers (ACIL 2006; 2007; Bushell & MacAulay 2007; WEA 2007).

![Figure 2-7. Structure of maritime entities as wheat handlers](source: Gurning and Cahoon (2010))

The next stage which affects the logistical flow of the wheat consignment is the forwarding services to shippers and consignees who are required to deliver and receive cargo as shown in Figure 2-7. The forwarding services in practice are carried out by forwarders, consolidators, and freight brokers (Blankfeld & Fritz 2001). There is also a need to fulfill any government or international quality regulations during the maritime operation in terms of fumigation, quarantine requirements and also customs procedures.

Based on an exploratory study, Gurning and Grewal (2007) found that maritime services play a significant function in terms of costs in a particular supply chain of wheat from Australia to Indonesia. They estimate that on average, maritime related
services contribute about 21 per cent to total contract value. In their study, five major cost items related to maritime service such as freight, fumigation, quarantine and inspection services, port fees and cargo insurance were identified. Further, it was estimated that the portion of maritime percentage could increase due to continued increases of dry bulk shipping for grain transport (Situmorang, G. 2007, pers.comm., 14 September).

In general, the transportation terms are negotiable items for both consignees and shippers in Australia and Indonesia. Maritime related activities of the wheat chain from Australia (farm gate) to Indonesia have a number of transportation arrangement levels such as silo delivered or delivered to processors, delivered to port, pool delivered, free on board (FOB), and cost insurance freight (CIF) (Anderson & Garlinge 2000; Bushell & MacAulay 2007). These arrangements are explained in Figure 2-8 which include the pricing mechanism among farmers, traders (buyers or sellers), and marketing controllers.

Wheat traders among two countries regularly use CIF and FOB for trade terms depending on the price level of wheat, volume of wheat imported, number of voyages, and type of consignment used (Anderson & Garlinge 2000; ITS-Global 2006; APTINDO 2007). Similar to these arrangements, Indonesian buyers in international trading use the two options of CIF and FOB as their common transport applications.

The CIF option is chosen by BULOG and primary buyers from Indonesia (such Bogasari Ltd) if the contractual agreement of wheat trade is arranged by the AWB over a period of time, which is usually decided on an annual basis. FOB is usually applied by Indonesian buyers when purchasing the wheat directly from Australian farmers without the mediation of the AWB (ITS-Global 2006; Nadia 2006; Bogasari 2007). In parallel to international arrangements, domestically the distribution process of wheat commodities in raw and flour products uses three formats of transport arrangements namely CIF, FOB, and delivered port basis (BULOG 2007). Specific to the CIF option, both BULOG and the AWB control and organise the shipping arrangement from one particular loading port in Australia to the destination or unloading ports in Indonesia (BULOG 2007). The selection of shipping companies is made on the basis of long-term
agreements such as annual and consecutive chartering parties and the competitive price and time of sea freight services (Reichert & Vachal 2003).

![Figure 2-8. Wheat trading terms and transport process](Image)

When pricing decisions are calculated by farmers, handlers or processors, and traders for the international wheat market, these groups rely on the arrangements formulated by the AWB or BULOG. This includes any adjustments in relation to bunkering prices, congestion events, and shortage of dry and container ships as happened during 2006-2007 (APTINDO 2007; BULOG 2007). The AWB offered the opportunity to use containerised wheat shipment from the dry-bulk arrangement that had previously been set up in response to the trend of higher costs of dry bulk shipping when compared to international containerised services (Quigley 2007; Ray 2007).
2.5 The impact of maritime disruptions on the wheat price

Figure 2-9 shows the maritime disruptions in relation to the increase of shipping freight rates due to natural reasons and the shortages of dry bulk ships in the wheat supply chain between Australia and Indonesia during 2006-2008. In this period, recurrent maritime disruptions resulted in significantly higher prices in the wheat and flour market, especially to Indonesia’s consumers.

In 2006-2008, due to the severe effect of drought, the harvest quantity of Australian wheat was approximately only at 11 million tonnes (at the end of 2006) compared to 24 million tonnes in 2005. This nature-based wheat disruption increased the prices of wheat in the range of 50 to 60 per cent during 2006-2007 (BULOG 2007). Following the drought, in January 2006 the price of hard wheat (APH1 and APH 13) was about US$ 170 per tonnes FOB to Indonesia (as in Drewry 2007; Fearnsearch 2007; APTINDO (Asosiasi Produsen Tepung Terigu Indonesia) 2008). Further, in October 2006, the price rose more rapidly to US$ 227 per tonnes FOB. If the trading term based on CIF in 2007 is compared to the January 2007 price, the wheat level achieved US$ 326 per tonnes CNF in contrast to US$ 212 per tonnes CNF in January 2006 (Drewry 2007).

More significantly, the shipping sector, especially ocean carriers, contributed considerably to the increase in wheat prices in the period of February 2007 – February 2008. The increase of wheat prices due to maritime-related operations was nearly 102 per cent (if the CNF wheat price is considered). The main reason for this impact is due to an imbalance in the dry-bulk shipping market which started in the middle of 2006, and subsequently created a significant increase in the charter rate for the dry bulk fleet especially for Panamax and Handymax (for example Blas 2007; BULOG 2007; Clarkson 2007; WEA 2008).

Between January and September 2007, the cost continued rising from US$ 54 to US$ 95 per tonnes which represents an increase of approximately 76 per cent (Blas 2007; Clarkson 2007). However, millers and wheat traders in Indonesia were not able to respond to this increasing trend directly by an increased selling price of the flour.
because of the relatively low ability to pay by Indonesian consumers (Peter 2007; Siagian 2007). During 2006-2007, Bogasari Ltd, as the biggest wheat-miller in Indonesia, increased the selling price of their flour product to the market by only 12 per cent which was significantly far below the expectation of 76 per cent. Therefore, it appears that maritime disruptions due to the shortage of dry bulk ship increases the commodity price of wheat, transport and supply chain costs and subsequently reduces the profitability of entities across the chain.

Figure 2-9. The 2006-2008 trend of Indonesian wheat prices due to maritime disruptions
Sources: APTINDO (2009); Edijatmiko (2007); FAO (2008); Gunawan (2007); WEA (2008)

In responding to the above disruptive factors of maritime operations, the wheat industry, especially between Australia and Indonesia, has been using containerised wheat transport in contrast to the dry bulk pattern that had been creating a substantial problem for the wheat trade. In addition, entities in the wheat supply chain recognised that exploiting bulk shipping and dry bulk terminal operations was presumably no longer able to provide optimal benefits, sustainable growth and competitive success when compared to containerised shipping due to its loss of economic scale (Ray 2007). Further, the transportation costs of using containers can possibly be reduced further if
the volume of container traffic reaches levels at which economies of scale can be obtained with the assumption that there will be no supply disruptions due to drought (Abbas & Aly 2004; Song et al. 2005). It was reported by APTINDO (2007) that the monthly demand by wheat buyers in Indonesia was about 275,000 tonnes with 20 per cent of this quantity being transported by containers.

However, despite the increasing usage of containerised shipments, the container imbalance in the wheat trade may limit the effectiveness of the containerised option. In relation to the availability of containers, particularly in Australia, there is an imbalance in container trade between Asia and Australia, which results in a continuous repositioning of empties to Asia from Australia. Annually, there are about 200,000 empty containers left in Australia with an estimated five million tonnes of capacity (WEA 2007). Hence the transformation of bulk cargo transport to containerised transport has been a reasonable alternative to the higher freight rate of bulk shipping during 2006-2007. The other important impact of these maritime disruptions was the result of longer transportation time (delays) during the wheat distribution process especially in reaching rural consumers in inter-islands’ locations in Indonesia. It was reported that in September 2007, the longest period that consumers waited for the supply of flour and wheat related products in Indonesia was about 30 days (Edijatmiko 2007; Siagian 2007; WEA 2007). In Australia, the average span of delays in the same period was 14 days due to two important activities, namely rail transportation and loading operations at wheat terminal operations (WEA 2007, 2008).

During 2005-2006, Australian wheat farmers complained about the slow performance and limited capacity of the national rail system (CSIRO 2007; DFAT 2007). These reports indicated a limitation of carrying volume for wheat transportation including the insufficient number of trains allocated to each of the relevant ports of Portland, Geelong, Melbourne and Port Kembla. This is due to the reduction in a number of wagons allocated by Pacific National to those ports (CSIRO 2007). As a consequence, the transport capacity of rail services for the wheat chain in Australia was decreased. Also under investigation was the bottlenecks in Australian port infrastructure in relation to the wheat chain (CSIRO 2007). As reported by the Commonwealth Scientific and
Industrial Research Organisation (CSIRO), which surveyed the food logistics progress in Australia in the period of 2004-2006, four main problems exist. These are; (1) the drought problems for certain ports, especially those terminals handling wheat based commodities; (2) the insufficient capacity of the rail track to ports with the need to be heavy duty rail; (3) lack of road access to ports, and (4) urban encroachment around grain terminals which affects port handling operations. Consequently, these infrastructure-related problems in Australian ports have created considerable congestion effects in the supply chain with significant delays at all Australian dry bulk terminals, for on average a total of six days in September 2007 (G-Ports 2007). Interestingly, due to these factors, growers in Australia have to bear the commercial consequences of their business. As stated by one grower: “We're also seeing substantial increases in freight and supply chain costs which we as growers have to bear ourselves” (Jenkins 2009, p.12).

The other important factor is the small parcel size for wheat regularly demanded by Indonesian small millers in containerised form (APTINDO 2003). Consequently, these small millers need a particular shipping arrangement for small parcels of imported wheat in the range of 4,000-5,000 tonnes per month. Therefore, it is neither appropriate nor efficient to use either Handymax or Panamax ships which have the minimum carrying capacity of more than 40,000 tonnes per shipment (Peter 2007; Siagian 2007; WEA 2007). In response to this, the common strategy implemented and practised to date by wheat shippers and consignees is to share the space on a dry bulk ship. Another alternative is to use bags or flexible intermediate bulk containers (FIBC) for bulk movement (FIBCA 2004; APTINDO 2007). In Indonesia, the disruptive factors in maritime operations that generate further widespread impacts for domestic wheat distribution are the congestion problems of inland access to and from the main ports of Indonesia, the congestion within ports itself, and problems of inter-island networks of ferry and short sea shipping services (see Figure 2-10).

In relation to the wheat trade, Indonesia has more complex problems with port infrastructure than Australia due to limitations of port draught, narrow channel problems, and high port waiting levels caused by the lack of terminal availability. In terms of inland transport systems, this is the most disadvantaged area for Indonesia.
because of the lack of rail facility and connections to support port operations in general and the wheat handling process in particular. Moreover, port congestion in Indonesia as discussed by Gurning (2008, p. 112) reveals various aspects such as the ‘lack of terminal storage, limited draught of berth, and lengthy customs procedures’ affecting cargo handling services in dominant ports managed by Indonesian port corporations. These factors subsequently become major reasons for the increase of terminal handling charges by shipping companies, container handling charges by terminal operators and longer ship time at ports (Ditjenhubla (Direktorat Jenderal Perhubungan Laut) 2006; Patunru et al. 2007; Gurning 2008).

Figure 2-10. Maritime disruptions in the Australian-Indonesian wheat supply chain. Source: Gurning and Cahoon (2009)

In terms of domestic distribution, in the period of 2006-2008, the wheat supply chain was interrupted by natural factors such as severe wave height and wind in the Indonesian waters. Information and reports provided by Badan Meteorologi dan Geofisika Indonesia (BMG) during 2007-2008 reported a trend of severe wave height of on average more than three metres, mostly in Indonesian waters (BMG 2007, 2008). During this period, the BMG further reported a trend of tropical storm interventions across Indonesian waters which had never occurred before. These consequently generated several marine navigational warnings (Maklumat Pelayaran in Indonesia) by
the Ministry of Transport of Indonesia. It was calculated that during 2007-2008 there had been seven navigational warnings which halted shipping operations.

2.6 Summary

This chapter explained the complexities of the Australian-Indonesian wheat supply chain including the trade structures, the categories of wheat, and the business processes and entities across the chain that rely on maritime transport both for international and domestic wheat flows. The chapter also documented recent maritime uncertainty and disruptions in the period 2006-2008 in the Australian-Indonesian wheat supply chain that will be referred to when exploring the conceptual framework of maritime disruptions in Chapters Five and Six. The Australian-Indonesian wheat supply chain was used to explore the impact of maritime disruptions and in later chapters will question how effective and efficient mitigation strategies can be implemented in response to disruptive maritime events.
CHAPTER THREE

MARITIME DISRUPTIONS IN A WHEAT SUPPLY CHAIN
3.1 Introduction

In this chapter, maritime disruptions are discussed in the context of a wheat supply chain. This chapter also explores the major drivers of maritime disruptions and the resulting consequences and impacts. Also explained are the principal stages of maritime disruptions both within the maritime service boundary and a wheat supply chain. Further, the concept of managing disruption events from previous research is discussed to explain how general supply chain operators implement their responses when managing various maritime disruptive events. In particular, this chapter extends the analysis of maritime disruptions and develops initial models of disruption management relevant to a wheat supply chain using a Markov-chain approach.

3.2 Disruption framework of supply chain risk

In the supply chain literature, disruption is defined as a risk event or stage that disturbs internal processes of an entity and supply chain network. Yu and Gi (2004, p. 17) explain disruptions as being ‘various unanticipated events’ as does also Craighead et al. (2007, p.132) who refer to disruptions as ‘unplanned events’ which appear along the supply chain. Table 3-1 shows a number of definitions of disruption in the context of risk and supply chain.

Table 3-1. Definitions of disruption in the literature

<table>
<thead>
<tr>
<th>Authors</th>
<th>Definition of disruption</th>
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<tbody>
<tr>
<td><strong>Related to disruption risks</strong></td>
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<tr>
<td>Clausen et al. (2001, p. 41)</td>
<td>‘A state during the execution of the current operation, where the deviation from plan is sufficiently large that the plan has to be changed substantially’.</td>
</tr>
<tr>
<td>Yu and Gi (2004, p.17)</td>
<td>‘Various unanticipated events caused by internal and external factors which significantly deviate original plans of a system and consequently affect its performance severely’.</td>
</tr>
<tr>
<td><strong>Events in a supply chain as supply chain disruption</strong></td>
<td></td>
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<tr>
<td>Craighead et al. (2007, p.132)</td>
<td>‘Unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain and, as a consequence, expose firms within the supply chain to operational and financial risks’.</td>
</tr>
<tr>
<td>Gaonkar and Viswanadham (2007, p.267)</td>
<td>‘Non-availability of certain production, warehousing, and distribution facilities or transportation options due to unexpected events caused by human or natural factors’.</td>
</tr>
</tbody>
</table>
In the context of risk, disruption is an unwanted event occurred in an operational of an entity internally. Whilst the definition of a disruption in a supply chain presents a slightly different view because it is considered as an unwanted event in a complex supply chain network.

Research surrounding disruptions in supply chains may be considered from the perspective of three separate risk events: uncertainty, vulnerability and crisis, depending on the focus of managing the disruptive events (as shown in Figure 3-1 below).

![Figure 3-1. Disruptions and supply chain risks taxonomy](Source: Author)

Firstly, uncertainties are events in a supply chain are difficult to predict (Parlar & Perry 1996; Jack & Adrie 2002; Vorst 2002; Brown 2008) and forecast (Haigh & Holt 2000; Blackhurst et al. 2004; Rodrigues et al. 2008). The internal and external causes of disruptive events of a firm may be recognised in terms of their likelihood or probability level which may occur in the supply chain. Uncertainty in supply chain systems has
been widely discussed. For example, Wilding (1998) presents the complexity triangle of a supply chain to understand the generation of uncertainty in a supply chain and concludes that swings in demand result from the design and operation of the system rather than external events. Van der Vorst and Beulens (2002) however, treat uncertainty as a stimulant for safety buffers in time, capacity and inventory in food supply chains. Vidal and Goetschalckx’s (2000) contribution is the development of a mixed-integer programming (MIP) model to demonstrate how uncertainties affect the global logistics systems design. Similarly, Tsiakis et al. (2001) also use MIP to model a multi-echelon supply chain network, in particular, under demand uncertainty.

Vulnerability is the second means of discussing disruptions in terms of disturbances and the impact from low to severe levels of consequences as disasters in the supply chain (Svensson 2000). An example of this is explored by Svensson (2002) who investigates the production impact of disruptions in terms of inbound and outbound flows of an automotive assembler. Peck (2006) and Volodymyr (2006) claim there are two vulnerability sources in the supply chain incorporating disturbances (unexpected deviations from the norm) and their negative consequences. For all the attention on these studies, there is little interest regarding the detailed stages of disturbances that supply chain players have in the maritime industry. The most common argument is that the greater the complexity, density, and severity of a supply chain network, the higher the probability of disruption occurring from and through that network (Yu & Qi 2004; Craighead et al. 2007; Parmar 2007; Handfield et al. 2008).

Following the argument above, maritime operations then may be considered as one of the most vulnerable and critical areas where a high likelihood of disruption events may happen. A major reason for this is because maritime operations have global interface functions connecting supply chain networks, specifically on transportation and distribution platforms of international, regional and domestic trade, including the potential capability to generate wide-scale disruptive effects to other tiers in the supply chain. Similar to this, maritime disruptions may create a range of divergence propagated to the platform of the supply chain as negative consequences or disturbances (Svensson 2002).
Thirdly, a disruption is discussed as from a crisis perspective as it creates critical and chaotic conditions (Aguilera 1990; Smith 2000; Powner 2008) and a resulting loss of capabilities in providing services in a supply chain (Bowlby 1969; Barnes 2004). However, the loss of capabilities also presents opportunities for a supply chain entity to develop other improved ways to provide services (Fink 1986; Pearson & Clair 1998; Brockner 2008). In relation to this, shipping operations are considered as important factors that may create a supply chain crisis. Akaha (1986), Levy (1995), Watkins (2008) and Wagner and Bode (2008) investigate international supply chain disruptions and categorise the unavailability of shipping services as being a supply side risk that can lead to unexpected supply chain costs when shipping lead-times are long and unacceptable. It is also interesting to note that Levy (1995) and Wagner and Bode (2008) find that when crises due to shipping disruptions in a supply chain do occur, managers tend to handle them as one-time events rather than understanding that they may result from a lack of robustness in the supply chain. Additionally, the cost of supply chain disruptions to a company can be significant. For example, Rice and Caniato (2003) present results from respondents in their research who estimate the daily loss due to their disrupted supply network is between US$ 50 million–100 million.

The topic of supply chain disruption is of increasing interest both in academic research and industry practice due to the fact that failure at any stages and points in the supply chain can cause the entire network to fail (Cavinato 2004). In relation to trade disruption risks, two major aspects are widely discussed, namely demand (Brill & Chaouch 1995; Qi et al. 2004; Yang et al. 2005; Koo et al. 2006) and supply (Arreola-Risa & DeCroix 1998; Ross et al. 2008). However, despite increasing awareness among practitioners, the concept of supply chain disruption is still in an early stage (Juttner et al. 2003) because the focus tends to be mainly within a production plant as a single entity in a supply chain. Due to this reason, Peck (2006) proposes attitudes and approaches on disruption risks based on a networking and functional supply chain perspective. However, the impact of a disruption risk in a supply chain network is not intensively investigated.
In general, the supply chain disruption research concentrates on the decision making process in managing the disruption risks (Aven 2004; Baldwin et al. 2006; Wagner & Bode 2008). Research on supply chain performance however, due to the occurrence of supply disruptions, focuses predominantly on production (Lindsey 1989; Yang et al. 2005), distribution (Svensson 2000, 2002), the combination of production-distribution system (Allen et al. 2006; Rodrigues et al. 2008) and the inventory process (Arreola-Risa & DeCroix 1998; Tomlin 2006, 2009).

Under the production distribution system, the role of transport operations is essential with its critical linkages connecting the global transport of freight in the supply chain which may have a large density and complexity (Craighead et al. 2007). The research on transportation disruptions in supply chains is predominantly on road transport (Bertrand 1996; Chang 2000; Rodrigues et al. 2008), air transport (Yu & Qi 2004) and pipelines (Edward & Steven 1997; Mudrageda & Murphy 2007). These studies mainly focus on transportation performance in a supply chain (Bertrand 1996; Edward & Steven 1997; Wilson 2007) and the uncertainties of carriers in terms of service unavailability (Chang 2000; Rodrigues et al. 2008). In relation to the causes of transport disruptions, Rodrigues et al. (2008, p. 391) argue that disruptions in the transportation process occur if there is a ‘logistics triad’ imbalance between carriers, shippers, customers in a supply chain. Additionally, transport operators still do not consider their businesses as the origin of disruptions but take the view that they are suffering from the impact of disruptions in supply chains (as discussed in Arreola-Risa & DeCroix 1998; Brown 2008; Rodrigues et al. 2008).

Of interest is that the concentration of disruption research has not fully considered the distributors that include the maritime operators as being contributors to disruptive events but instead mainly focus on the perspectives of sellers and buyers in the supply chain (Moinzadeh & Aggarwal 1997; Chopra et al. 2004). Surprisingly, supply chain operators do not always consider maritime operations as being examples of uncertainties even though they figure strongly in research, such as port strikes (Blackhurst et al. 2005; Handfield et al. 2008; MacDonald 2008), piracy and terrorism (He 2009; Ho 2009; Kraska & Wilson 2009), and port closure (Lewis et al. 2006; Gaonkar & Viswanadham 2007; Parmar 2007). This may lead to a situation that any
responses taken to manage a maritime disruption will be limited and ineffective in a supply chain.

3.2.1 Disruption stages

Understanding the stages of maritime disruptive events within supply chain operations can be derived from the generic disruption stages. In general terms, some studies describe the stages of a disruption risk by the operational outcomes of disruptions (Clausen et al. 2001) and their effects on supply chain performances (Yu & Qi 2004). In terms of the scale of disruptions, the four stages (as shown in Figure 3-2) may range from a recurrent risk of individual events defined as delays (Craighead et al. 2007) to disaster events that demolish the service platform of a supply chain (Gaonkar & Viswanadham 2007; Wagner & Bode 2008; Paul & Maloni 2010). As seen in Figure 3-2, the first stage through which a maritime risk passes is referred to as the ‘delay’ stage; here the focus is on the recurrent changes displayed by performance of a service operation in the supply chain and the cancelation of previous planning by its institutions (Howick & Eden 2001; Zsidisin et al. 2004; Wright 2008).

![Disruption Stages Diagram](image)

**Figure 3-2. The stages of disruptions in a supply chain**

Source: Author

Stage two is the ‘deviation’ stage or the criteria that planners of a service operators have to evaluate their external and internal service plans due to a span of changes of current operation over the previous objectives (Gaonkar & Viswanadham 2007). Deviation risks in supply chain services are mainly related to operational changes in service scheduling (Gaonkar & Viswanadham 2007; Parmar 2007), total lead-time (Goh et al. 2007), upstream delivery processing (Larry et al. 2004; Smyrlis 2006; Goh
et al. 2007) and the total quantity of cargo handled (Chopra et al. 2004). In addition, in terms of changes, Yu and Gi (2004) indicate seven types of significant changes from an original plan which could severely affect performance. These changes are in (i) the system environment, (ii) unpredictable events, (iii) changes in system parameters (iv) availability of resources, (v) new restrictions, (vi) uncertainties in system performance, and (vii) new considerations or practices.

Stage three is the stoppage stage in which some existing services become unavailable due to direct and indirect factors interrupting the services’ provisions (Yu & Qi 2004; Gaonkar & Viswanadham 2007; Handfield et al. 2008). A stoppage is considered to have taken place if an interim discontinuation in the supply chain network occurs due to changes in environmental systems such as severe weather conditions (Yu & Qi 2004; Gaonkar & Viswanadham 2007), supply blockages (Mudrageda & Murphy 2007), union strikes (Bill 2002; Farris 2008; Wilson 2008; Anonymous 2009), and maritime piracy (Ho 2009; Kraska & Wilson 2009, 2009; Meija et al. 2009).

The fourth stage is the loss of service platform where the service platform is damaged and as a consequence, service operators in the supply chain are unable to provide their services due to the destruction of their logistic platforms (as discussed in Aguilera 1990; Gaonkar & Viswanadham 2007), unavailability of transport facilities (Chang 2000; Chang 2000; Paul & Maloni 2010), and the shutting down of any service points in the trade (Barnes 2004). Major contributors to the loss of a supply chain platform are earthquakes (Chang 2000; Loannis 2006; James 2008; Carpignano et al. 2009), severe weather conditions (Frittelli 2005; Mudrageda & Murphy 2007), and security threats (Christopher & Lee 2004; Parfomak & Frittelli 2007; Snediker et al. 2008).

3.2.2 The cycle process of a disruption

Ideally, disruptions can be minimised if effective disruption management systems are in place, if senior managers understand how to handle them, and if the cycle of disruptions is forecasted prior to occurring (Yu & Qi 2004; Gaonkar & Viswanadham 2007; Handfield et al. 2008). Therefore, strategic responses to disruptions need to
consider the complete cycle process to decrease disruption consequences and their propagation effect. Studies on the cycle process of a disruption indicate that the investigations of a crisis lifecycle have provided the foundation for researchers in discovering the disruption risk related events (see Table 3-2).

Table 3-2. Categorisation of crisis and disruption lifecycle

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Event based cycle</th>
<th>Response based cycle</th>
<th>Short cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisis</td>
<td>Fink (1986):</td>
<td>Barton (1993); Mitroff (1994)</td>
<td>Roberts (1994);</td>
</tr>
<tr>
<td></td>
<td>* Prodormal</td>
<td>* Detection</td>
<td>* Pre-event</td>
</tr>
<tr>
<td></td>
<td>* Acute</td>
<td>* Probing / prevention</td>
<td>* Emergency/intermediate phase</td>
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<td></td>
<td>* Chronic</td>
<td>* Containment</td>
<td>* Long-term phase</td>
</tr>
<tr>
<td></td>
<td>* Resolution</td>
<td>* Recovery</td>
<td>* Lauge et al.(2009)</td>
</tr>
<tr>
<td></td>
<td>* Consequence</td>
<td></td>
<td>* Crisis</td>
</tr>
<tr>
<td></td>
<td>* Caution</td>
<td></td>
<td>* Post crisis</td>
</tr>
<tr>
<td></td>
<td>* Coping</td>
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<tbody>
<tr>
<td></td>
<td>* Normal</td>
<td>* Reaction</td>
<td>* Discovery</td>
</tr>
<tr>
<td></td>
<td>* Failure</td>
<td>* Recovery</td>
<td>* Recovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* Lauge et al.(2009)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>* Pre event</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Event occurs</td>
<td>* Long-term phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Plan activated</td>
<td>* Emergency/intermediate phase</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Critical processes</td>
<td>* Lauge et al.(2009)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>resumed</td>
<td>* Pre crisis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Event occurs</td>
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<td>* Plan activated</td>
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<td>* Critical processes</td>
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<tr>
<td></td>
<td></td>
<td>resumed</td>
<td></td>
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</tbody>
</table>

Source: Adapted from Gurning and Cahoon (2010)

The research on risk lifecycles generally focuses on crisis management (Fink 1986; Barton 1993; Shrivastava 1993; Mitroff 1994; Pearson & Clair 1998; Lauge et al. 2009) and disruption related events (Blackhurst et al. 2004; Tomlin 2006; Handfield et al. 2008). In addition, the risk lifecycles analysis framework identifies either a crisis or disruption based on an event, the response and the combination of these two (event and response) as a short cycle. Hence, in order to identify that a maritime disruption has occurred, the recognition of disruptive events such as delays, deviations, stoppages, and disasters will enable entities in a supply chain to implement a mitigation strategy effectively.
Fink (1986) appears to be the first study exploring the behaviours of a risk-related event called crises with four major stages namely prodormal, acute, chronic, and crisis resolution. The investigation of Fink which is mainly derived from medical cases is elaborated on by Gottschalk (1993), Parlar and Perry (1996), Pearson and Clair (1998), and Coombs (2004) in various general public applications including transport operations. During these four stages, unexpected negative events including their causes can be observed by a cognitive assessment approach, which in turn impacts on only one crisis resolution. Using industrial accidents (significant and non-significant) as the research context, Williams and Treadaway (1992) and Shrivastava (1993) report that an internal controllable catastrophe (which has a high consequence such as infrastructure failure or fire due to outdated equipment) led to higher caution and responsibility by an organisation. Shrivastava (1993), Manion and Evan (2002), Sriramachari (2005) and Chang et al. (2007) define the crisis cycle as having the four stages of cause, consequence, caution, and coping; and propose mitigation initiatives for industrial situations. However, these event based cycles on industrial accidents are limited to internals operation of an organisation and the industrial network beyond certain crisis cycles is not considered significantly in their research.

Three studies of response based cycles by Barton (1993), Mitroff (1994) and Seymour and Moore (2000) report that internal inadequate controllable responses resulted in worse risk reactions than external uncontrollable influences. Using natural disasters, Mitroff (1994) reveals that the external uncontrollable triggers (severe weather and earthquake) resulted in less resistance, greater support and higher cautions and response than the internal controllable cause (poor maintenance system). By providing five risk stages namely detection, probing/prevention, containment/damage containment, recovery, and learning, Barton (1993) and Mitroff (1994) find that the more a crisis is internally managed, the more responsible that entity is considered to be. Therefore, unlike the research by Fink (1986), the scope of the crisis lifecycles, as noted by Mitroff (1994), is more related to disaster-related responses rather than the cycle behaviour of the delay, deviation, and stoppage.

Similar to a natural disaster, a less complex crisis based on short cycle is proposed by Roberts (1994) and Lauge et al. (2009) who define risk-related events mainly into three
stages such as pre-crisis, crisis (emergency and intermediate phase), and post crisis. Their suggestions provide another perspective by providing a simple structure of a crisis cycle that was adopted by other researchers in exploring risk short cycle.

The importance of disruption risk lifecycles in supply chain studies was initiated by Blackhurst et al. (2004) and firstly explored the term of disruption in the study of short lifecycles. The study of Blackhurst et al. (2004) is followed by Handfield (2008). The study of Blakhurst et al. (2004) and Handfield et al. (2008) suggest two stages to the cycle of disruptive events namely discovery and recovery. In their studies, they also recommend the use of this cycle combined for disruptive events that occur recurrently. The other finding of Stephan and Christoph (2008) in relation to the short cycle process of disruptive events including studies of maritime disruptions is that the statistical dyadic conception is used for analysing the disruption risks into two main stages namely pre and post disruption periods. Research by Pinto and Wayne (2006), Lewis et al. (2006), may be cited as examples in which the assessment and response strategy of maritime interruptions are determined by two short cycle namely before and after the disturbances occurred along maritime operations.

Unlike the research on short cycles, the cycle investigations by Tomlin (2006, 2009), Kuster (2008), and Lauge et al. (2009) on disruption in the supply chain mainly discusses the combination of events such as delay and deviation and risk management strategies such as delay and deviation and focuses on risk management strategies. Tomlin (2006, 2009) proposes four stages starting from the normal condition to failures, reaction, and recovery prior to returning to normal condition again. The process of the disruption cycle of Tomlin (2006, 2009) focuses mainly on the combination of a disruption response phase with strategies taken in a short period of time and relating it to past events. Following the research of Tomlin (2006), the British Standards Institute (2009) identifies disruption as five stages namely, when the event occurs, damage assessment, disaster assessment, disaster declared plan activated, and the critical process resumed. However, the recommendation of the disruption cycle of BS25999 focuses on the application of a disastrous event.
The studies of risk lifecycles as assessed so far in this chapter do not take into consideration the interval periods and the tendencies of disruptive events investigated. Therefore, it can be argued that effective disruption management may be organised in advance of the actual realisation of the disruption. An early detection of the pre-disruption period can assist entities in the supply chain to significantly handle disruptions. In addition, during the post-disruption phase, senior managers may recognise why the disruption occurred and how to prevent it from happening again. Following the analysis of the cycles above, the pattern of crisis lifecycles recommended by Fink (1986), Barton (1993), and Mitrof (1994) and the British Standards Institute (2009) are assessed in the data collection process of this research using the stages of delay, deviation, stoppage and disaster for a maritime disruption. The disruption cycle as proposed by Blackhurst et al. (2004), Tomlin (2006), Handfield et al. (2008) will be used in the data collection process of this research to assess the maritime events of delay and deviation.

### 3.2.3 Maritime disruptions

There appears to be few studies that precisely define a maritime disruption. For example, Bearing-Point and Hewlett-Packard (2005, p. 2) explain that:

> The maritime industry is directly impacted by a variety of disruptions to the flow of legitimate trade and travel. These range from minor weather disruptions to hurricanes and typhoons, from workforce shortages to work stoppages and from security breaches to potential terrorist attacks.

The above definition of maritime disruptions assumes them to be crises or disasters. Similarly, Barnes and Oloruntuba (2005), Pinto and Wayne (2006) and Paul and Maloni (2010) argue that disruptions in maritime operations are considered as crises in supply chain activities. In the context of maritime disruptions defined by these three studies, the focus was on disaster-related events rather than the categories of delays, deviations, work stoppages, and disasters. For example, the research on container (cargo) shipment disruptions by Arnold (2006) and Wu et al. (2007) defined the events as delay and deviation rather than considering them as a total stoppage of the shipment of containers. Similar to this, the assumptions of Lindsey (1989), Sheffi (2001), Cavinato (2004), Pinto and Wayne (2006) and Friedman et al. (2006) considered a
diversity of maritime threats as being deviation events due to the risk of disruption. Hence, the detailed stages of maritime disruption in terms of delay, deviation, stoppage, and loss of service platform (disaster) are not completely explored and investigated in the supply chain risk literature.

Further, studies of disruption risks including maritime services in the supply chain risk management (SCRM) literature are inconsistent in terms of the consequences of maritime disruption and their significance in a supply chain. Studies by Chang (2000), Lewis et al. (2006), Snediker et al. (2008) and Paul and Maloni (2008) do not consider maritime disruption events in the form of four risks as one transforming process. These studies assume that any disturbances which occur in the maritime services are considered as common internal operational risks and not as risks for all entities in a supply chain (Banomyong 2005; Casaca 2005; Farris 2008). The other internal operational risks investigated in the literatures are low shipping performance (Song et al. 2005), trade security (Banomyong 2005; Kraska & Wilson 2009), security threats (Williams & Treadaway 1992; Barnes 2004), low port performance (Pettitt 2007; Robinson 2007; Paul & Maloni 2010), higher transportation costs (Lewis et al. 2006; Pinto & Wayne 2006; Michaelowa & Krause 2008) and negative economic and social impact (Vanags 2002; Everett 2006).

In contrast, the research of Wagner and Bode (2008, p. 310) suggest that, in terms of consequences, the impact of maritime disruptive events may subsequently ‘threaten normal business operations of firms in the supply chain’. Further, the impact of maritime disruptive events in supply chains may be negative commercial impact (Handfield 2008), low supply chain performance (Wilson 2007) and propagation effects (Wu et al. 2007). Gaonkar and Viswanadham (2007) appear to be the only researchers who define maritime disruptions separately from deviation and disaster. In their research that involves a port closure, the disruption effects are investigated in terms of cost increases along supply chain points. This means that although one particular port closure occurs in the supply chain, it does not consider maritime operations as a blocked linkage - as a disaster - by which the supply chain platform is removed. Similarly, the research on maritime services presumes events as being in tdisaster stage of supply chain risks rather than determining the interactions in the
perspectives of delay, deviation, disruption and finally as disaster outcomes (for example like discussions in Sheffi 2001; Blackhurst et al. 2005; Elkins et al. 2008; Handfield et al. 2008). However, the consequences of port closure due to maritime services such as shipping operations at port are not discussed in detail.

3.3 The drivers of supply chain risks in the maritime leg

The causes of maritime disruptive events are mainly related to maritime operation factors such as the lack of vessel capacity, channel overload and strain on ‘various related port infrastructure and services’ (Handfield et al. 2008, p.35). Moreover, on a broad scale in terms of supply chain practices, Murphy (2009) suggests, in more detailed points, there are 16 factors that may be considered as delays along grain and wheat cargo movements. These factors are access to market information, heavy vehicle access, insufficient rail facilities, complexity of global grain trade, shortage of food grade containers, coordination in transport flows, equipment suitability when selecting ships, shorter lead times, the need for 24/7 operations at ports, availability of shipping services, environmental issues, inconsistency in the decision making process of regulatory bodies, safety issues, drought, lack of an import permit, and financial issues.

When exploring the determinants of operational factors in maritime disruptions, these can be categorised into three domains:

- factors related to the stoppage of ship and cargo handling operations (Chang 2000; Chang 2000; Chopra et al. 2004; Kleindorfer & Saad 2005);
- causes in relation to commercial factors such as market turbulence (Horlick-Jones & Rosenhead 2002; Christopher & Lee 2004), organisational risks (Horlick-Jones & Rosenhead 2002; Handfield 2008), and global sourcing (McCormack 2008); and
- port closures due to inadequate infrastructure (Faisal et al. 2006; Handfield 2008), congestion, and the problems of hinterland access (Vorst 2002; Pinto & Wayne 2006; Gaonkar & Viswanadham 2007; Qiang et al. 2008; Snediker et al. 2008).
These three domains of empirical research lead to the identification of various reasons for maritime risks related to trade interruptions. In general, there is a consistent assumption that presumed risks in maritime operations are predominantly recognised as disaster events. However, the implementation of risk management may be categorised into non-disaster events, which is supported by highly variable data sets and methodologies. Moreover, there are a growing number of maritime risk studies on the availability and non-availability of maritime services which predominantly discuss two major topics namely security (Akaha 1986; Sheffi 2001; Banomyong 2005; Barnes & Oloruntoba 2005; Comfort 2005; Lewis et al. 2006; Pinto & Wayne 2006) and events of disaster (Barnes 2004; Cavinato 2004; Casaca 2005; Lewis et al. 2006; Guerrero et al. 2008). Further, it appears that supply chain operators consider risks in the maritime leg as being fundamental determinants of the existence of maritime disruptions. Conversely, in practice, most maritime operations in relation to supply chain risk may generate various non-disaster events (for examples in Vanags 2002; Watanabe 2002; Woodburn 2007; Robert 2008; Saidi 2008; Syamsudin 2008) which recurrently deviate the performance of maritime operations, and introduce a significant threat to maritime industry.

In particular, the consequences of maritime service deviations include the emergence of maritime congestion (Vanags 2002) which subsequently lowers traffic handling capacity and efficiency (Patunru et al. 2007; Robinson 2007), reduces port accessibility and networks (Flor & Defilippi 2003; Trujillo & Tovar 2007) and decreases economical levels of demand (Haralambides 2005; Homan 2007; Garcia 2008). In addition, Peck (2006) and Craighead et al. (2007) argue that disruptive events in maritime services may fundamentally interrupt the continuity process and the inter-connecting relationship across supply chain operators. As argued by Chopra (2004), Alexander and Irwin (2005) and the Commonwealth Scientific and Industrial Research Organisation (2007), maritime disturbances may further influence the effectiveness of the distribution process.

Maritime disruptions may also increase transportation costs (as found in Gargett 2005; Blas 2007; Gurning 2008) and lead-times (Howick & Eden 2001; Rural Industries Research and Development Corporation 2005). Tiwari et al. (2003) and Emmanuel
(2006) further indicate that various maritime interruptions may attract shippers in changing their planning and transport scenarios in their supply chain. Twenty variables can be categorised as potential driving factors for maritime disruptions in the supply chain (see Table 3-3). They are collected from 46 selected journal papers and research reports on maritime risks in the literature taken over the period of 1983-2010.

Political events are cited before the 1990s as instigating factors of maritime disruptions (Loury 1983; Scrafton & Starkie 1985; Akaha 1986). In the period of 1991-1999 four factors are frequently raised such as earthquake (Rose et al. 1997; Flynn et al. 1999), handling equipment breakdown (Cullinane 1991; Bertrand 1996) and port congestion (Cullinane 1991; Bertrand 1996). During the period of 2000-2010, the four factors of 1991-1999 are still discussed including three other dominant factors such as security (Van de Voort et al. 2003; Barnes & Oloruntoba 2005; Ho 2009; Paul & Maloni 2010), customs and administration (Sawhney & Sumukadas 2005; Wilson 2007), and severe weather conditions (Berry & Linda 2003; Mudrageda & Murphy 2007; Picazo & Martin 2007; Paul & Maloni 2010).

In order to distinguish the causes and impacts of the maritime disruptive events listed in Table 3-3, 20 maritime disruptive events in supply chains are categorised into six groups namely security and safety, service, infrastructure, market, organisation and relationship, and environmental (see Table 3-4). This classification follows the recommendation of various studies in the literature on grouping the disruption risks (Yu & Qi 2004; Bearing-Point & Hewlett-Packard 2005; Handfield et al. 2008). Events such as ship accidents, riots due to political events, piracy, and terrorist attacks are classified in the security and safety-related disruptions (Sheffi 2001; Banomyong 2005; Bearing-Point & Hewlett-Packard 2005). Equipment breakdown and electrical outages are classified as service-related disruptions due to their direct activities on shipping and port operations (Bearing-Point & Hewlett-Packard 2005).
The next category is infrastructure-related disruptions (Ho & Ho 2006; Wagner & Bode 2008) which include the failure of communication facilities, insufficient rail facilities, port congestion, and inland accessibility problems (see Table 3-4). These four issues exist in various maritime-related services and are highly probable of occurring along the supply chain due to an inadequate level of transport infrastructures in the supply chain process (Vanags 2002; Bearing-Point & Hewlett-Packard 2005; Lewis et al. 2006). Furthermore events such as uncertain bunkering (fuel) costs, shortage of dry bulk ships, and insufficient empty containers may be categorised as market-related group (Bearing-Point & Hewlett-Packard 2005; Sheffi & Rice 2005) which increase the probability of occurrence of maritime disruptions, especially in the shipping leg.

Table 3-3. Summary of factors identified as causes of maritime disruptions

<table>
<thead>
<tr>
<th>No</th>
<th>Disruptive events</th>
<th>Researchers and factors identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Security issues</td>
<td>*</td>
</tr>
<tr>
<td>2</td>
<td>Political events</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>Rail related operations</td>
<td>*</td>
</tr>
<tr>
<td>4</td>
<td>Port strikes</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>Customs and administration</td>
<td>*</td>
</tr>
<tr>
<td>6</td>
<td>Quarantine process</td>
<td>*</td>
</tr>
<tr>
<td>7</td>
<td>Severe weather condition</td>
<td>*</td>
</tr>
<tr>
<td>8</td>
<td>Earthquakes</td>
<td>*</td>
</tr>
<tr>
<td>9</td>
<td>Tsunami</td>
<td>*</td>
</tr>
<tr>
<td>10</td>
<td>Electrical outages</td>
<td>*</td>
</tr>
<tr>
<td>11</td>
<td>Equipment/stock shortage</td>
<td>*</td>
</tr>
<tr>
<td>12</td>
<td>Empty containers</td>
<td>*</td>
</tr>
<tr>
<td>13</td>
<td>Ship accidents in port areas</td>
<td>*</td>
</tr>
<tr>
<td>14</td>
<td>Shipping-port disputes</td>
<td>*</td>
</tr>
<tr>
<td>15</td>
<td>Port congestion</td>
<td>*</td>
</tr>
<tr>
<td>16</td>
<td>Ship shortages</td>
<td>*</td>
</tr>
<tr>
<td>17</td>
<td>Fuel and bunkering costs</td>
<td>*</td>
</tr>
<tr>
<td>18</td>
<td>Inland accessibility problems</td>
<td>*</td>
</tr>
<tr>
<td>19</td>
<td>Telecommunication system</td>
<td>*</td>
</tr>
<tr>
<td>20</td>
<td>Shortage of service demand</td>
<td>*</td>
</tr>
</tbody>
</table>

Source: Author
Table 3-4. The categories of maritime disruption risks

<table>
<thead>
<tr>
<th>Type of maritime risk disruptions</th>
<th>Security and safety</th>
<th>Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Ship accidents</td>
<td>- Uncertain bunkering (fuel) costs</td>
<td></td>
</tr>
<tr>
<td>- Political events (riots and war)</td>
<td>- Shortage of dry bulk ships</td>
<td></td>
</tr>
<tr>
<td>- Piracy</td>
<td>- Insufficient empty containers</td>
<td></td>
</tr>
<tr>
<td>- Terrorist attack</td>
<td><strong>Organisation and relationship</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Service related factors</th>
<th>Infrastructure related factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Port strikes</td>
<td>- Port strikes</td>
<td></td>
</tr>
<tr>
<td>- Equipment breakdown</td>
<td>- Equipment breakdown</td>
<td></td>
</tr>
<tr>
<td>- Slow cleanliness checking (quarantine)</td>
<td>- Slow cleanliness checking (quarantine)</td>
<td></td>
</tr>
<tr>
<td>- Long customs process</td>
<td>- Long customs process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The failure of communication facility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Lack of rail facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Severe weather</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Port congestion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Earthquakes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Inland accessibility problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tsunami</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author

Port strikes, slow cleanliness checking by quarantine, long customs processes, and shipping-port disputes are categorised in the organisation and relationship category. This category relates to the inefficiencies of external supporting agencies (as discussed in Haughton & Desmeules 2001; Sawhney & Sumukadas 2005) within maritime services, including industrial disputes among maritime communities (Sawhney & Sumukadas 2005; Farris 2008), that may have a substantial impact along supply chains. Further, maritime disruptive events which are indirectly triggered from external aspects of maritime boundaries are categorised as the environmental-related group (Kleindorfer & Saad 2005; Gaonkar & Viswanadham 2007).

From Table 3-3, it is also apparent that eight factors are cited more frequently than any other category in the literature possibly due to their high value of losses and significant operational impacts on the supply chain network. These factors are severe weather conditions, security issues, port strikes, port congestion, earthquakes, political events, equipment breakdowns, and customs and administration. These eight factors will be explored in detail in the next sub section.
3.3.1 Severe weather conditions

In the period of 2001-2008, hurricanes and cyclones including tropical cyclones are reported as the major factors of disruption in maritime-related operations. Alexander and Irwin (2005), Brown (2008), Coy et al. (2005), Shultz (2006), Seba (2008) analyse the impact of Hurricanes Katrina, Rita, and Dolly on ports, and shipping channels in the US, including the unavailability of some important services especially for ships and cargoes. Due to the severe weather conditions, maritime services were disrupted in terms of delay, deviation, stoppage and loss of service platform for containerised, dry, and liquid bulk cargoes.

Frittelli (2005) reports that in 2005, Hurricane Katrina had considerably increased port disruptions by including much higher shipping costs, as well as transport capacity shortages in terms of grain exports. A further point is that the disruption events by Hurricane Katrina had significantly reduced the port service level by 50 per cent. It resumed partial service after six months (particularly on cargo handling operation) due to the damage of handling cranes, considerable damage of port buildings, railroads, key truck-link, bridges, and shipping channels in the Port of New Orleans, Baton Rouge, South Louisiana, Gulfport, Mobile, Alabama, and Pascagoula.

The impact of cyclones in generating disruptive events on maritime operations was considerable during the period of 2005-2007 (Drum 2007; Yank 2007; Gurning 2008, 2008). The destruction of the Mississippi River in the US due to tropical cyclones in 2005-2006 reduced the ship traffic using this river to the Ports of New Orleans, Baton Rouge, South Louisiana, Gulfport, Mobile, Alabama, and Pascagoula by two-thirds. Studies on the impact of tropical cyclones in Indonesia show that wave levels after the cyclones remained higher than the normal calm sea conditions in the year 2007 (Badan Meteorologi dan Geofisika 2007; Badan Meteorologi dan Geofisika 2008) and that higher wave levels and strong winds were factors in creating maritime disruptions. Other reports of the cyclone impact on LNG and crude-oil terminals (Qalhat LNG terminal in Iran and Mina Al Fahal in Oman) resulted in terminal closure for 14-18 days (Drum 2007; Yank 2007). However, these reports have no damage and impact analysis to confirm the findings.
Available reports between 2007 and 2009 indicate the significant rate of occurrence of interruptions of port and shipping operations (Mahbub 2007; Gurning 2008; Gurning & Cahoon 2009). The reports found 20 impacts of maritime disruptive events in Indonesian ports, inter-island shipping, short-sea shipping, inland road, and coastal areas (as shown in Table 3-5). The reports of Gurning and Cahoon (2009) and Mahbub (2007) indicate four main instigators that create essential disruptions in the maritime operations internally due to severe weather conditions in Indonesia such as the increase of wind speed, the higher wave level, and the increase of sea and tidal level. High winds and waves from the regional cyclones render ports out of service due to navigational warnings by which freight for short-sea and inter-island shipping are not allowed to be operated due to safety considerations. The real economic impacts however, were the higher price of food commodities including grain and wheat-based products in the range of 200-250 per cent, and longer lead-time (50 to 70 per cent from the average level) due to unavailability of certain shipping services from three days to two weeks.

The Australian Transport Safety Bureau (2007) reports the impact of major storms that cause considerable higher disruptive events at Newcastle Port in 2007 compared to the period of 2004-2006. The severe weather conditions during that year generated a significant increase of ship queue numbers, interrupted the rail connection because of flooding and the closure of the port as a result of a ship grounding in the port channel. Further, the wide effects of various disruptive events due to severe weather considerably increased demurrage costs, decreases of the coal throughput of the port and consequently lowering the coal chain capacity from that region to overseas markets. Maritime users consider these conditions as being specific operational problems that create additional costs within a supply chain (Berry & Linda 2003; Mahbub 2007) if port users and cargo owners do not anticipate the extent to which their freight and supply chain will be impacted. Hence, the instigating factors of severe weather conditions and their impacts beyond the maritime leg will be explored in detail in the case of Australian-Indonesian wheat supply chain.
Table 3-5. Instigators and impacts on domestic maritime services in Indonesia in the period 2007-2009.

<table>
<thead>
<tr>
<th>INSTIGATORS</th>
<th>IMPACTS</th>
<th>Port</th>
<th>Short-sea Shipping</th>
<th>Inland road</th>
<th>Coastal area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increased wind speed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased vulnerability of structures</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Reduce the working hour of port equipment</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reduced capacity of port service</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Increased wave agitation in port basin</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Exposure decks of wharf and jetties</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Higher wave level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increased overtopping to decks and jetties</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reduced regularity of the port</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>The closure of ferry terminal</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Increased port damages</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Vessel speed reduction</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Detour of shipping route</td>
<td>x</td>
<td>x</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Frequent shipping delay</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Unavailability of ferry service</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td><strong>Increase in sea-level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Problems with bridge clearance</td>
<td>-</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Low land flooding</td>
<td>-</td>
<td>x</td>
<td>-</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Congestion at port road accessibility</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Congestion around ferry terminal</td>
<td>x</td>
<td>-</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td><strong>Higher tidal level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Problems in ship's manoeuvring</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Increased damage to coastal channel</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Changed dredging requirements</td>
<td>x</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Adapted from PIANC (2009)

### 3.3.2 Security issues

Maritime security risks are largely under significant concerns of international maritime communities especially in the whole of the maritime transport chain (Sheffi 2001; Thai 2007; Kraska & Wilson 2009, 2009). Terrorist attacks and piracy may restrict shipping routes (Akaha 1986; Meija et al. 2009) and create a considerable decrease of shipping trade to the particular region having security issues (Banomyong 2005; Barnes & Oloruntoba 2005; Bearing-Point & Hewlett-Packard 2005; Carafano 2007). The security incidents in maritime operations may generate port closure (Banomyong 2005; Barnes & Oloruntoba 2005), uncertainties and chaotic situation in maritime operations (Pinto & Wayne 2006; He 2009; Ho 2009). Special targets of maritime pirates/terrorists are cargo vessels, fuel tankers, ferries, cruise ships, port areas with dense populations,
ship channels, port industrial plants, and offshore platforms (Bearing-Point & Hewlett-Packard 2005; Parfomak & Fritelli 2007).

### 3.3.3 Port strikes

Labor disputes, particularly in port operations, are one important recurrent risk in a supply chain within the maritime stage (Chopra et al. 2004; Simpson 2004). Labor-based disruptions to port operations are caused mostly by contractual disputes between shipping companies and stevedoring or port workers (Farris 2008). As indicated in Table 3-6, the causes of port strikes are mainly relate to higher pay demand (Wood et al. 2003; Lanka Business Online 2006; BDP 2009; Irish-News 2009), job security (Keifer 2008; TCRC 2008), demands for annual bonuses and better pension agreements (Portworld 2007; Hartley 2009), resistance to port privatization programs (Lanka Business Online 2006; Kent 2008), and the expectation of having better working conditions (BDP Wood et al. 2003; Keifer 2008; 2009).

 Strikes in a port may have a major impact on inland transfer operations such as road transport (Chu & Hansen 2005) and rail operations (CBC News William et al. 2004; 2007; Woodburn 2007), and may further affect port operations if inland transfers depend on railway services or trucking networks. In Coffin’s (2002) impact analysis of port strikes between West Port and Pacific Maritime Association on cargo movement through that port in 2002, he found that economic loss was incurred. This disruptive event was estimated at $US two billion a day in conjunction with the 54 per cent loading and unloading throughput of the port from normal level.

 Studies and models to measure the effect of port strike on the cargo supply chain found considerable impact (Conrad (2004), Watanabe (2002) Watkins (2008). Similarly, port strikes in some ports have various operational impacts such as, insured delay or demurrage costs at $US 60,000 per ship day (Lanka Business Online 2006), cargo and ship rerouting for two to four days (Keifer 2008; Kent 2008), irregular and selective work interruptions for four to six hours (BDP 2009; Hartley 2009), temporary port closure from one day to 14 days (Dearmaley 2008; Mark 2009) and the damages of port facilities for 17 days (Wood et al. 2003).
However, in general, the impact investigations and reports on port strikes predominantly consider how to solve the unsettled negotiations between port management of the port and organised labor (Farris 2008; Watkins 2008) and do not consider the congestion responses or strategies to manage its effect on a supply chain. This study therefore intends to explore the effective mitigation approach not just as an

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Port</th>
<th>Causes</th>
<th>Cost impacts ($US)</th>
<th>Time impacts (days)</th>
<th>Consequences</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>India</td>
<td>Chennai</td>
<td>Demand higher pay</td>
<td>1.5</td>
<td>17</td>
<td>Destruction of port equipment and damage of port facilities</td>
<td>Wood et al. 2003</td>
</tr>
<tr>
<td>2005</td>
<td>Canada</td>
<td>British Colombia</td>
<td>Job security</td>
<td>20 million</td>
<td>2</td>
<td>Port closure</td>
<td>TCRC 2008</td>
</tr>
<tr>
<td>2006</td>
<td>Sri Lanka</td>
<td>Colombo</td>
<td>Demand higher pay</td>
<td>1</td>
<td>10</td>
<td>30 ships waiting outside the port, Container handling rate down to 5 TEUS/hr from 20 TEUS/hr, 10 ships rerouting to other ports, Uninsured delay costs at 60,000 U.S. per ship-day</td>
<td>LBO 2006</td>
</tr>
<tr>
<td>2007</td>
<td>The Netherlands</td>
<td>Smit</td>
<td>Annual bonus</td>
<td>Not provided</td>
<td>4</td>
<td>- Barge congestion, - 30 ships stranded, - No fuel service provided, - Loading delays, - Hurts port image, - Court stops the strike</td>
<td>Portworld 2007</td>
</tr>
<tr>
<td>2008</td>
<td>UK</td>
<td>Dover</td>
<td>Dispute over the privatisation of around 190 jobs at the port</td>
<td>Not provided</td>
<td>2</td>
<td>- Traffic of cargoes and ships stayed away</td>
<td>Kent 2008</td>
</tr>
<tr>
<td>2008</td>
<td>USA</td>
<td>West coast ports (29 ports in California, Oregon, and Washington)</td>
<td>Better benefits</td>
<td>1 billion</td>
<td>1</td>
<td>- Temporary port closures, - Reduce 20-25% of productivity for each port, - Shipment rerouting</td>
<td>Keifer 2008</td>
</tr>
<tr>
<td>2008</td>
<td>New Zealand</td>
<td>Auckland</td>
<td>Application of more causal workers that hampered permanent workers</td>
<td>Not provided</td>
<td>1</td>
<td>- Temporary stoppage of cargo and ships handling, - Decrease port reputation</td>
<td>Deamaley 2008</td>
</tr>
<tr>
<td>2009</td>
<td>Belgium</td>
<td>Antwerp</td>
<td>Demand higher pay</td>
<td>Not provided</td>
<td>6 hours</td>
<td>Irregular and selective work interruptions for port services</td>
<td>BDP 2009</td>
</tr>
<tr>
<td>2009</td>
<td>Ireland</td>
<td>Dublin</td>
<td>Demand higher pay</td>
<td>Not provided</td>
<td>2</td>
<td>- No container and ferry service, - Disrupting the entire city especially the city transport</td>
<td>Irish_News 2009</td>
</tr>
<tr>
<td>2009</td>
<td>Kuwait</td>
<td>KNPC</td>
<td>Annual bonus</td>
<td>Not provided</td>
<td>4 hours</td>
<td>No operation impact due to quick settlement</td>
<td>Hartley 2009</td>
</tr>
<tr>
<td>2009</td>
<td>Ivory Coast</td>
<td>Ivory Coast</td>
<td>Pay dispute</td>
<td>Not provided</td>
<td>14</td>
<td>Temporary stoppage of port operations</td>
<td>Mark 2009</td>
</tr>
</tbody>
</table>

Source: Author
internal response of a port but also across a full range of the supply chain as a means of minimising the effects of port strikes.

3.3.4 Port congestion

A significant factor creating a disturbance state particularly at a port is congestion where the density of service input has exceeded the maximum capacity of its normal operation (Vanags 2002; Lewis et al. 2006; Pettitt 2007; Ross et al. 2008). It is a wide-scale interruption that embraces service structures for cargo related operation, its connection to inland transport, administration processes, and in particular, services for ships due to under-capacity conditions of existing port facility (as discussed in Tiwari et al. 2003; Michelle & Terry 2005; Robinson 2007; Saidi 2008).

Further, port congestion may have three consequences for port operations. Firstly, it can minimise the accessibility and availability of various port and shipping services by generating substantial delays or additional waiting time for ships and cargo (Slack & Wang 2002), secondly followed by utilisation reduction of port facilities (Slack & Wang 2002; Pettitt 2007; Robinson 2007). Thirdly, port congestion also ultimately diminishes the availability of essential services such as cargo handling operations at berth and yard (G-Ports 2007; Garcia 2008), warehouse and open-shed (Garcia 2008), hinterland connection (Notteboom 1997; Gurning 2008) and inland container depot (Chopra et al. 2004). There are 27 potential causes that may create port congestion in the literature (as seen in Figure 3-3).

These causal factors may occur on six different spots at a port such as in the area before port channeling, waterways, at port berth, port service platform, port gate, in the area of inland corridors, and port hinterland. In the area before port channeling, there are two main problems that include an inadequate ship anchoring area (Merrick & Dorp 2006), and the inspection by port state control officers on board (Guerrero et al. 2008) that may increase delay time of a ship at port. Similar to the consequence of delays in waterways, there are six possible events indicated in the literature. Four of them are
identified by Jason et al. (2002) such as ship accidents, siltation of port channel, hazardous spill and low tide level.

Figure 3.3. Diagram of possible factors generating port congestion at a port
Source: Author

The other two factors are severe waves (Williams & Treadaway 1992; FitzGerald et al. 2008) and tsunamis (Pitana & Kobayashi 2010). At port berth (see Figure 3-3), there are nine possible factors that relate to ship handling (Merrick & Dorp 2006; Garcia 2008) and cargo handling (Bearing-Point & Hewlett-Packard 2005). At the port service area, there are six possible factors such as power failure (Chang et al. 2007; Bosch 2008), heavy rain (Galil et al. 2007), immigration and administration process (Sawhney & Sumukadas 2005), the failure of information system and insufficient of container yard (Garcia 2008). At the port gate and in the area of inland corridors, factors related to cargo inspection (Garcia 2008), cargo movement within terminal (Pinto & Wayne 2006; Paul & Maloni 2010), insufficient road (McKinnon 2006; Woodburn 2007), inland transport facility to and from a port supply chain network (Vanags 2002; Tiwari et al. 2003; Lewis et al. 2006) are identified.
However, congestion at a port is mainly considered as specific problems of a port authority or operator due to insufficient level of port infrastructure and facility and not considering its effect beyond port complex in its foreland and hinterland including how to handle when it occurs (Vanags 2002; Pettitt 2007). Therefore, the 27 possible factors generating port congestion will be assessed in terms of their impact and consequences in the Australian-Indonesian wheat supply of this research.

3.3.5 Earthquakes

Many previous studies about the impact of earthquake at ports in most occurrences focused on the long-term impact of a disaster to port operations such as in the earthquakes in Kobe Japan and its impact on Kobe port in 1995 (Chang 2000; Wisner et al. 2004). Further, Pachakis and Kiremidjian (2005) investigated the downtime and annual loss caused by earthquake events on ports to various degrees and scenarios especially on container ports.

In their study, Pachakis and Kiremidjian (2005) find the most common facilities at a port affected by an earthquake to be berths, loading and unloading equipment, warehouses, utilities, and inland connecting roads and bridges. However, the study assumed all events as being at a disaster stage but did not recognise if services needed to be offered or new facilities or infrastructure built. In fact, if the earthquake is of a low magnitude, not all port facilities may be damaged but some port services could be affected and disruptive events consequently occur (Chang 2000). For example in the 1989 Loma Prieta earthquake, the Port of Oakland (Dames & Group 1999) suffered short term damage at three of the port main berths, deformed rail-lines, and tilted container cranes. Through immediate reaction and adaptable responses, the port facilities were able to remain in providing services to users following the earthquake, resulting in only one ship being rerouted (Oakland-Port 1999 in Chang 2000a).

Thus, in general, the earthquake factor is predominantly considered by researchers as natural risks following damages of port assets and deviate its operational performance. However, the impacts of earthquake in a supply chain network are not explored when it
occurs. Therefore, the issue of earthquake impact and strategies to respond the event will be investigated in this research via the data collection process.

3.3.6 Political events

The political environment is an important source of disruption risk to maritime businesses. The political risk is defined as the probability of disruption to the business emanating from a variety of political conflict some of which may be affected by a war (Keirstead 1994), political instability (Ho 2009) and social riots (Paul 1984; Stevenson 1993) which then consequently impacts the level of demand and supply of maritime services both at port and shipping operations (Pinto & Wayne 2006; Kraska & Wilson 2009). A new government may move the nation into a policy direction that can have dramatic effects on a particular maritime trade (Akaha 1986; Banomyong 2005). In the international economic structure, the political environment is even more complex. A dramatic change in trade pacts, quotas and tariff and non-tariff barriers can be a major source of risk of disruption to maritime business that may create commercial impact to a supply chain (Banomyong 2005), inventory delay (Loury 1983; Psaraftis 2005) and deviation flow of cargo transport (Bergstrom et al. 1985; Cheng 1989).

However, there is a little intention on exploring the real consequences of political events in terms of cost and time factors on maritime operations. A political event is a possible factor in instigating maritime disruption, mainly in relation to security disturbances following damages to port and shipping assets (Paul 1984; Stevenson 1993) and not taking into consideration its impact beyond the maritime platform into a supply chain network. Therefore, the issue of political factors such a war and riot including strategies to respond these events will be investigated in this research.

3.3.7 Port related equipment

Cranes and other equipment involved specifically in moving cargoes (Bearing-Point & Hewlett-Packard 2005; Saïdi 2008), and utility systems, including water and sewers may be seen as recurrent variables for disruptive events in the port area (Parfomak & Fritelli 2007; Handfield et al. 2008). In addition, due to a lack of on-site electrical
power generators, port operations are limited to daylight hours only. A power outage limits the operation of certain hangar doors that require electrical power to be opened (as a case in Bosch 2008). The down-time of a port’s crane equipment in many cases introduces the delay period and if it is not managed various services at ports will be unavailable (Bearing-Point & Hewlett-Packard 2005; Frittelli 2005; Saidi 2008).

Further, the problems of port related equipment in the literature are not considered as essential risks in a supply chain but predominantly is considered as operational risks of a port on service performance (Tongzon 1995; Lin & Tseng 2007), profitability (Ro-Kyung Park and Prabir 2004; Loannis 2006) and regional economic losses (Vanags 2002; Boske & Cuttino 2003). Similarly, if down time is not anticipated, a certain port may be left by its major users and operators as a result of equipment problems (Emmanuel & Bruno 2006; Jarzemskiene 2009). In several cases, tenants left the port and moved elsewhere. This was the situation of the Port of New Orleans (Frittelli 2005) and the Port of Kobe (Chang 2000) where, due to operators of those ports being unsure if departed tenants at the ports will return, they have been reluctant to replace three severely damaged handling equipment (Bearing-Point & Hewlett-Packard 2005; Frittelli 2005). Therefore, the impact of insufficient port-related equipment and strategies to respond to the disruptions due to insufficient port-related equipment will be investigated via the collection data process in this research.

3.3.8 Customs clearance

In many countries, customs procedures and the clearance processes are still very severe logistics hindrances (Pearson et al. 1998; Sawhney & Sumukadas 2005). Haughton and Desmeules (2001) argue that slow customs service is often considered as a node in maritime operations with its potential disruption to the network flow of global supply chain. In addition, the customs infrastructure (Carter et al. 1997) and info-structure may interface insufficiently with maritime facilities especially at ports (Sawhney & Sumukadas 2005). The information support system such as electronic data interchange and other communication and information networks connecting customs warehouses, ports, railway operators and shipping operators are unreliable in many cases such as lack of coordination between customs authorities and cargo owners (Haughton &
On this basis then, cargo delay (Garson 1995), and cargo rerouting (Garson 1995; Sawhney & Sumukadas 2005) may occur due to the slow tracking including inspection of cargo handled by custom agency at ports.

However, there is a little intention on exploring the real consequences of inefficient cargo services by customs authorities in terms of cost and time factors in a supply chain process. Customs clearance is one possible factor in instigating maritime disruption at ports and is predominantly recognised as being an additional trade disturbance rather than facilitation following additional supply chain costs (Jose et al. 2003), and additionally its impact beyond port into a supply chain network is not considered. Therefore, the issue of additional costs and time of slow customs clearance at ports will be more investigated in this research.

### 3.4 Disruption management process

The study of mitigation has been approached by researchers in two separate ways in supply chain risk management analysis. One relates to a set of mitigation preparations (Braunscheidel & Suresh 2009; Faisal et al. 2006; Weibel & Hansman 2005) and the other is driven by its response in handling the disruptions (Martinovski et al. 2006; Ward 1999; Kurosawa 2006).

#### 3.4.1 Definition of mitigation approach

Despite there being continued discussion about the definition of mitigation, a common understanding is that there are three different paradigms – the debate on definition (a topic as a contestable difference of definition); the orientation gap theme (a factor as a gap between the responses of a section of an organisation and the actual form of disruptions); and the procedures theme (a matter as an event, tendency or situation which generates, or has the ability to originate, a significant disruption affecting the entity in a supply chain).
However, there is no such wide consensus about how to define disruption mitigation itself. Disruption mitigation appears to be commonly defined as a risk preparation specifically planned to enable an organisation to avoid and not simply respond to disruption or disturbance issues which have the potential to impact on the organisation (Caffi 1999; Martinovski 2000; Weibel & Hansman 2005; Zsidisin & Smith 2005). In addition, Faisal et al. (2006) suggest mitigation is also an understanding of risks, while Braunscheidel and Suressh (2009) recommended mitigation as being a capability, instead of the effort to minimise risks (see Table 3-7).

Martinovski (2005) is one of the few to suggest mitigation also has linguistic values, and is a social phenomenon rather than a cognitive perception on risk events. The other common conceptions of mitigation can be identified from the procedures or processes of mitigating a risk. These include risk prevention (Kunreuther 2001; Pinto & Wayne 2006; Rundmo & Moen 2006; Boehm-Davis & Remington 2009), risk assessment (Sinha et al. 2004; Zsidisin et al. 2004; Fiorucci et al. 2005; Alan 2006; Merrick & Dorp 2006), monitoring and controlling (Ward 1999; Ward 2003; Comfort 2005; Denis 2005; Manuj & Mentzer 2008), financial allocation (Kunreuther 2001; Hendricks & Singhal 2005; Laurie & John 2005; Papadakis 2006), risk evaluation (Drongelen 2001; Arns et al. 2002; Young & Hobbs 2002; Rundmo & Moen 2006), and risk policy (Arreola-Risa & DeCroix 1998; Fischer et al. 1999; Comfort 2005; Denis 2005; Kurosawa 2006; Lewis et al. 2006; David 2007; Li-ping et al. 2007; Michaelowa & Krause 2008).

There is an observable overlap between the two methods (definition and procedures), and both have supported variations of mitigation definition and procedures beyond the specific risk events in a supply chain application. The mitigation mechanism (Grabowski & Roberts 1999; Haigh & Holt 2000; Snediker et al. 2008) that combines risk policy (Yeh et al. 2008) as a business response to adverse disruption risks and the plan to refocus from reaction to preparation, is driven by the idea that identifying and managing risks early improves supply chain entity capacity to handle disruptions and their consequences rather than responding to them ex post facto.
<table>
<thead>
<tr>
<th>Research focus</th>
<th>Definition</th>
<th>Gap</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and perception on mitigation</td>
<td>‘Mitigation is a cognitive but also a linguistic and a social phenomenon. It is applied to describe both expressions of politeness and reactions to stressors, such as blame. Another way of integrating potentiality and actuality is the distinction between preventive and active coping strategies/discourse moves’ (Martinovski et al. 2005, p. 1)</td>
<td>The hierarchical structure of identifying risks, assessing, implementing solutions, conducting effect analysis, and continuously monitoring risks (Sinha et al. 2004)</td>
<td>The activities in gathering, interpreting, reasoning and communicating the results of risk assessment (Marczyk et al. 2003)</td>
</tr>
<tr>
<td></td>
<td>Understanding the risks and minimising the impact by addressing, e.g. probability and direct impact (Faisal et al. 2006, p. 535)</td>
<td>Vulnerability management for reducing losses from natural disasters and allocating financial resources to victims of various devastating events (Kunreuther 2001)</td>
<td>Priority programs to prevent and evaluate risk consequences (Rundmo &amp; Moen 2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A set of preparation and action plan</td>
<td>A set of procedures to undertake static risk assessment, dynamic risk assessment and real time risk assessment (Fiorucci et al. 2005)</td>
<td>A set of activities in monitoring, and controlling progress and developing plans on a rolling basis in a risk management process (Ward 1999)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>‘Capability of the firm, both internally and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions’ (Braunscheidel &amp; Suresh 2009)</td>
<td>Robust policy and strategic options to achieve long-term goals in reducing natural-based risks (Yeh et al. 2008)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strategies to manage the exposure of the risks’ effects (Weibel &amp; Hansman 2005)</td>
<td>A preparation which various possible risks are assessed, reviewed, evaluated and adopted (Martin et al. 2009)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mitigation involves participation, which is a more general strategy for practice and change of corporate social responsibility (Maloni &amp; Brown 2006)</td>
<td>Mitigation involves participation, which is a more general strategy for practice and change of corporate social responsibility (Maloni &amp; Brown 2006)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual responses</td>
<td>Generally as weakening or reducing of interaction variables, which affects allocation and rearranging of resources and obligations to reduce risks (Caffi 1999)</td>
<td>An effort to develop recognizable mechanisms that increase structure fluidity of an organisation in handling risks (Grabowski &amp; Roberts 1999)</td>
<td>‘Activities to limit access to disaster prone areas, create physical appurtenances in protecting community, to educate populace to take action in reducing the likelihood, and to replace property loss during a disaster’ (Fischer et al. 1999, p. 715)</td>
</tr>
<tr>
<td></td>
<td>The decreasing of vulnerability (Martinovski 2000)</td>
<td>Responsibility involves attribution variables such as instigating factors, sharedness, target, visibility, choice, propagation, and capacity (Martinovski &amp; Marsella 2003)</td>
<td>Actions to realise comprehensive policy in spite of the uncertainty in technologies, climate dynamics, and socioeconomic conditions (Kurosawa 2006)</td>
</tr>
<tr>
<td></td>
<td>‘Mitigation means attempting to reduce the damage caused by disruption by means of a warning system’ (Pereira 2009, p. 374)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author
Thus, mitigation as risk policy eventually led to understanding mitigation as a preparation strategy to minimise disruption risks in the supply chain. This includes the capability of understanding actual programs to reduce risks by a comprehensive preparation stage in which the assessment, review, adoption, and evaluation process are undertaken (Marczyk et al. 2003; Martin et al. 2009).

Over the period of the mitigation research, social expectation and progress beyond the purely risk management approach has arisen. Martinovski and Marsella (2003), Sjoberg (2003) and Maloni and Brown (2006) suggest any particular issue may be adopted and customised by a number of novel community-based responses in supply chain risk management. These include risk communication, corporate social responsibility, and sustainability management. Given the mitigation studies in the literature, all results are specifically intended to establish a comprehensive review of the entire risk environment, but the involvement of entities in their upstream and downstream link, including mitigation or risk policy in supply chain networking, are very rarely elaborated. Studies by Weibel and Hansman (2005), Nilsen and Olsen (2007), Gojovic et al. (2009), and Wagner (2009) attempt to develop the simultaneous nature of disruption management and a network supply chain. However, these networking-based mitigations only consider a specific location in a supply chain not as an interactive set of processes in a supply chain network.

The current study therefore intends to explore the effective mitigation and disruption management approach not just as an internal response of an organisation but across the full range of relationships that link and coordinate disruption management processes and functions in supply chain activities.

### 3.4.2 Mitigation approach in disruption management

The importance of effectively managing supply chain disruptions as well as the lack of preparedness of most companies has drawn attention to both academia and industry. However, interestingly, supply chain disruption in maritime operations has not been discussed intensively as a disruption management topic in the overall context of the supply chain. The application of automotive (Skipper & Hanna 2009), capital market
(Sheffi 2001), chemical (Mitroff & Alpasian 2003), electronics (Kleindorfer & Saad 2005), information technology (Jia & Rutherford 2010), pharmacy (Rice & Caniato 2003), and toy production (Johnson 2001) dominates the study of mitigation strategies in the supply chain (see Table 3-8). In addition, the location of mitigation research in the USA and the issue of delay and deviation is evidence that the perception of disruption risk has a strong effect in the literature of risk mitigation strategies in supply chains.

Table 3-8. The literature of mitigation strategies in the supply chain risk management

<table>
<thead>
<tr>
<th>Application</th>
<th>Researcher</th>
<th>Country</th>
<th>Disruptive event</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace</td>
<td>Sinha et al. (2004)</td>
<td>USA</td>
<td>Delay and deviation</td>
<td>IDEF0 model</td>
</tr>
<tr>
<td>Military</td>
<td>Vactor (2007)</td>
<td>USA</td>
<td>Deviation</td>
<td>Composite plan</td>
</tr>
<tr>
<td>Automotive</td>
<td>Chopra and Sodhi (2004)</td>
<td>USA</td>
<td>Delay and deviation</td>
<td>Flexibility planning</td>
</tr>
<tr>
<td>Capital market</td>
<td>Skipper and Hanna (2009)</td>
<td>USA</td>
<td>Delay and deviation</td>
<td>Replanning tool</td>
</tr>
<tr>
<td>Chemical</td>
<td>Kunreuther (2001)</td>
<td>USA</td>
<td>Disaster</td>
<td>Insurance support</td>
</tr>
<tr>
<td>Chemical</td>
<td>Sheffi (2001)</td>
<td>USA</td>
<td>Deviation</td>
<td>Proactive plan</td>
</tr>
<tr>
<td>Chemical</td>
<td>Mitroff (1994)</td>
<td>India</td>
<td>Disaster</td>
<td>Quality approach</td>
</tr>
<tr>
<td>Chemical</td>
<td>Mitroff and Alpasian (2003)</td>
<td>Global</td>
<td>Disaster</td>
<td></td>
</tr>
<tr>
<td>Electronics</td>
<td>Kleindorfer and Saad (2005)</td>
<td>USA</td>
<td>Delay to disaster</td>
<td>Mitigation assessment</td>
</tr>
<tr>
<td>Fuel transport</td>
<td>Blos et al. (2009)</td>
<td>Brazil</td>
<td>Delay and deviation</td>
<td>Risk communication</td>
</tr>
<tr>
<td>Information technology</td>
<td>Jia and Rutherford (2010)</td>
<td>China</td>
<td>Delay and deviation</td>
<td>Cultural response</td>
</tr>
<tr>
<td>Information technology</td>
<td>Yeh et al. (2008)</td>
<td>USA</td>
<td>Delay</td>
<td>Bottom-up model</td>
</tr>
<tr>
<td>Information technology</td>
<td>Levy (1995)</td>
<td>USA</td>
<td>Delay</td>
<td>Stability flow</td>
</tr>
<tr>
<td>Inland transport</td>
<td>Ng et al. (2000)</td>
<td>China</td>
<td>Delay</td>
<td>Case-based model</td>
</tr>
<tr>
<td>Inland transport</td>
<td>Faisal et al. (2006)</td>
<td>India</td>
<td>Delay to disaster</td>
<td>Enabling model</td>
</tr>
<tr>
<td>Inland transport</td>
<td>Artikis and Artikis (2009)</td>
<td>UK</td>
<td>Delay to stoppage</td>
<td>Recovery strategy</td>
</tr>
<tr>
<td>Inland transport</td>
<td>Edward and Steven (1997)</td>
<td>Australia,</td>
<td>Delay and deviation</td>
<td>Holistic coordination</td>
</tr>
<tr>
<td>Inventory</td>
<td>Blackhurst et al. (2005)</td>
<td>USA</td>
<td>Delay and deviation</td>
<td>Networking plan</td>
</tr>
<tr>
<td>Inventory</td>
<td>Tomlin (2006)</td>
<td>USA</td>
<td>Delay to disaster</td>
<td>Supply contingency</td>
</tr>
<tr>
<td>Inventory</td>
<td>Wagner and Bode (2008)</td>
<td>Germany</td>
<td>Delay to stoppage</td>
<td>Strategic decision</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>Rice and Caniato (2003)</td>
<td>USA</td>
<td>Delay and deviation</td>
<td>Resilience concept</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Cavinato et al. (2004)</td>
<td>USA</td>
<td>Deviation</td>
<td>Integrated approach</td>
</tr>
<tr>
<td>Purchasing</td>
<td>Zsidisin and Smith (2005)</td>
<td>USA</td>
<td>Delay</td>
<td>Supplier involvement</td>
</tr>
<tr>
<td>Project management</td>
<td>Howick and Eden (2001)</td>
<td>UK</td>
<td>Delay</td>
<td>Incentive strategy</td>
</tr>
<tr>
<td>Road transport</td>
<td>McKinnon (2006)</td>
<td>UK</td>
<td>Delay and deviation</td>
<td>Macro assessment</td>
</tr>
<tr>
<td>Toy industry</td>
<td>Johnson (2001)</td>
<td>USA</td>
<td>Delay and deviation</td>
<td>Dynamic mitigation</td>
</tr>
</tbody>
</table>

Source: Author
Mitroff and Alpasin (2003) state that between five and 25 per cent of Fortune 500 companies are prepared to handle crises or disruptions. Farris (2008), Howick (2001), Lichtenberg (2004), Quiggin and Fisher (1994), and Shailesh et al. (2005) find that disruptions can be costly in supply chain systems and can cause a variety of problems such as long lead-times, stock-outs, inability to meet customer demand and increases in costs. Levy (1995) investigates international supply chain physical flows with disruptions in demand and finds that disruptions in an international supply chain can lead to unexpected costs when shipping lead times are long. It is also interesting to note that Levy found that when crises in a supply chain do occur, managers tend to handle them as one-time events rather than understanding that they may lack a robust supply chain. Additionally, the cost of supply chain disruptions to a company can be of significance. While many companies have not been able to quantify the cost of supply chain disruptions or crises, some work has been done in this area.

Rice and Caniato (2003) present results from a company survey that estimates a US$ 50-100 million cost impact for each day of a substantially disrupted supply network. Riddalls and Bennett (2002) suggest a model of a production–inventory system using differential equations to predict the consequence of production disruption.

The model allows disturbances to be transmitted through the system and found that as the system becomes unstable, costly demand swings and stock-outs occur. The research area of supply chain disruption management is an area of interest both in academic research and industry practice due to the fact that failure at any one point in the supply chain can cause the entire network to fail (Rice & Caniato 2003). Indeed, there is a new focus in this area beyond the four walls of the plant (Peck 2006). However, despite increasing awareness among practitioners, the concept of supply chain vulnerability and supply chain risk are still in their infancy (Juttner et al. 2003). In terms of a mitigation approach for managing disruptions (as seen in Table 3-9), there are four different categories of mitigation with 19 strategies implemented by supply chain entities in the literature. Those categories are (i) inventory and sourcing, (ii) contingency rerouting, (iii) business continuity planning, and (iv) recovery planning. In the next sub-sections, the four categories will be explored in detail.
3.4.2.1 Inventory and sourcing

Vachal and Reichart (2000), Sheffi (2001) and Kleindorfer and Saad (2005) suggests a mix of inventory/sourcing mitigation concepts as strategies for managing disruptions (as listed in Table 3-9).

Table 3-9. Mitigation strategies of managing disruptions from the literature

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Strategies</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory and Sourcing</td>
<td>Inventory polling at ports</td>
<td>Young 1999; Vachal &amp; Reichart 2000; Park &amp; Koo 2001; Sheffi 2001</td>
</tr>
<tr>
<td></td>
<td>Utilising agency service</td>
<td>RIRDC 2005; Tomlin 2006; Rick &amp; Van Horn 2008</td>
</tr>
<tr>
<td></td>
<td>Apply other chain links</td>
<td>Janzen &amp; Rice 2001; Kleindorfer &amp; Saad 2005; Tang 2006</td>
</tr>
<tr>
<td></td>
<td>Optimum ordering policy</td>
<td>Wilson &amp; Preszler 1993; Depak 2003; Tomlin 2006</td>
</tr>
<tr>
<td></td>
<td>Postponement delays</td>
<td>Sheffi 2001; Tang 2006; Tomlin 2006; Schlecht 2001; Buschel &amp; MacAulay 2005</td>
</tr>
<tr>
<td></td>
<td>Supply flexibility</td>
<td></td>
</tr>
<tr>
<td>Contingency Rerouting</td>
<td>Reserves routes</td>
<td>Biere 1998; Handfield &amp; McCormack 2008</td>
</tr>
<tr>
<td></td>
<td>Critical nodes mapping</td>
<td>Binkley 1983; Handfield et al. 2008; Blackhurst et al. 2005</td>
</tr>
<tr>
<td></td>
<td>Apply other chain links</td>
<td>Schlecht et al. 2004; Tang 2006</td>
</tr>
<tr>
<td></td>
<td>Contingency plan</td>
<td>Hoskisson et al. 1999; Lewis 2006; Tomlin 2006</td>
</tr>
<tr>
<td>Business Continuity Planning</td>
<td>Changes to working practices</td>
<td>CCTA (1995); Beatty (2001); Gibb (2006); Skelton (2007);</td>
</tr>
<tr>
<td></td>
<td>Maximum allowable interruption</td>
<td>William (2002); Haque &amp; Burton (2004); Tomlin (2006); Farber (2008);</td>
</tr>
<tr>
<td></td>
<td>Develop warning system</td>
<td>Craighead et al. 2007</td>
</tr>
<tr>
<td></td>
<td>Implication monitoring</td>
<td>Howick and Eden (2001); Rosamond et al. 2007; Elkins et al. (2008)</td>
</tr>
<tr>
<td>Recovery Planning</td>
<td>Risk-based budgeting</td>
<td>Craighead et al. 2007</td>
</tr>
<tr>
<td></td>
<td>Apply discovery responses</td>
<td>Blackhurst et al. 2005; Craighead et al. 2007; Garcia (2008)</td>
</tr>
<tr>
<td></td>
<td>Apply recovery actions</td>
<td>Pinto and Wayne (2006); Craighead et al. 2007;</td>
</tr>
<tr>
<td></td>
<td>Network &amp; procedures redesign</td>
<td>Handfield et al. 2008</td>
</tr>
</tbody>
</table>

Source: Author

These mix strategies are recommended for a firm that faces instability in supply and sources from two identical cost and infinite capacity suppliers when disruptions occur along a supply chain. The mitigation strategies in this category include inventory polling at ports, utilising an agency service, applying other chain links, an optimum ordering policy that postpones delays, and supply flexibility. These studies focus on how to minimise demurrage costs without incurring high government costs or distorting price signals. Following these two types of relevant costs, Schlecht (2001) and Schlecht et al. (2004) explore different inventory and sourcing strategies to mitigate supply chain risks such as delays and cargo handling deviations due to different grades of
commodities in the import market. This concept, is then broadly developed by Janzen and Rice (2001) who apply inventory and sourcing strategies focusing on two main joint risk measures, namely the wheat market and wheat shipments in a wheat chain.

3.4.2.2 Contingency rerouting

Contingency rerouting is another category of mitigation applied by supply chain entities in managing disruptions. Biere (1983), Handfield and MacCormack (2008) examine the concept of an international reserved route in a supply chain and its impact mechanism particularly on costs and benefits of alternative supply chains under dynamic conditions of transportation operation including fluctuating shipping freight rate. Further, Binkley (1983), Blackhurst (1993) and Handfield et al. (2008) suggest a general method of identifying critical nodes with uncertainty coefficients and risk probability index of suppliers on the import demand of a product. Their research also includes transportation and trade expenses to various importing countries. The main goal of their research is identifying critical points to determine the uncertainty of supply level and potential costs.

Similar to critical nodes, the mitigation strategy of applying other alternative chains is recommended by Schlect, Wilson and Dahl (2004) and Tang (2006) as one applicable response when any interruptive events occur in the targeted market. In relation to this, Duval and Biere (1998) develop a framework of parameters of a commodity model in a vulnerable supply chain system and examined logistical risks associated with the marketing of homogenous corn between an inland and export terminal. Operational uncertainties included in the study are yearly supplies of commodities, deliveries into the system, railcar and barge placements, vessel arrivals, and transportation transit times. Further, Zsidisin et al. (2004), and Philip and Smyth (2007) examine the formal logistical risks assessment technique of marketing grain in a dynamic domestic price system. Logistical risks that are included in the research are defined as shipment-related uncertainties in terms of vessel arrivals, inventory levels of grain at the port, mis-grades that arrive at port, and the rail car unload rate. Their research confirm the previous research result of Faruqee et al. (1997) that find an increase of mis-handling wheat
based on its grade is a major limiting factor in the efficient movement of grain from the producer (farm) to the port.

3.4.2.3 Business continuity

Another mitigation strategy that can be implemented when disruptions occur is business continuity planning. In relation to supply chain disruptions, Beatty (2000) and Gibb (2006) emphasise the importance of changes to working practices of a company when disruptions occur in order to achieve the optimum efficiency under interruptive supply chain operations. This may be achieved through transferring risk or risk-sharing decision methods such as insurance plans and outsourcing strategy. Given the application above, the implication of monitoring supply chain flow through a certain supply chain process, as well as the damage control plans are discussed by Elkins et al. (2008) and Howick and Eden (2001) in order to find continuity actions in the period of disruptive events. On the basis of these particular models, Rosamond et al. (2007) also propose a broad business continuity mitigation model examining three main risk factors such as cargo availability, security and the environment factors.

3.4.2.4 Recovery planning

The wider literature of recovery planning studies on a wheat supply chain appears to have begun by Clark and Miller (1967) who initiated the impact analysis study on export related costs because of the uncertainty of cargo shipment availability. The study provides a cost analysis and comparison of various changes to transportation and shipment arrangements to international markets. A similar research focus is then continued by Garcia (2008) which expand on the inter-correlation impact of port operator, agents of shipping companies, shippers, and agricultural consignees. A study undertaken by Craighead et al. (2008) builds a comprehensive assessment technique to identify threats in the grain industry and the warning system of various threats. A study by Pinto (2003) provides a discussion on security risks incurred when a port is facing disruptive events. The study developed incident cycles including a comparison of ships versus container movements. Many benefits of containerised shipping are included, and a justification for their use is thoroughly analysed. Figure 3-4 shows 19 mitigation strategies which are recommended in the literature of disruption management (as listed
in Table 3-9). In terms of a disruption period, the 19 mitigation strategies may be categorised into three different groups at pre disruption, on disruption, and post disruption stages. The sequence of strategies implemented during pre, on, and post disruption stage is linked with arrows as discussed in the literature (Kleindorfer & Saad 2005; Rundmo & Moen 2006; Tomlin 2006; Nilsen & Olsen 2007; Gojovic et al. 2009).

Figure 3-4. Mitigation strategies for supply chain disruption
Source: Author

3.4.3 Disruption management approach in the transportation processes

The goal of managing disruptions is to alleviate the consequences of disruptions or, simply put, to increase the robustness of a supply chain through transportation links including the maritime leg. However, there are very few qualitative concepts of managing transport disruptions from a time-based perspective (pre disruption, on disruption, and post disruption stage). The majority of transportation issues in disruption papers (as mentioned in Table 3.10) also focus on the combination of the
three mitigation strategies as discussed in Section 3.4.2, such as inventory and sourcing mitigation (ISM), contingency rerouting (CR), business continuity planning (BCM), and recovery planning (RP).

Table 3-10. The literature disruption management in the transport processes

<table>
<thead>
<tr>
<th>Year</th>
<th>Disruption management topics</th>
<th>Application in transport operation</th>
<th>Researchers</th>
<th>Objectives</th>
<th>Methods</th>
<th>Management Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Security on supply chain risk assessment</td>
<td>Terrorist attack</td>
<td>Sheffi</td>
<td>Propose postponement delays, imported inputs, and input limitation</td>
<td>Risk Pooling Analysis</td>
<td>√</td>
</tr>
<tr>
<td>2003</td>
<td>Business continuity planning</td>
<td>Multimodal application</td>
<td>Depak</td>
<td>Developed business continuity scenario of a firm facing disruptions</td>
<td>Continuity cycle</td>
<td>-</td>
</tr>
<tr>
<td>2004</td>
<td>Formal risk assessment</td>
<td>Inbound supply</td>
<td>Zuidis, Carter, &amp; Caiinao</td>
<td>Procedures and techniques</td>
<td>Agency theory</td>
<td>√</td>
</tr>
<tr>
<td>2005</td>
<td>Disruption visibility</td>
<td>Service stoppages</td>
<td>Blackhurst et al.</td>
<td>Actions related to disruption discovery, recovery, and redesign</td>
<td>Focus group interview</td>
<td>√</td>
</tr>
<tr>
<td>2008</td>
<td>Resilient supply chain</td>
<td>Operation stoppage due to severe weather</td>
<td>Tang</td>
<td>Robust mitigation strategy</td>
<td>Lessons learned from cases of Nokia, Dell,</td>
<td>√</td>
</tr>
<tr>
<td>2001</td>
<td>Quantification of mitigation and contingency strategies</td>
<td>Blockages of supply</td>
<td>Tang</td>
<td>Flexible scenarios of optimal inventory strategy and environment risk index</td>
<td>Optimal ordering policy under Markov chain</td>
<td>√</td>
</tr>
<tr>
<td>2007</td>
<td>Security threats</td>
<td>Supply chain entry</td>
<td>McCormack</td>
<td>Develop procedures to estimate the probability of supplier attributes</td>
<td>Risk probability index</td>
<td>√</td>
</tr>
<tr>
<td>2008</td>
<td>Transport network</td>
<td>Supply chain entry</td>
<td>Wu et al.</td>
<td>Develop a network method to assess the propagation of disruption network (DA_NET)</td>
<td>Disruption analysis network</td>
<td>√</td>
</tr>
<tr>
<td>2009</td>
<td>Complex transport network / routes</td>
<td>Service scope</td>
<td>McHenderson et al.</td>
<td>Develop a decision support system for generic port disaster model</td>
<td>Generic port disaster model</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>The effects of disasters</td>
<td>Weather or security</td>
<td>Paul &amp; Maloni</td>
<td>Develop a decision support system</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Gurning and Cahoon (2009)
Note: ISM: Inventory and sourcing mitigation; CR: contingency rerouting; BCM: business continuity planning, RP: recovery planning

Depak (2003), Kleindorfer and Saad (2005) and Sheffi (2001) are the supply chain disruption papers that consider the mixture of inventory/sourcing mitigation and business continuity concepts in managing disruptions in the issues of terrorist attack, multi-modal application, and the closure of a transport facility such as a port. These strategies are recommended for a firm (as a maritime user) that faces constant demand and sources from two identical-cost and infinite-capacity suppliers. Further, Blackhurst et al. (2005) and Craighead et al. (2007) emphasise the importance for entities in supply chains to minimise the ultimate loss from transport operations by considering
the trade-off between the robustness of the supply chain to transport disruptions and the overall efficiency under normal operations of transportation services due to a transport union strike or other service stoppages. This may be achieved through risk-sharing decisions through insurance plans, redesign of a supply chain flow through certain supply chain delay management, and damage control plans (Howick & Eden 2001; Marley 2006; Elkins et al. 2008).

The studies of Wagner and Neshat (2009) propose an assessment approach to measure the effectiveness of a mitigation approach implemented in a supply chain network application by looking at variables of supply chain performances mainly on time. The studies apply graph theory and combine three different approaches such as CR, BCM, and RP. To continue the research of Wagner and Neshat (2009), Paul and Maloni (2010) recommend a generic model to measure the optimised strategy to handle port disaster events in terms of time and costs of the actions implemented. However, strategies applied in their applications are only assumed as being single mitigation reactions for whole supply chain entities. In fact, along a supply chain, each entity may have their specific strategies which may affect the network performance of a supply chain when disruptions occur.

Therefore, it may be identified that, the dominant reactions of maritime users in the supply chain management are adjusting to a new route in the maritime leg and providing back-up systems such as contingency plans and having strategic stock (where no alternative source is available). These are critical initial steps in disruption risk management in responding to the worst case scenarios of maritime disruptions.

3.5 Supply chain risk management in the wheat chain processes

The following discussion focuses on the transportation mitigation of the wheat chain from loading terminals to a destination market (as shown in Table 3-11). The content of this area of research involves logistical costs and risks associated with the wheat and grain marketing system. In addition, some studies evaluated the benefits and costs of mitigation risk systems.
Table 3-11. The literature of supply chain risk management of wheat transport

<table>
<thead>
<tr>
<th>Year</th>
<th>Researcher</th>
<th>Findings on risks and mitigation of wheat transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>Binkley</td>
<td>The concept of instability in the international grain trade and its impact mechanism to transport operation including shipping freight-rate</td>
</tr>
<tr>
<td>1993</td>
<td>Wilson &amp; Preszler</td>
<td>Identification method for uncertainty coefficient on import demand of wheat</td>
</tr>
<tr>
<td>1997</td>
<td>Faruqee, Coleman, &amp; Scott</td>
<td>Risk assessment technique based on dynamic domestic market price of wheat without incurring high government cost or distorting price signals</td>
</tr>
<tr>
<td>1998</td>
<td>Duval &amp; Biere</td>
<td>A framework of parameters for building wheat modelling toward grain producers’ attitude on supply chain vulnerability.</td>
</tr>
<tr>
<td>1999</td>
<td>Young</td>
<td>The impact analysis of export costs of wheat trade in Canada due to uncertainty of Wheat Board policy and changes of transportation and shipment arrangements to international markets</td>
</tr>
<tr>
<td>2000</td>
<td>Vachal &amp; Reichert</td>
<td>The concept and ideas of changing pattern from bulk to containerised shipment of wheat transport</td>
</tr>
<tr>
<td>2001</td>
<td>Park &amp; Koo</td>
<td>An empirical study on how ‘port-buying’ strategy in removing maritime risks for wheat shipments of domestic points</td>
</tr>
<tr>
<td></td>
<td>Schlect</td>
<td>A variety of distribution models of logistical risks transporting different grades of wheat to importing market.</td>
</tr>
<tr>
<td></td>
<td>Janzen &amp; Wilson</td>
<td>Two risk measures (wheat market-at-risk and wheat shipments-at-risk) of stages of a wheat-chain</td>
</tr>
<tr>
<td></td>
<td>Transport SA</td>
<td>Analyse the grain transport risk in South Australia in particular related to port and shipping facility and capability.</td>
</tr>
<tr>
<td>2002</td>
<td>Schlecht, Wilson, &amp; Dahl</td>
<td>Broadening the impact of risks on logistical costs in marketing and transporting different grade of wheat.</td>
</tr>
<tr>
<td>2004</td>
<td>RIRDC</td>
<td>The structure of logistics cost as a proportion of grain export prices from Australian farm gate to port.</td>
</tr>
<tr>
<td>2005</td>
<td>Bushel &amp; MacAulay</td>
<td>The impact analysis of inter-correlations of principal, agents and wheat marketing to the effectiveness of Australian wheat movement and competitiveness.</td>
</tr>
<tr>
<td>2006</td>
<td>Rosamond et al.</td>
<td>A grain chain mitigation model based on three risk factors of bio-fuel, food security and the environment including</td>
</tr>
</tbody>
</table>
Binkley (1983) examines the instability concept of international grain trade and its impact, particularly on the costs and benefits of alternative supply chains under dynamic conditions of transportation operations including the shipping freight rate. Further, Wilson and Preszler (1993) identify a general method of calculating the uncertainty coefficient on the import demand of wheat. Their research also includes transportation and marketing expenses to various importing countries. The main goal of that research was to determine the uncertainty of demand level and potential costs.

Faruqee et al. (1997) suggest a logistical risks assessment technique in a dynamic grain marketing system. Past research shows that an increase in grades is a major limiting factor in the efficient movement of grain from the producer (farm) to the port. Logistical risks included in the model are uncertainty in vessel arrivals, inventory levels of grain at the port, misgrades that arrive at port, and the rail car unload rate. Other factors that can cause supply disruptions are uncertainty in demand, quality, and performance. The study focuses on demurrage costs without incurring high government costs or distorting price signals. To extending this study, Schlecht (2001) and Schlecht et al. (2004) expand the supply chain risk assessment due to different grades of commodities to an importing market. This concept, is then broadly developed by Janzen and Rice (2001) who focus on two main joint risk measures namely wheat market and wheat shipments in a wheat chain.

Duval and Biere (1998) develop framework parameters of a wheat model in a vulnerable supply chain system and examine logistical risks associated with marketing homogenous corn between an inland and export terminal. Uncertainties included in the
study are yearly supplies of commodities, deliveries into the system, railcar and barge placements, vessel arrivals, and transportation transit times. Given that application, Philips and Smith (2007) expand a similar study with the establishment of a risk analysis framework for the management of liabilities of a wheat supply chain. On the basis of these particular models, Rosamond et al. (2007) propose a broad grain chain mitigation model examining three main risk factors such as bio-fuel, food security and the environment.

The wider literature of risk impact studies on wheat transport started with Young (1999) who initiated the impact analysis study on export related costs of Canadian wheat due to uncertainty of Wheat Board policy. The study provides a cost analysis and comparison of various changes of transportation and shipment arrangements for international markets. A similar research approach is continued by Bushel and MacAulay (2007) which enlarge the inter-correlation impact of principals and agents within Australian wheat marketing policy. A further study undertaken by Rick and Van Horn (2008) builds a comprehensive assessment technique to identify threats in the grain industry and the prediction of opportunities of agri-flation.

Another study by Reichert and Vachal (2003) provides a discussion of risk incurred when organising identity preservation shipments. The study developed a cost analysis including comparison of bulk versus container movements. Many benefits of containerised shipping are included, and a justification for their use is thoroughly analysed. A simple comparison concludes the study by comparing transportation expenses of shipping soybeans from Iowa to Japan across alternative modes, including container, truck, single rail car, and unit train shipments. Truck transportation is found to be the most expensive at $4.05 per bushel, and unit trains are the least expensive at $1.65 per bushel. The difference in unit train versus container shipment costs are reported to be 33 cents per bushel. Given that application, Transport SA (2002) establish a transport risk study in South Australia in particular related to shipping facility and capability.
Further, Park and Koo (2001) undertake an empirical study in order to assess whether or not ‘port buying’ strategy has succeeded in removing maritime risks for wheat shipments of domestic points. The study found that active and flexible responses of port facilities and services are evident concerning the acceptable optimum costs and price of wheat under various maritime risks particularly on various sizes and capacity of available ships and the freight rate. In the particular case of Australia, Rural Industries Research and Development Corporation (2005) explored the structure of logistics costs and prices calculated from Australian farm gate to port.

The wider literature on recovery planning studies on the wheat chain can be traced to Clark and Miller (1967) who initiate an impact analysis study on export related costs of Canadian wheat due to the uncertainty of wheat shipment availability. That study provided a cost analysis and comparison of various changes in transportation and shipment arrangements to international markets (as shown in Figure 3-4). Similarly, Duval and Biere (1998) suggest recovering responses as framework parameters of a wheat model in a vulnerable supply chain system and examined logistical risks associated with an homogenous marketing system between an inland and export terminal. Uncertainties included in the study are yearly supplies of commodities, deliveries into the system, railcar and barge placements, vessel arrivals, and transportation transit times. This type of strategy is taken to anticipate various risks in the process of maritime transport in the wheat supply chain in the research of Garcia (2008). Further, in the study of Garcia (2008), a risk warning system is developed that assesses past risk events that generate an inter-correlation impact on port operators, agents of shipping companies, shippers, and agricultural consignees.

3.6 Maritime disruption analysis using the Markov process

In practice, researchers and maritime operators during maritime disruptions primarily concentrated on the efforts to prevent (Barnes & Oloruntoba 2005; Bearing-Point & Hewlett-Packard 2005), react to (Bill 2002; Flor & Defilippi 2003; Lewis et al. 2006; DPC 2008), prepare for (Barnes & Oloruntoba 2005; Bearing-Point & Hewlett-Packard 2005; Lewis et al. 2006) and recover from the benefits of their boundary as a maritime
entity being hit by disruptive events and not on the scale of a whole process in a supply chain (Vanags 2002; Stasinopoulos 2003; Van de Voort et al. 2003; Lewis et al. 2006; Sakhuja 2007; Robert 2008). As a result, various maritime disruptive events are treated similarly to common disruption events along the supply chain process disruption.

Similar to this in practice, maritime disruptions mostly respond to intervention strategies using the approach of the general decision support system, consisting of four main components namely mitigation, preparedness, response and recovery methods (Wallace & Balogh 1985; Vanags 2002; OECD 2003; Emmanuel & Bruno 2006; Lewis et al. 2006; Sakhuja 2007; Garcia 2008). However, these actions are not real-time responses and are considered as relatively passive approaches when maritime disruptions occur. According to Handfield et al. (2008) and Elkins et al. (2008), to get a better understanding of supply chain disruptions, a map of critical nodes and the inter-connections of those are needed in order to increase the visibility of the occurrence of disruptive events between disruption discovery and recovery. Therefore, maritime operations as critical nodes in the supply chain process, due to their higher density and complex inter-connection, may need a set of additional business processes. These may improve information visibility, reduce the time span between the period of disruption discovery and recovery, and subsequently minimise the consequences of maritime disruptions. Further, the recovery process in maritime disruptions is not able to properly restore the issues of market and service levels of maritime operators. The examples of the Port of Kobe (Chang 2000; Chang 2000) and Port of New Orleans (Frittelli 2005; Schultz 2006; Seba 2008) are the empirical maritime events where the authorities need post disruption responses to redesign their facility in order to minimise the market implications of their loss of services.

3.6.1 The application of the Markov chain

Supply chain entities can implement a number of strategies to manage uncertainties in their transport flows (see Figure 3-5). Strategies that are provided in the literature are contingency planning, robust optimisation, pure scheduling, and stochastic modelling (Cheng 1989; Parlar & Perry 1996; Wilding 1998; Barbarosoglu & Arda 2004; Blackhurst et al. 2004; William et al. 2004; Held et al. 2005; Tang 2006; Tomlin 2006; Ross et al. 2008).
The theories of stochastic models, analysis and assessment are becoming more important as feasible and optimal solutions in real time are essential in today’s chaotic supply chain platform. Numerous papers and books have been written on the topic of stochastic disruption modeling (Yu & Qi 2004; Yang et al. 2005; Tomlin 2006; Parmar 2007; Wu et al. 2007; Kuster 2008; MacDonald 2008; McCormack 2008; Snediker et al. 2008; Xiao et al. 2009).

In this research, a stochastic approach is selected because this strategy in managing disruptions may be effective mainly in a wide application of disruption which is not limited, clearly understood, network-oriented, and recurrently managed on a specific control system (as discussed and recommended in Ward 2003; Christopher & Lee 2004; Yu & Qi 2004). In addition, for the exploration of uncertainties in a network and complex system, a stochastic approach is an effective tool for exploring the process of service unavailable due to the uncertainties of interruptions and their unwanted consequences including both the severity and the likelihood of the consequences. Thus, a stochastic model is principally applied to approach maritime disruptions due to its capability to adapt open system functions with changing events and effective optimisation. A lot of research results and applications regarding stochastic approach of disruption management are reported in the literature. These include real-time
Multi-criteria decision making is implemented in this thesis as the significant advantage of this approach as its capability to manage a set of disruptive events is based on stages, and may provide acceptable and optimal mitigation policy in a particular period of time (Yu & Qi 2004). Most multi-criteria decision making studies in supply chain risk management have dealt with independent trials processes based on classical probability theory (Aven 2004; Cavinato 2004; Allen et al. 2006; Baldwin et al. 2006; Craighead et al. 2007; Elkins et al. 2008). In addition, when a sequence of chance experiments forms an independent trial process, the possible outcomes for each experiment are the same and occur with the same probability. Further, by using a multi-criteria decision making approach, the knowledge of the outcomes of the previous mitigation responses influences the outcomes of the next mitigation strategies. Hence, the distribution for the outcomes of a single response is sufficient to construct a tree analysis for a sequence of n responses and for any probability results about these responses by using these previous measures (Jong & Greig 1984; Parlar & Perry 1996; Chen & Lin 2008; Mundt 2008; Ross et al. 2008).

One potential approach to modelling a supply chain system and its disruptions is a Markovian-based methodology.

The Markov probabilistic theory studies estimating processes for which the knowledge of previous outcomes influences predictions for future experiments (Loury 1983; Jong & Greig 1984; Chao 1987; Parlar et al. 1995; Mundt 2008). In principle, when a sequence of future probability is investigated, all of the past outcomes can influence the predictions for the next experiment. In this process, the outcome of a given maritime disruptive event can affect the outcome of the next disruptive event to occur. Taking this process, therefore, the Markov chain concept has been utilised in assessing the
mitigation scenarios in the transportation systems including maritime operation. In the previous risk simulation literature in the transportation systems, a Markov chain approach has been explored as one important method instead of probabilistic and risk analysis arguments, Bayesian simulation modelling and integer analysis (see Table 3.9).

The Markov chain analysis has been utilised as a general tool for modelling network and dynamic disruption systems due to its ability to predict precedence, concurrent and asynchronous events by mathematical basis and capability to present a system graphically (Wagner & Neshat 2009). Initially, disruption issues particularly in a trade interruption condition is modelled as a Markov process by Loury (1983), Bergstorm, Loury and Persson (1985), Chao (1987), Cheng (1989), and Lindsey (1989). These researchers discuss the dynamics of price difference under intermittent trade disruptions of two different regions of buyers and sellers. In the 1990’s, Parlar et al. (1995) initiated the research of disruption processes and strategies to respond in a time-homogeneous period review of inventory setting and policy. The research is further followed up by Parlar and Perry (1996) by using the transient probabilities of a four-state continuous-time Markov chain \( P_{ij}^{(4)} = \Pr (X_4 = j \mid X_0 = i) \) for predicting average cost in objective function models for single, two, and multiple suppliers. Following this concept, ten years later Tomlin (2006) expands the four-state continuous time of the Markov chain application in measuring the average cost function of a disruption event which affected manufacturers, wholesalers, and retailers in the transportation and distribution process of a given unit commodity.

3.6.2 Maritime risk approach by Markov chain

The initial exploration in maritime risk probability may be found in Parlar, Wang, and Gerchak (1995) which apply time-homogeneous Markov analysis for discrete inventory level with transportation and port problems as the uncertainty events (as seen in Table 3-12.
### Table 3-12. Literature on a maritime risk approach

<table>
<thead>
<tr>
<th>Year</th>
<th>Researchers</th>
<th>Country</th>
<th>Stages in maritime flow</th>
<th>Risk Stages</th>
<th>Simulation Needs</th>
<th>Simulation Method</th>
<th>Objectives Assessed</th>
<th>System Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Parlar, Wang &amp; Gerchak</td>
<td>Canada</td>
<td>Manufacturers, retailers and Wholesalers</td>
<td>- x x x - - x -</td>
<td>Time-homogeneous</td>
<td>Period inventory</td>
<td>- x - x</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>Jason et al.</td>
<td>USA</td>
<td>Shipping Channel</td>
<td>- - x x x - - x -</td>
<td>Probabilistic risk analysis</td>
<td>Probability of oil spill accidents</td>
<td>- x - x</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Conrad</td>
<td>USA</td>
<td>Port Operations and Queueing problems</td>
<td>- x x - x x - - x -</td>
<td>Long-term economic viability and risk assessment method</td>
<td>Port security action plan and long-term economic impact</td>
<td>x - x -</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Pachakis and Kiremidjian</td>
<td>USA</td>
<td>Port Operation</td>
<td>- - x x - x - x -</td>
<td>Seismic Hazard and Risk assessment analysis</td>
<td>Downtime analysis and revenue loss impact</td>
<td>- x - x</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Brian, Erera, and White</td>
<td>USA</td>
<td>Port Operations</td>
<td>- - x x x x - - x -</td>
<td>Markov Decision and Model with value iteration algorithm</td>
<td>The impact of temporary port closure</td>
<td>- x - x</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Merrick, Van Dorp, &amp; Dinesh</td>
<td>USA</td>
<td>Short-sea shipping</td>
<td>- - x x x x - - x -</td>
<td>Bayesian simulation technique</td>
<td>Model framework for maritime uncertainties</td>
<td>- x - x</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Pinto and Wayne</td>
<td>USA</td>
<td>Port Operation</td>
<td>- - x x x x - - x -</td>
<td>Risk-based assessment and risk-based return-on investment</td>
<td>Total loss in throughput of incident until port operations restored</td>
<td>- x - x</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Tomlin</td>
<td>Canada</td>
<td>Manufacturers, retailers and Wholesalers</td>
<td>- x x - - x -</td>
<td>Four-state continuous time of Markov Chain</td>
<td>Average costs and Functions</td>
<td>- x x -</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>Gantikar and Viswanadham</td>
<td>Singapore</td>
<td>Port Operations and Manufacturers</td>
<td>- x x - x - - x -</td>
<td>Simple integer quadratic Markowitz model</td>
<td>Risk propagation in supply chain</td>
<td>x - x -</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Garcia</td>
<td>USA</td>
<td>Port Operation and Inland Transport</td>
<td>- x x - - x x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Guerrero, Munoy, and Flood</td>
<td>USA</td>
<td>Port and Vessel traffic area</td>
<td>- x x - - x x</td>
<td>Large scale integer programming</td>
<td>Restoration/ recovery process</td>
<td>x - x -</td>
<td></td>
</tr>
</tbody>
</table>

Source: Gurning and Cahoon (2009)

Note: I: Integrated; CP: Coupled; CN: Continuous; D: Discrete, DEL: Delay; DEV: Deviation; DISP: Disruption; DIST: Disaster

In the next step of exploring the Markov chain probability of maritime risk, Jason et al. (2002) apply a probabilistic risk analysis approach for discrete shipping channel activities with uncertainty events of oil spill accidents considered.)
Another study two years later expanded this approach by using a semi-Markov probability analysis (Hallikas et al. 2004) to identify transport vulnerabilities including the risk of shipping operations. This became a recognized approach for various transport-related operations using various risk selections with discrete methods as can be found in the research of port closure (Lewis et al. 2006), vessel traffic accident (Uluscu et al. 2008), inland distribution (McCormack 2008) and shipping unavailability (Xiao et al. 2009). Probability analysis is then applied to various risk selection with discrete methods coupled with performance analysis. Tomlin’s study (2006) initiates this in the area of inventory and distribution operations.

Following this combined approach Qi et al. (2008) apply the Markov chain coupled with the performance analysis in the context of shipping channel risk. However, the risk assessment in this research is considered as an individual event including its probabilities within a boundary region in a specific channel. Given this application, different types of maritime risk events such as ship groundings and collisions (Lee & Lee 2005; Kolowrocki & Soszynska 2009) have not been proposed, particularly in identifying the wide impact along the supply chain.

Conrad (2004) suggests there is a long-term economic viability combined with a Markov risk assessment method for port operations, especially in queuing problems. Through this study, a port security action plan is proposed in the context of delay operations assessed with various scenarios of long-term economic impact along supply chain activities. Another study similar to Conrad (2004) is undertaken by Pinto and Wayne (2006) who combined a risk-based assessment and return on investment by using a Markov chain process to calculate the total loss in throughput of incident cycles of a port until port operations were restored.

On the basis of conducting a risk assessment analysis, Pachakis and Kiremidjan (2005) apply a similar Markovian approach, although their focus is on measuring the probability of seismic hazard on port facilities and operations in order to predict the potential revenue loss and downtime quantity of a disrupted port. Another similar study that attempts to determine the impact of temporary closure of a port is undertaken by Brian, Erera and White (2005) in applying the Markov decision process combined
with a value iteration algorithm for future operational risks. The study combines three consecutive synchronous events (inventory response, queuing problem and port closure) in modelling the average logistics lead-time and costs through a port. However, the random selection of incident probabilities in this study introduces a significant threat of internal validity as all processes through the port is assumed synchronously as one process.

To accommodate the internal validity of probabilistic assessment in the maritime risk analysis by Brian, Erera and White (2005), Merrick and Van-Dorp et al. (2006) recommend the concept of Bayesian simulation combined with Markov decision process in building a general framework model for maritime uncertainties. The framework uses a proportional approach in predicting probabilities of maritime risks in a disaster event of a short-sea shipping service in USA. However, there is an apparent location bias where shipping and inland activities are assumed as one shipping activity. The users of short-sea shipping (cargo owners or passengers) are also not fairly represented in order to indentify the effect of uncertainties (stoppages and disaster) as one random event.

The application of Markov chain analysis in a maritime operation risk has been developed into process that assesses whether maritime risks create substantial impacts on supply chains (Gaonkar & Viswanadham 2007; Guerrero et al. 2008; Paul & Maloni 2010). Gaonkar and Viswanadham (2007) show the generalisation of propagation processes along supply chain operations due to a port closure. Another study using a simple integer quadratic Markowitz model is done by including the connection of a port and manufacturers (port users) in order to identify the transition process and input–output relationships of disruptive events. In the same method of integer programming, Guerrero et al. (2008) expand the criteria of risk propagation by using a large scale integer process and Markov chain in evaluating the options of restoration or recovery process of a firm under delay and deviation stages. Garcia (2008) proposes a Markov decision process that combines three consecutive synchronous events (inventory response, queuing problem and port closure) to model average logistics lead-time and costs through a port. In addition, the random selection of incident probabilities in the
study introduces a significant threat of internal validity as all processes through the port are assumed synchronously as one process.

Given the studies above, the use of the Markov approach in supply chain risk management has been coupled with the supply chain performance analysis of more stages beyond transportation to various interdependent factors in supply chains. The dynamic probability mechanism of a Markov decision process is a strong point of this approach in examining maritime disruptions as changing events in a complex system. However, studies on uncertainties in the context of port and shipping-related disruptions are predominantly considered as being individual probabilities within a boundary region of a complex networking process (Lewis et al. 2006; Pinto & Wayne 2006; Guerrero et al. 2008; Qiang et al. 2008; Ross et al. 2008). Further, none of these studies consider the effectiveness of decision making processes planned and implemented in mitigating maritime operation risk in supply chains. Aside from the applications using the Markov approach in supply chain risk management, there has been little attention paid to constructing propagation effects of the disruptive events around maritime operations beyond the maritime boundary to the supply chain stages.

3.7 Propagation scenario

Understanding various risk events that propagate along the supply chain network is a critical point to be considered by maritime service providers in this time of uncertainty. This is due to the correlation between supply delivery and risk propagation, which has been strongly suggested as being a factor that influences the effective outcome of strategic decision making processes in relation to uncertainty (Juttner et al. 2003; Hallikas et al. 2004; Gaonkar & Viswanadham 2007; Wu et al. 2007; Cheng & Kam 2008). Moreover, exploration of risk propagation effects should not only consider the consequences that may occur as a result of the maritime risks such as disruptions, but researchers also need to recognise the treatment of risk in terms of its preconditions, events, footprints, and backlash as depicted in Figure 3-6.
Research on risk propagation effects mainly focuses on identifying the limited effects and determining their overall impact on the incident or maritime area. In fact, current investigations on maritime disruption effects cover the potential for propagation effect consequences beyond maritime boundaries upstream or downstream the port supply chain networks (Gurning & Cahoon 2009). Often, mathematical models simulating maritime propagation effects are demanding due to the complexity of the maritime boundaries (simulation of the source term, interruptions, recurrent disturbances, delayed service, severe deviation of service original plans, and unavailability of service platform) and the complexity of the input data required (Gurning et al. 2009). The likelihood of risk events in maritime services may depend on preconditions that could provide advance warnings of impending events. These may include, for example, the status of infrastructure maintenance or disrepair, increasing problems in supply delivery along a congested port location, and discontented employees about to negotiate new agreements.

![Figure 3-6. The illustration of the propagation effect on risk mechanisms](source: Cheng and Kam (2008))

### 3.7.1 The concept of propagation effect on the supply chain network

In relation to disruption models, the propagation analysis and assessment of maritime disruptions are becoming more important as feasible and optimal solutions in real time are essentially needed in today’s chaotic supply chain platform. Numerous papers and books in the supply chain risk literature have been generated on the topic of
propagation effects of a disruptive event (Kleindorfer & Saad 2005; Craighead et al. 2007; Gaonkar & Viswanadham 2007; Wu et al. 2007). However, none of this research focuses on maritime operations as critical considerations. These models mainly propose that revised plans are focused on worst case scenarios of small probability and thus create operational and mitigation plans that are too conservative and passive by not including maritime service disruptions.

Further, Hanfield and McCormack (2008), Clausen et al. (2001) and Yu and Qi (2004) recommend a need to explore real time optimisation techniques in minimising the propagation effect that should be developed in supply chain networks, including transport operations such as maritime service operations. The reasons for this are due to the urgent need to apply a quick solution when one operational disruption occurs in order to localise the impact of disruptive events. This problem solution is generally regarded as ‘a one-time effort’ (Yu and Qi 2004, p.23) for normal hours of an operational period. To build such a method, the concept of propagation effects, in particular on supply chain networks, should be well defined. Although there is no generally accepted definition of what constitute propagation effects, various authors have provided suggestions.

Table 3-13 presents an overview of current definitions identified in a review of relevant documents. The generalised definitions provided by Delvosalle (2002) and Kim and Lim (2007) in Yang et al. (2007) have the advantage of allowing for the introduction of a mathematical approach to propagation incident optimisation problems. According to this definition, a propagation effect implies a primary incident or interruption concerning a primary state (this event might not be a major risk along supply chain networks), inducing one (or more) risks(s) in one main pathway of a network, including some probable secondary pathways through sub-networks and individual nodes or links (Cheng & Kam 2008). The secondary incidents must be major and extend the consequences of the primary incident or risk.

Thus, propagation effects in a chain involve a number of pathways and nodes. Consequently, each node represents a direct or an indirect risk to every other node
along the supply chain networks. Therefore every node in maritime boundaries can be represented as a node in a directed network of maritime services. All nodes are connected by a pair of unidirectional arcs. By using transition matrix units of the Markov chain as weights on the arcs, the amount of risk from one node to another is expressed. Therefore, all possible sequences of two adjacent arcs in a complex supply chain network may then be analysed.

**Table 3-13. Current definition of risk propagation effect on supply chain networks**

<table>
<thead>
<tr>
<th>Author</th>
<th>Propagation effect definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merrick and Van Dorp. (2006); Merrick, Dorp and Dinesh (2003); Parnell, Driscoll and Henderson (2008)</td>
<td>A process to explain the impact of direct and indirect variables of risks from layer to layer with its orientation both towards forward propagation and backward propagation along supply chain networks.</td>
</tr>
<tr>
<td>Kleindorfer and Saad (2005); Cheng and Kam (2008); Huang et al. (2008); Bodea and Dascalu (2008)</td>
<td>A progress of breakdown in the network, sub-network, and individual nodes and links due to inability to resist and recover from internal and external risks.</td>
</tr>
<tr>
<td>Delvosalle (2002); Gaonkar and Viswanadham (2007); Kim and Lim (2007); Blackhurst, Wu, and O’Grady (2004)</td>
<td>A cascade of events in which the consequences of a previous incident or risk are distributed and increased by following one or more attribute of network entities spatially as well as temporally, leading to a major effect.</td>
</tr>
</tbody>
</table>

Source: Author

### 3.7.2 Propagation effect based on Markov process

In this section, the maritime disruption propagation effect model based on the Markov process is explored which continues the previous works of Kim et al. (2007), Kim et al. (2006), Blackhurst, Wu and O’Grady (2004). This propagation model proposes four steps as a comprehensive process: risk-state definition, disruption state transition matrix, initial mitigation scenario with its results of the expected frequency and probabilities, and finally the risk propagation evaluation. A more detailed description is presented in the following subsections.

Three processes are explored in defining disruptive states: the gathering of occurrence data of disruptions, disruption analysis, and the defining of a set of disruption states for
a fixed mitigation policy are applied (Howard 1960 in Jensen 2010; Dreyfus and Law 1977). To assist understanding and defining the propagation effect evaluation problem, it is useful to categorise propagation effects into the various types that may occur. The various propagation effects characteristics are explained in Table 3-14 below.

Table 3-14. Classification of propagation effect

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th>CHARACTERISTICS</th>
<th>DEFINITION OF THE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE I (Scope)</td>
<td><strong>Internal</strong></td>
<td>Occurring within the boundaries of maritime entities where the disruptive risks propagate</td>
</tr>
<tr>
<td></td>
<td><strong>External</strong></td>
<td>Occurring outside the maritime boundaries where the disruptive events propagate as a direct or indirect result</td>
</tr>
<tr>
<td>TYPE II (Consequences)</td>
<td><strong>Direct</strong></td>
<td>Occurring as a direct impact of the previous disruptive event</td>
</tr>
<tr>
<td></td>
<td><strong>Indirect</strong></td>
<td>Occurring as an indirect impact of a preceding disruptive event</td>
</tr>
<tr>
<td>TYPE III (Character)</td>
<td><strong>Delay and deviation</strong></td>
<td>Occurring with delay and deviation effects from its original plans and targets</td>
</tr>
<tr>
<td></td>
<td><strong>Stoppage</strong></td>
<td>Occurring with unavailability of dominant services</td>
</tr>
<tr>
<td></td>
<td><strong>Stoppage</strong></td>
<td>Occurring with a disaster event</td>
</tr>
<tr>
<td>TYPE IV (Process)</td>
<td><strong>Serial</strong></td>
<td>Occurring as one of several simultaneous impact links of interruptive chain caused by preceding events</td>
</tr>
<tr>
<td></td>
<td><strong>Parallel</strong></td>
<td>Occurring as one of several simultaneous impact links of interruptive chain caused by preceding events</td>
</tr>
</tbody>
</table>

Source: Adapted from Reiners et al. (2009)

Four different parameters are used to unambiguously identify the nature of the propagation effect under this consideration. By using the enumerative approach in categorising the effects into four types, maritime providers may select effective and acceptable mitigating plans appropriately. Undertaking a similar direction to the exploration, the mitigation scenario assessment attempts to propose the application of the Markov approach in analysing the disruption propagation including impacts of maritime operations in a supply chain using wheat transport between Australia and Indonesia.
3.8 Summary

This chapter has comprehensively reviewed the literature on supply chain risk management and has started to configure the concept of disruption, the possible types of disruptions in the maritime leg of a supply chain. Thus, this research proposes a new continuum concept of supply chain disruption based on uncertainties incorporating four different types of maritime disruptions from various direct and indirect factors namely delay, deviation, stoppage of service, and loss of service platform. Next, this chapter reviewed the concept of mitigation approach. Whilst this approach has been well explored in literature, it is found that the networking-based mitigation plans have been researched rarely and seemingly not concentrated on operational dimension of mitigations among entities in a supply chain when managing maritime disruptions. Hence, this research has reconfigured the mitigation strategies by linking together the application in a supply chain and wheat trade.

Overall, four major supply chain mitigation approaches are investigated from a broad mitigation perspective, in that entity interaction in a supply chain is explored and then operational disruption strategies are conceptualised and identified. Next, the chapter has explored stochastic methods applied to manage the individual and networking chain wide factors in the maritime disruptions by the concept of Markov decision process. This analysis approach allows insights into how entities and their disruption management strategies impact on the enacted wheat supply chain performance. In addition, the Markov decision method is also adopted to explore the propagation effect of disruptive events in a supply chain, and how the consequences of disruption affects the performance of a supply chain. Finally, this chapter has demonstrated that supply chain disruptions are dominated by various unwanted driving factors from entities along a supply chain process on the one hand, and the internal factors of maritime operations on the other. In Chapter Four, the description of disruption and mitigation response will be now incorporated into a research and data collection method.
CHAPTER FOUR

RESEARCH METHODOLOGY
4.1 Introduction

This study uses a research approach that combines elements of quantitative and qualitative methods. This mixed-mode is deemed a suitable way to proceed as the research questions require not only a multi-modal approach to investigate the existence of disruption risk but also to assess the effectiveness of previous mitigation scenarios. This mixed-mode approach has been applied by Handfield et al. (as discussed in 2008), Gaonkar and Viswanadham (2007), Lewis et al. (2006), MacDonald (2008), McCormack (2008) and Martin and Hau (2004) to enable the exploration of various risk factors, consequences, and mitigation development in a supply chain. Under this mixed-mode approach in the current study, the perceptions of senior managers are investigated in relation to maritime disruption risks, the stages and parametric values of various disruptive events such as probabilities and occurrence rates in the supply chain, including the mitigation strategies used in managing maritime disruptions.

This chapter outlines the data collection process by implementing an interview approach using a structured questionnaire to survey views on maritime disruption in the Australian-Indonesian wheat supply chain. As indicated earlier, this data collection process is an intermediate step to address the primary research question: Does the maritime leg contribute to disruptions in the wheat supply chain between Australia and Indonesia? More specifically, this study applies a telephone interview methodology as a data collection technique to explore the extent of the consequences of maritime disruptive events in a wheat supply chain, and how the effectiveness of mitigation responses can be explained by the quantitative rate of disruption risks and the qualitative risk perception of maritime disruptions when they occur.

Further, the procedures of preparing, pre-testing, and administering the telephone interviews, including the error control process of the interviews, are discussed. Statistical tests such as the t-test, p and mean values relating to the reliability and validity of the data gathering process, and the subsequent generalisability of the findings are also discussed later in this chapter.
4.2 Research design

By definition, the research design is the planning stage of collecting and analysing research units and variables that provide relevancy, causation, and integration according to research objectives (Gable 1994; Hitt et al. 1998; Lakshman et al. 2000; Zikmund 2007; Ketchen et al. 2008; MacDonald 2008; Jarzemskiene 2009). Further, it is also recognised as being ‘the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research purpose’ (Gable 1994, p. 116). The collecting and analysing processes can take many forms including exploratory versus explanatory research, case studies, field experiments versus laboratory experiments, cross sectional versus longitudinal, observational versus survey research, and descriptive versus causal methods (Emory 1980 in Gable 1994; Zikmund 2007).

The research design in this thesis enables the experiences of respondents, and their understanding and managing of previous disruptive events as a basis for future effective mitigation plans, to be discussed and analysed in depth. In order to do so, the research process is designed to give a detailed description according to the research questions. As discussed in Chapter One, the main objective of this research is to investigate the contribution of maritime operations and services to the supply chain performance of wheat commodities. This is achieved by focusing on the primary research question (PRQ):

(PRQ): *Does the maritime leg contribute to disruptions in the wheat supply chain between Australia and Indonesia?*

To explore this research question three subsidiary questions are established to address PRQ. The three subsidiary questions (SRQ) are:

**SRQ 1** *Are shippers and consignees aware of the disruptions that may occur in the maritime leg of the Australian-Indonesian wheat supply chain?*
SRQ 2  Are shippers and consignees in the Australian-Indonesian wheat supply chain implementing supply risk assessments or mitigation strategies to minimise the maritime disruption events?

SRQ 3  Are current risk mitigation and detection processes in maritime operations effective in the Australian-Indonesian wheat supply chain system?

Figure 4-1 shows the full process of this research outlining the five main steps in which all the research questions are highlighted. As shown in step 1, the research process is aimed at initially recognising the full supply chain process of the Australian-Indonesian wheat trade in terms of time, costs, and volume of wheat transported. In step 1, the secondary data to be collected relates to the operational processes in the supply chain and maritime services. This data is categorised into three major supply chain performance factors namely volume of cargo, time needed for the processes of shipment and cost needed for using maritime facilities in 78 selected wheat routes from 13 grain terminals in Australia to six grain terminals in Indonesia.

In the second step, all entities in the Australian-Indonesian wheat supply chain are included, so various factors that may instigate a maritime disruption in the upstream and downstream chains of the empirical case can be explored via a case study approach. Performance data on time, costs, and risk consequences is included. The results of this step will provide a detailed description of whether entities of the wheat supply chain are aware of various maritime disruptive events that may occur in their transport networks (as per SRQ1). In addition, in this second step, the likelihood of future potential disruptive events in the wheat supply chain is investigated by probing historical experiences of senior managers when managing maritime disruptions in their supply chain processes.

At the third step, previous and existing mitigation strategies are explored and measured from qualitative and quantitative perspectives. Each entity, whether a maritime user or maritime operator in the wheat supply chain, has their own view and perception about previous and current disruption problems, including how these should be resolved.
The mitigation strategies obtained from respondents are categorised into three phases namely pre-disruption, during the disruption, and post disruption. The results of this step will provide a detailed response for SRQ2. In the fourth step, previous mitigation cases are identified and constructed as a basis for the assessment of effective mitigation scenarios to various maritime disruptive events. Further, in this process, the propagation effects of maritime disruptions on supply chain performance in terms of costs and time can be estimated and quantified. Finally, in the fifth step, the framework analysis of maritime disruptions will be constructed to provide a comprehensive insight to maritime disruption and its operational behaviours in the wheat supply chain. All results in the fourth and fifth steps will address SRQ3.
4.3 Research approach

Many researchers have explored and applied the relative merits of qualitative and quantitative research methods in strategic risk management (Hoskisson et al. 1999; Horlick-Jones & Rosenhead 2002; Phillips et al. 2008; Eppler & Aeschimann 2009) decision support systems (Ritchie & Spencer 1993; Horlick-Jones & Rosenhead 2002), and policy making processes (Wallace & Balogh 1985; Weber et al. 2002; Tiwari et al. 2003; Cavinato 2004).

In addition, how decision makers implement their mitigation responses have received significant attention in the risk and uncertainty management literature using the combination of qualitative and quantitative approaches (as discussed in Zhao 1991; Elliot 2000; Horlick-Jones & Rosenhead 2002; Wood 2002; Kallman & Maric 2004; Baldwin et al. 2006; Kewell 2007; Nilsen & Olsen 2007; Cairns et al. 2008; Keegan & Kabanoff 2008; Bea et al. 2009; Corvellec 2009; Eppler & Aeschimann 2009; Jarzemksiene 2009; McKelvey & Andriani 2010; Zhu 2010). The above mentioned research recognises the potential contribution of adopting a qualitative and quantitative methodology for a risk-related study.

Table 4-1 summarises the previous applications of qualitative, quantitative, and mixed research methods (qualitative and quantitative) in the fields of strategic risk management and mitigation processes. The approach and objectives along the three main research methods are also provided in the table below. Critical discourse analysis, comparative analysis, and using an empirical case are applied in this study as recommended in the literature to explore the strategic and risk management approach implemented by supply chain entities (Ellram 1996; Doll et al. 1998; Aven 2004; Phillips et al. 2008). Further, in the quantitative methods, simulations, statistics, and the combination of data intrusion and simulation are approaches that have been selected by researchers in the investigation of risk management and the decision making processes in the field of supply chain management (Allen et al. 2006; Baldwin et al. 2006; Kuster 2008; Corvellec 2009; Jarzemskiene 2009).
<table>
<thead>
<tr>
<th>Methods</th>
<th>Approaches</th>
<th>Objectives</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative</td>
<td>Critical discourse analysis</td>
<td>Examining linguistic meaning</td>
<td>Philips et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>Comparative analysis</td>
<td>Combination of descriptive analysis units</td>
<td>Doll et al. (1998)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problem structuring</td>
<td>Greckhamer et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>Observation in case studies</td>
<td>To interpret the frequencies and risk probabilities</td>
<td>Horlic-Jones and Rosenhead (2002)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Eppler (2009)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ellram (1996)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aven (2004)</td>
</tr>
<tr>
<td>Quantitative</td>
<td>Risk reduction through simulation</td>
<td>Simulation of decision making process</td>
<td>Kuster (2008)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Applying discrete choice of risk perception</td>
<td>Baldwin et al. (2006)</td>
</tr>
<tr>
<td></td>
<td>Statistics approach</td>
<td>Monte Carlo approach for projected cost and time probability</td>
<td>Gaonkar and Viswanadham (2007)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comparative analysis for performing regressive approach</td>
<td>Cairns et al. (2008)</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Faisal et al. (2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jarzemskiene (2009)</td>
</tr>
<tr>
<td></td>
<td>Data intrusion and simulation</td>
<td>Population uniqueness and a multi-risk perspective</td>
<td>Carpignano et al. (2009)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Elliot (2000)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zhu (2010)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yee Ming and Chun-Ta (2008), Zografos and Tanos (2007)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cassel et al. (2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sorensen et al. (2010), MacCormack (2008), McDonald (2008)</td>
</tr>
<tr>
<td></td>
<td>Mixed (qualitative and quantitative)</td>
<td>Innovative mixing-methodology</td>
<td>Pragmatist and action-oriented</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zhu (2010)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Keegan and Kabanoff (2008)</td>
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<td></td>
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<td></td>
<td>Miller and Waller (2003)</td>
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<td></td>
<td></td>
<td></td>
<td>Sneidiker et al. (2008)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wallace and Balogh (1985)</td>
</tr>
</tbody>
</table>

Source: Author
There are four main reasons the mixed qualitative and quantitative method is applied in the current study of maritime disruptions. First, this method provides an effective means to assess transport networks that have high levels of uncertainty events (Chen & Lin 2008; Sorensen et al. 2010; Zhu 2010), thus lending greater weight to the operational risks studied both in the explorative and explanation approaches. Second, there is the uniqueness of entities along the wheat supply chain either in Australia or Indonesia that may have a variety of risk perceptions including the quantifiable requirements in providing responses and preparedness (Sorenson 1973; MacDonald 2008; McCormack 2008). Therefore, applying this mixed-mode may provide alternative perspectives on the perception and mitigation approach when disruptive events occur. Combining qualitative and quantitative approaches provides the benefits of synergising the strengths of both.

Third, in many cases, decision makers adopt a qualitative approach in that ‘probabilities are not numerical but verbal’ (Thomas 2007, p.52). In addition, supply chain planners are often kept trying to find out the occurrence rate of a low probability event (McCormack Sitkin & Pablo 1992; Miller & Waller 2003; Thomas 2007; 2008). In addition, Thomas (2007) states that probability is relatively vague, and differs between risk assessors (Gonzales et al. 2005 in Thomas 2007). Hence, supply chain planners and decision makers generally want to quantify the probabilities of events occurring as much as possible in order to avoid vagueness (Khun et al. 1996; Thomas 2007; McCormack 2008). The fourth and final reason for applying a mixed qualitative and quantitative approach in the current study is that it enables the possibility of exploring the effective mitigation scenarios by assessing and measuring the effectiveness of previous subjective decision making processes when maritime disruptions occur. However, it should be noted that the limitations of this study in terms of time and resources prevent a full mixed-mode approach. Therefore, in this study, the mixed-mode focuses on the topic of change management on the assessment of mitigation scenarios.
4.3.1 Survey approach

In relation to the qualitative data collection in a research process, many types of surveys can be undertaken to collect primary data, for example, a single pilot case study, a multiple case study, model specification, and a survey (Gable 1994; Cycyota & Harrison 2006; Dixon-Woods et al. 2006; Zikmund 2007). The survey approach is selected for the current study as it refers to a group of methods including mail questionnaires, face-to-face interviews, telephone interviews, and internet survey (Peng et al. 1991; Walton 1997; Ashok & Fan 2001; Zikmund 2007; Ketchen et al. 2008; Jarzemskiene 2009; Sorensen et al. 2010), all of which are potentially useful for collecting data from organisations in a supply chain.

By studying a representative sample of organisations, the survey approach seeks to discover relationships that are common across entities in the wheat supply chain and hence to provide generalisable statements about the likelihood and consequences of maritime disruptive events. Given that objective, collecting primary data from geographically diverse regions both in Australia (West Australia, South Australia, NSW, and Victoria) and Indonesia (Java, Sumatera, Kalimantan, and Sulawesi) with a significantly large number of entities in the wheat supply chain cannot be done easily or cost effectively with face-to-face interviews (Walton 1997; Harden et al. 2004; Zikmund 2007; Greckhamer et al. 2008; Thomas & Harden 2008; Arnon 2009). Further, mail and telephone methods are able to achieve national and international scope in research (Loomis & King 1994; Walton 1997; Hitt et al. 1998; Dixon-Woods et al. 2005; Cassell et al. 2006; Ketchen et al. 2008). Therefore when trying to collect data from a large sample, mail and telephone survey methods are more appropriate than face-to-face interviews. In addition, as the target of research respondents are senior managers, Cycyota and Harrison (2006, p. 148) suggest that: ‘One way to address the correct combination of techniques may be to simply ask executives what would encourage their response to organisational questions’.

To support the argument above, research on senior managers’ responses may obtain significant benefit from interviews and discussions with the targeted senior managers to clearly establish the processes they employ in the decision to respond to a survey or
what stimulates their interest (Cycyota & Harrison 2006; Dixon-Woods et al. 2006). Similarly, in the pretesting stage of the survey (as discussed later in this Chapter), due to the mobility of senior managers in dealing with operational and commercial activities within the wheat supply chain, two pretested respondents in Australia and two in Indonesian preferred to have a telephone survey with the aid of mailed or emailed documents to guide them when answering survey questions over the telephone. Therefore, by combining these approaches (telephone survey with the aid of email documents), the social and work pressures that senior managers may face when participating in a telephone survey may be reduced and may result in higher response rates (Dillman 1991 in Loomis & King 1994; Beer & Katz 2003; Cycyota & Harrison 2006; Maguire 2009).

### 4.3.2 Telephone interviews

Of all the methods employed in qualitative surveys, a telephone survey is recommended to maximise response rate and to maintain control over the quality of the data as it produces a relatively high response rate compared to other qualitative approaches, especially compared to face-to-face interviews (Leon et al. 2005; Zikmund 2007; Fowler 2008). As the study has a limited budget, the telephone survey is an efficient and cost effective means of collecting data (Walton 1997; Leon et al. 2005; Zikmund 2007; Saunders et al. 2009).

A telephone survey also allows for data to be collected in a complete and accurate format with an acceptable level of total error at the time of the interview (Groves et al. 2004; Rubin & Rubin 2004; Gray et al. 2007). The benefits of using this technique include a richness of data and deeper insight into maritime disruptions on the wheat supply chain.

### 4.4 Data collection

In relation to secondary and primary data collection, Figure 4-2 shows the comprehensive steps of the data collection process. The main objective of this data collection process is to obtain information related to operational and risk management.
Secondary Data
1. Source of wheat
   A. Regions in West Australia
   B. Regions in Victoria
   C. Regions in South Australia
   D. Regions in Queensland
2. The types of wheat cargoes
3. The movements of wheat commodities
   A. Main origin and destinations
   B. Down and upstream positions
4. Port facilities of selected ports of call
   A. Special terminals in two countries
   B. Productivity and operational problem
   C. Limited size and throughput
5. Performance of logistics operations
6. Existing shipping fleets domestic/Int'l
7. Ship traffic and routes
8. Previous various maritime disruptions
9. Retail price of wheat products
10. Regulation and policy of wheat-trade

Primary Data
1. Consequences of disruptions
2. Costs and lead time of consequences
3. Acceptable consequences
4. Frequency of disruptive events
5. Probabilities of disruptive events
6. Maritime contributions
7. Dominant and recurrent events
8. Domain commodity transferred
9. Current response and actions
10. Current mitigation plan
11. Management decision making process
12. Existing recovery plan
13. Existing redesign plan
14. The impact of maritime disruptions

A set of data

Data assessment
- General risks in the cluster of delay, deviation, disruptions and disasters
- General consequences and impacts of maritime disruptions on the existing wheat supply chain
- Existing risk assessment practices of wheat supply chain entities and maritime operators
- 20 maritime severe disruptive events and its impact on maritime services operations
- 27 possible events that may generate port congestion and commercial impacts
- Internal management process in decision making process while maritime disruptions are occurring
- Mitigation, recovery, and redesign plan in response to 20 maritime disruptive events

Data analysis
- The propagation effect and the range of consequences of maritime disruptions on the wheat supply chain
- Analysis of logistical and management reactions required based on cargo criteria per selected routes by optimisation method
- Maritime disruption index of wheat supply chain in terms of: - Likelihood - Time - Costs
- Effectiveness of current management plan and decision making process in recovering from maritime disruptive events

Assessment results
- Multi-scenarios of maritime disruptive events
- Multi-level performance of wheat supply chain
- Operation standard of ship services for various routes
- Optimal indicators based on acceptable and realistic management response: - Recovery stage - Continuity management
- Implementation techniques on various stages of maritime disruption: - Pre-disruption stage - During the disruption stage - Post-disruption stage

Figure 4-2. The comprehensive steps of data collection process
Source: Author
As shown in Figure 4-2, there are ten secondary items and 14 primary items to be collected in this research which, as discussed are based on items recommended by researchers in the literature who focus on supply chain risk in transport operations and their performance impacts on a supply chain. Thus, the data collection process considers past and current data including the experiences of senior managers when managing disruptions by entities in the wheat supply chain. To obtain a high confidence and generalisability of the information collected, the primary data gathered from survey interviews is triangulated with secondary data gathered from formal and informal sources of entities in the wheat supply chain (Wilson 1984; Drongelen 2001; Cycyota & Harrison 2006; Zikmund 2007). The detailed discussions of primary and secondary data including data assessment are provided in the sub sections below.

4.4.1 Secondary data

Relevant data, including the sources of wheat, annual quantities produced, production rates based on their production region, and exporting and importing units of the markets in Australia and Indonesia, are analysed to gain an overview of the wheat supply chain conditions to provide inputs for the primary data. This data is later used to explore details about selected grain terminals (both in Australia and Indonesia) and the historical data of previous disruptive events such as strikes, congestions, natural disasters, and operational problems. Such information and events may exhibit themselves in a profile of annual trade data that creates maritime disruptions which may be reported as an unusual spike or depression in the level of growing or decreasing demand. In addition, demand and supply information may provide a generic operational indication of maritime disruptions that has been occurring in the port-to-port operations of maritime services. This analysis may be useful to assess the performance of existing wheat transport flows and importantly the logistics operations of the Australian and Indonesian wheat supply chain. For example, a survey by CSIRO (2008) provides a profile of wheat supply chain processes in Australia. The survey explicitly collected information on the rate of usage of several wheat terminals in Australia, the rail link and its facilities, truck/road transport link, Australian loading ports, and containerised shipments.
Further, the performance of supply chain operations such as technical performance and any related cost data that specifically comes from maritime transport operations, wheat shipment documents, inspections, and operational reports are also included. In addition, the schedule, quantity, and capacity level of various ship traffic or routes from Australia to Indonesia as international services is collected and similar information of Indonesian inter-island domestic routes is also taken as past information data of wheat transport in the Australian-Indonesian chain. The increasing price of wheat commodities at final consumer points is also compared with the increasing supply chain costs, including the shipping-freight costs of various routes from ports in Australia to Indonesian ports.

Other secondary sources of data collected include databases containing recurrent and severe maritime disruptions in various maritime places (shipping and port services). Such information from the literature and various reports of similar events is focused on:

1. The inability of the maritime operators to have knowledge of the disruptions within their service boundaries that create severe consequences to areas beyond maritime services in the wheat supply chain.

2. The management of disruptions (how they were handled) in the original data.

3. Knowledge of the mitigation processes used and how they compare to the current scenario being implemented.

4. The inability of maritime users to prepare for and react effectively to previous maritime disruptions along their wheat supply chain.

Further, the secondary data of maritime operations when disruptions occurred may initially specify some weaknesses of action plans taken by entities in the wheat supply chain in anticipating the maritime disruptive events. This may be confirmed by delays, deviations, stoppage, and disruptive parameters that could be quantified in terms of costs and time data. Furthermore, it is important to note that the capacity both in terms of quantity and quality aspects of the wheat supply chain may be dependent on the existence of wheat authorities along the wheat supply chain (Young & Hobbs 2002; Canadian Wheat Board 2003; Ferguson 2004; as discussed in Bushell & MacAulay 2007).
4.4.1 Primary data

Data required and categorised as primary data is mainly aimed at highlighting the primary and subsidiary research questions. Five important factors arise as the objective of the primary data is explored, namely demographic-related data on respondents, factors instigating disruptions, disruption phases, the consequences of disruptive events, and disruption management implemented when disruptive events occurred. These categories of questions are explained in detail when discussing the preparation of the survey questionnaire.

4.4.2 Data assessment

This research has an inclusive nature due to various interactions between the market conditions and supply chain performance of the wheat commodities. For example, the Australian milling section of the wheat supply chain cannot be examined separately from the Australian-Indonesian wheat market. Supply and demand of the Indonesian flour market determines the price and to some extent the market requirements that Australian wheat has to meet (APTINDO 2007, 2008). In addition, disturbances in the world wheat market, including various delays, deviations, stoppages, and the losses of service platform, may also impact on the Australian-Indonesian wheat market and reduce the performance of the chain. Therefore, the general impact of various disturbances from delays to the loss of service platform, including their consequences, is considered as initial data assessment of the data processing activity. There are eight main subjects that are considered in categorising the analysis input of the research. These eight main subjects are structured so that disruption risk management is identified starting from (1) delay, (2) deviation, (3) stoppage, (4) disaster, and moving to (5) consequences, (6) risk assessments, (7) preparing the contingency plan for 20 disruptive events, and (8) internal management process including the mitigation, recovery, and redesign process of the supply chain.

Both primary and secondary data, which necessarily address the 20 issues of maritime disruptive events raised from the literature (as per discussion in previous chapters), also require some assessment to test whether they have a specific attribute for various supply chain performances, or have a different impact level on any individual disruption. The
different stages of disruption development require a different approach to obtain the desired information. As an example, the best way to determine the disruption in the supply chain requires the use of a single maritime disruption event on a case by case basis (Bearing-Point & Hewlett-Packard 2005). Therefore, to determine these, a direct assessment of those individual events in terms of time, costs, and its likelihood is applied.

It is essential to assess two factors in this study. Firstly, as the survey has been designed for testing the decisions in various internal work settings, the previous general risk management strategies including the mitigation plan implemented by respondents will be assessed. Secondly, the views and opinions of entities on factors enabling effective results in managing maritime disruptions when they occur will be examined. Understanding management strategies and measurements is indicated by their mitigation plans, recovery reactions and redesign adjustments upon uncertain maritime disruptive events. However, assessing various decision making processes, whether they are appropriate or not, as optimum maritime disruption responses is quite complex. This is due to several parties in the chain having their own role to play based on a variety of disruptive events. In addition, each of these entities has their own views and visions about current problems and how these should have been resolved in regard to their limited resources and business objectives.

To measure and assess which strategies are effective and efficient, the differences between the ideas and points of view of the relevant entities will be considered based on their awareness and organisational criteria for each disruption category. As explained earlier, a combined approach of qualitative and quantitative parameters is selected as being the most appropriate to deal with the complexities of decision making practices. Such an approach enables opinions about current circumstances to be aired and ideas about the future response to be implemented.
4.5 Population and sample generation

Deciding the population to be sampled brought several concerns. The first was that research needed to cover the two countries, Australia and Indonesia, to capture the disruptive events over the complete wheat supply chain. Also important was the selection of entities in the wheat industry from the countries, the market orientation of the entities, whether they are focused on the Australian-Indonesian wheat chain only or others, the problems of their access to the wheat supply chain, and other practical considerations.

4.5.1 Population frame

As the research question is focused on maritime disruption along the wheat supply chain, it was necessary to select a population that contained established supply chain relationships between the Australian-Indonesian markets. As explained in Chapter Two, the wheat and flour manufacturing sector was identified as performing a major role along the supply chain. In addition, this sector is the leading entity that transform the new role of Australian Wheat Board in Australia and BULOG in Indonesia. This sector is also presumed to be the major trader or main controller of the wheat business between the two countries as well as existing in both countries.

Thus, considering the product reference included in the frame, there would need to be inputs from the respondents who supply both raw wheat and durum as well as in Indonesian domestic distribution channels to move the end product of wheat in the form of flour within the market. In addition, the relationship between wheat buyers and suppliers was selected as an important factor to investigate, as it was assumed that the AWB losing control as a single marketing body in Australia will have a practical influence on buyers as they now have greater flexibility and opportunity to purposefully change their supply chain relationships as opposed to previous deals through the AWB. Therefore, this research focuses on the buyer-seller aspect of the producer, collector and processor (miller) relationships in the wheat trade. In addition, wheat producers, processors, and buyers that are geographically located in Australia (mainly in Western Australia, South Australia, and New South Wales) and Indonesia (surrounding Java,
North Sumatera, South Sulawesi, and Kalimantan) are deemed the most appropriate way to meet the aims of this research as the main wheat supply chain entities are located in those regions.

It was also important to limit the population to those suppliers and processors that handled equal and greater than 100,000 tonnes of wheat annually (the number of 100,000 is based on the minimum capacity of silos in Australia and Indonesia with 8,000 tonnes per month) so as to eliminate sole traders and other less significant firms in terms of trade. No lower limit was placed on the size of the sample frame to be selected. The above described criteria were entered into database search engines (discussed in next sub-section) and subsequently a list of producers, processors, and collectors matching the criteria was extracted. This list forms the basis of the sample frame and was entered into an Excel spread sheet for easier management. The original intention was to apply the three important criteria (mentioned above, namely country, entity, and practice) as broadly as possible across the whole spectrum of wheat supply chain operators and maritime operators. It is, however, difficult to directly target or approach people working in the wheat supply chain, for example, many farmers and buyers spend relatively little time in conferences and similar group gatherings to gain new information regarding developments in the wheat business. For those attending conferences, this is likely to be a busy time for networking and thus the motivation for filling in forms or participating in surveys or focus groups would be low. The most effective method therefore was deemed to be to use telephone interviews as a platform for conducting the survey.

4.5.2 Area frames

In this subsection and the next, the two categories of area frames used as the samples for the maritime disruption surveys are discussed. It is important to note that in this multi-stage clustered sampling, the frame for each stage must be considered as a separate component. A specific frame is identified for each stage due to the different characteristic of that frame. The sample design for this survey uses the concept of a sampling frame for the early stages and area frames discussed in this subsection for the latter stages.
In the current study, the area sampling frame comprises units from Australia and Indonesia in a hierarchical arrangement based on the wheat supply chain. The units typically include such entities as farmer or grower association, collector, processor, grain terminal operator, ship operator, wheat export authority, and distributor. For survey purposes, Australia and Indonesia are further classified into administrative subdivisions. In Australia the sampled areas are South Australia (SA), Western Australia (WA), Eastern Australia (EA), which combines the states of New South Wales and Victoria, and Queensland (QLD), while in Indonesia, the areas considered are Java, Kalimantan, Sulawesi, and Sumatera. Coverage of the entire geographical area of the two nations is essential, because it is one of the principles for achieving a *bona fide* probability sample if two different countries are considered (United-Nations 2005; Zikmund 2007; Creswell 2008; Fowler 2008).

From the targeted population there are 151 respondents representing the potential population. This number was determined from a total of 250 possible wheat supply chain entities between the two countries in respect to their production or service capacity being more than 100,000 tons and a market orientation focused on Australia and Indonesia. This targeted population number is determined through 13 cross-referenced internet searches by using Google (www.google.com), Wheat Exports Australia (www.wea.gov.au), National Farmer’s Federation (http://www.nff.org.au), the National Wheat Grower Association (www.wheatgrowers.com.au), the Grain Grower Association (www.graingrowers.com.au), the National Agricultural Commodities Marketing Association (www.nacma.com.au), the Australian Bulk Alliance (www.bulkalliance.com.au), the Australian Wheat Board (www.awb.com.au/growers/), Bulog (www.bulog.co.id/eng/), Bogasari (www.bogasari.com), Aptindo (www.apitindo.or.id), the Indonesia National Shipowner’s Association (www.insa.or.id), and the Indonesian Logistics Association (www.ali.web.id/). The information supplied by the databases was quite comprehensive and even detailed the names and contact details of the key executives or managers. This information greatly improved the researcher’s ability to locate and contact the most appropriate key informant, and improved the response rates.
4.5.3 Sampling frames

At the start of the primary data collection, sample size was unknown. There was a high degree of heterogeneity in the respondents in the supply chain. As a result, a large sample was needed to achieve a complete overview. In addition, in order to attain a systematic collection of data from the potential population of 151 respondents, multi-cluster sampling is applied. This method is selected as the main approach to constructing the sampling frame due to the various classifications of targeted respondents, mainly wheat farmers through to grain farmer associations, buyers, transport operators, and supply chain or distribution providers. In applying this method, the complex population can be classified with more objective characteristics.

There are four parameters used to classify the sample and they are similar to the approach used for selecting the population. First, the trade orientation has to deal only with the wheat market between Australia and Indonesia. Second, as it was intended to include the whole wheat trade population of the maritime industry in the results, the selected sample population needs to represent the views of wheat supply chain entities in every sector from Australia to Indonesia, and thus includes both dry bulk and containerised wheat shipments. In terms of transportation and maritime operations, the process of agricultural shipment through maritime operations should be clearly indicated as the dominant mode of transport with a handling capacity of wheat of more than 100,000 tonnes annually.

The third factor is the quantity of shipments which may be referred to as consecutive voyages of wheat cargo from Australia to Indonesia. The fourth is the job position of the respondents, which is expected to be from the middle management level such as Chief Executive Officer (CEO), Chief Operating Officer (COO), or Risk Manager (RM). These four selection factors of potential sample respondents were determined primarily to fulfil the generalisability concept across the wheat supply chain population. Under these requirements, the web addresses listed previously helped the study to locate the sample who were ultimately selected for interview for the maritime disruptions survey. Further, people who had not worked in the wheat supply chain may not have an accurate perception of supply chain practices. These people, therefore, did not
participate in the survey. Only people whose work activities related closely to the wheat trading process, including its supply chain operations, fulfilled the criteria of being entities with supply chain experience. The size of the selected sample size influences the degree of accuracy that can be provided from the results (Groves et al. 2004; Zikmund 2007; Fowler 2008). Therefore, factors between sample size, effect size, and the power of a statistical test should be reasonably considered when dealing with sample size. Cresswell (2008), Larossi (2006) and Saunders and Thornill (2009) suggest that confidence levels, confidence intervals, and the total population size are factors that decide the size of the sample. To achieve the appropriate level of statistical standards, the confidence level is chosen at both alpha levels ($\alpha = .05$ and $\alpha = .01$). The confidence interval was taken in the range of 40 per cent and 50 per cent as it was presumed that respondents would have different perspectives on disruptions from their experiences in relation to disturbances and disasters.

However due to the pragmatic limitations of time and the research budget, it was necessary to apply the sampling frame so that the study yields sufficient information about the entire population. Table 4-2 below shows the structure of the sampling frame based on the locations of the respondents between Australia and Indonesia. In the 13 internet searches, there were 50 targeted samples representing entities in the supply chain out of 151 units of population, of which 32 respondents were in Australia and 18 were located in Indonesia including two respondents representing WEA in Australia and BULOG in Indonesia. The nature of wheat traders disperses maritime disruption widely across Australian-Indonesian routes. The 50 targeted companies were selected as these companies focused their supply chain links between Australia and Indonesia.
Table 4-2. The sampling frame of wheat supply chain entities

<table>
<thead>
<tr>
<th>Items of Research Goals</th>
<th>Respondent Targets in Numbers (30%-50% of Estimated Population)</th>
<th>Targeted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Australia (Sample/Population)</td>
<td>In Indonesia (Sample/Population)</td>
</tr>
<tr>
<td></td>
<td>SA</td>
<td>WA</td>
</tr>
<tr>
<td>A. Farmers/Growers Associations</td>
<td>1/1</td>
<td>1/1</td>
</tr>
<tr>
<td>B. Collectors</td>
<td>1/5</td>
<td>1/7</td>
</tr>
<tr>
<td>C. Millers/Processors</td>
<td>1/5</td>
<td>1/7</td>
</tr>
<tr>
<td>D. Grain Terminal Operators</td>
<td>1/3</td>
<td>1/4</td>
</tr>
<tr>
<td>E. Ship Operator</td>
<td>2/9</td>
<td>3/10</td>
</tr>
<tr>
<td>F. Wheat Export Authority/WEA</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>G. Badan Urusan Logistik (BULOG)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H. Distributors</td>
<td>1/3</td>
<td>1/6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>7/26</td>
<td>8/36</td>
</tr>
</tbody>
</table>

Source: Author

As individual entities they were clearly not easily accessible. Two methods of access were identified. The first was conferences and seminars where wheat farmers, buyers, collectors, and millers congregated for training and information sharing purposes, which as explained earlier is problematic. The second method was to contact them through their professional organisations, like the Wheat or Grain Associations.

### 4.6 Survey development and administering

This section describes four sub-sections in developing and administering the maritime disruption survey. The first sub-section explains the research objectives of the survey. The second sub-section discusses the quality and quantity data with several types of questions and measurement scales to achieve the research objectives and questions. The third section presents the general process of a pre-testing survey in order to assess the effectiveness of procedures, survey questions, and response cards used in the telephone interview process. The fourth discusses the procedure for conducting telephone interviews.
4.6.1 The objectives of the maritime disruption survey

The questions in this study are mainly designed to assess the responses or reactions of wheat supply chain entities when dealing with decision making processes in the three main stages of disruption namely pre-disruption, during the disruption, and post-disruption. The number of instruments necessary to adequately highlight the maritime disruption factors raised was also a matter that required some consideration. As the primary focus of this thesis is on the management of maritime disruptions, two instruments are deemed necessary. These two factors are current response and probabilities as suggested by the literature for different stages of disruption (Bearing-Point & Hewlett-Packard 2005; Handfield et al. 2008). For determining the current response and probabilities of maritime disruptions, a direct questioning approach is used. As management decisions involve different factors and perspectives from that of the broader organisational practice, the assessment of disruption management is used as a third validated instrument.

The telephone survey is constructed with three main objectives. First, the telephone survey process, uses the direct questioning method to obtain information on maritime disruption awareness including responses and the decision making process implemented by senior managers during maritime disruptions. The second goal of the survey aims to gain information on the maritime disruption discovery, impact, and recovery processes used by entities in the wheat supply chain, particularly between Australia and Indonesia. The third objective of the survey is to explore the various quantitative values needed as inputs for mitigation scenario assessment despite the majority of them being gathered from the secondary data collection process.

4.6.2 Survey questions and measurement scales

The questionnaire consists of eleven parts and its main aim is to achieve three important targets. The first series of questions, known as the discovery points, is designed to obtain general information about the disruptions that the wheat supply chain had experienced (Handfield et al. 2008). A thematic questionnaire structure as used by Cahoon (2004) is applied to group similar questions together and thus keep the respondent focused on a particular theme during the telephone interview of this
research. Further, Table 4-3 explains the structure of the telephone survey in relation to the goals, orientations and expected outcomes of the research, and the various categories of questions asked of respondents.

Analysis assisted in determining if any linkage exists between pre- and post-disruptive events, and the other items in the questionnaire. The second part of the instrument, probes the initial responses, and consists of items designed to obtain information on previous experiences and emergency responses within each organisation. The third part identifies parametric values such as probabilities, frequencies or occurrence rates, and operational logistics factors (see for example questions D3, E1, E4, E5, E6, F2, and F3 in Appendix A). There are ten items in the discussion on responses. Mitigation responses are grouped according to specific characteristics and functions of entities as maritime users in the three organisational categories of producers, buyers, and wheat millers as proposed by Bushell (2007) and Janzen and Wilson (2001). There are three items that identify the behavioural pattern of maritime operators as shipping and port operators and freight-forwarders.
<table>
<thead>
<tr>
<th>Items of Research Goals</th>
<th>Goals &amp; Orientations</th>
<th>in Australia</th>
<th>in Indonesia</th>
<th>Output expected from various questions</th>
<th>Expected targets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Far</td>
<td>Col</td>
<td>Mil</td>
<td>MarOp</td>
</tr>
<tr>
<td>SRQ1. Are shippers and consignees aware of the disruption that may occur in the maritime leg of the wheat supply chain?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Demographic questions</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>B. Disruptions process</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>C. Major maritime disruptive events</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>H. Maritime disruptive events at port</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SRQ2. Are shippers and consignees in the wheat supply chain implementing supply chain risk assessment or mitigation strategies to minimise disruptive events in maritime operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Consequences (costs and lead time)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>F. Rerouting in the wheat supply chain</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>G. Single wheat marketing board</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SRQ3. Are current risk mitigation and detection processes in maritime operations effective in the wheat supply chain systems?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Indentifying potential disruptions</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>J. Operational factors of maritime disruptions</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>K. Mitigation process</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>L. Propagation effect on supply chain</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Output expected from various questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected targets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output expected from various questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4-3. The structure of the telephone survey questions**
Disruptions were highly structured with supply chain design set out explicitly. Delays, deviations, stoppages, and disasters from laid down plans, procedures, and decision making process were listed. Each item is scored on a five-point Likert scale (Zikmund 2007; Creswell 2008) with a scale ranging from ‘extremely likely’ to ‘extremely unlikely’ being used to probe the possible future disruptive events. Another five-point Likert question scale from ‘strongly agree’ to ‘strongly disagree’ is also used to measure positive or negative responses about various possible maritime disruptions. Examples of these Likert scales can be found at items C1, E2, G1, section J, K1, and L1 (see Appendix A). In addition, a ranking system is also applied to survey questions based on specific factors to be compared. In the positively worded statements, ‘Yes’ was scored with 1 and ‘No’ was scored with 5, while the answering point of ‘Unsure’ was scored with 2.5. Further, there were two versions of each question, one worded positively and the other negatively in accordance with the principles of good instrument design (Fuse 2007; Zikmund 2007; Arnon 2009). The examples of the dichotomous questions are A2, A4, B2, F1, H1, M1, M2, and M4 (see Appendix A).

The advantage of the individual survey questions in the survey is that people who have worked in any maritime-related service may be able to respond accurately in detail. For example, there are many millers and processors who are also involved with many maritime-related operations and may contribute their perspectives in relation to maritime operations. The study’s goal is to determine the nature of organisational response and the implementation of decision making processes. Therefore, the recognition of services in the maritime leg from people who had already worked there and been involved in risk management related issues in the wheat supply chain would determine the accuracy and effectiveness of the research (Ljungberg 2006; MacDonald 2008; McCormack 2008; Qiang et al. 2008).

4.6.3 Pre-testing

Before undertaking the actual telephone survey, the study was pre-tested. Pre-testing is a necessary stage of developing a survey because it reveals the strengths and weaknesses of the survey in relation to question format, wording, bias and order. In addition (Reynolds & Diamantopoulos 1998; Zikmund 2007), pre-testing may also improve the ensuing questionnaire and interviewing procedures, reduce the burden on
respondents, improve sample frames, and ultimately increase the quality of data collected in the telephone interview survey (Walton 1997; Leon et al. 2005; Cycyota & Harrison 2006; Arnon 2009). In this study, a participating pre-test approach, where the questions were still being modified as a result of comments from the pre-test sample, is applied (Czaja & Blair 2004; Presser & Rothgeb 2004; Dixon-Woods et al. 2006; Zikmund 2007; Eppler & Aeschimann 2009).

In this study, the pre-test sample were clearly informed that the pre-test is a practice run. As part of error control process, the pre-test for clarifying the content of the survey question and for polishing the survey process were undertaken and was not only asking them to simply fill out the questionnaire as applied in the undeclared pre-test (see Appendix B). The content pretesting is worthwhile because it may produce some major wording changes (Conklin 1999; Arnon 2009), reordering questions about the research topic and survey questions (Dracther 2007; Fuse 2007; Cahoon 2008). There were ten respondents involved in the content pre-testing including lecturers in the Department of Maritime and Logistics Management (MLM) at the Australian Maritime College (AMC); grain farmers; shipping managers; terminal managers; research students and colleagues. The content pre-testing was carried out using a broad pre-test sample consisting of academics and industry representatives similar to the sample, which allows for a wider spectrum of issues to be raised and in doing so, improve the questionnaire and reduce error.

In the polishing stage, there were four respondents involved in the interviews who were two lecturers in the Department of MLM at AMC, and two colleagues. The interviews lasted for approximately 40 minutes and the full survey questions were tested to explore potential problems and identify issues that may occur during the telephone interviews with the sample. Questions on the wheat business process were modified to explore impacts on maritime disruptions in more detail. In addition to the interview questions; pictures, tables, and response cards were revised to assist with the respondent’s recall of some of the key definitions. The response cards, although containing only text, were printed on yellow sheets so as to provide a sensory stimulus and for the respondents to easily find on their desk during the interview (Cahoon 2004).
During pre-testing, it was confirmed that providing response cards (as shown in Appendix C) was beneficial because respondents then did not have to commit scales and other details to memory when responding to questions. This is of particular importance given that telephone interviews will be used and thus respondents do not have the convenience of the researcher being present or the hard copy of the survey instrument being available. Pre-testing found that as a result of having response cards, respondents will progress through the interview quicker whilst reducing error. Further detail on the response cards is provided in the next sub-section.

When recording the interview over the telephone, the researcher has few options for administering and recording the data; these generally include audio recording, notes written during the interview, and the researcher’s memory (Zikmund 2007; Fowler 2008; Saunders et al. 2009). Given that the memory is a very poor data repository, the more effective means to record the qualitative data was via a digital voice recorder to support the process of data collection taken during the telephone interview. Due to ethical considerations, prior to beginning recording, the respondent’s permission would be sought.

4.6.4 Survey development

Senior managers of maritime operations along the wheat supply chain are the central focus of analysis in this study. To approach them in administering the survey, as suggested by Cahoon (2004; 2008), Fuse (2007), and Arnon (2009), an advance letter, follow up telephone call and email were utilised in order to increase the response rate and reduce total non-response.

As suggested by Cahoon (2004; 2008) and Arnon (2009), an advance letter, response cards, a participation information sheet, and a consent letter from UTAS’ ethic committee were delivered to respondents one week prior to telephone survey appointment. In addition, as suggested by Cahoon (2004, p. 207), the advance letter was printed on a university letterhead to provide ‘evidence of the academic nature of the research, increase authenticity and give a professional appearance’. For Indonesian respondents, the UTAS’ ethic committee letter was effective in increasing the
credibility of this research due to sensitive information that respondents may have to protect in this research. Advance letters (see Appendices D and E) were delivered to two groups of respondents, first to individual potential respondents and second to the groups of wheat growers, collectors, milling companies, and maritime distributors in both Australia and Indonesia.

Two main tools were utilised in order to follow up the participation of respondents in the survey. These were a follow up call or ‘confirmatory telephone interview’ as suggested by Cahoon (2004, p. 211) and a follow up email (see Appendix F). The confirmatory calls were utilised to ask potential respondents whether they would be willing to participate in the survey. In addition, the introductory sections including the name of the respondents, their positions, and companies were included in a call log or email. The call or email also confirmed whether the advance letter had been received.

Once a respondent agreed to participate in the study, a date was set for the interviews to take place (see confirmatory letter in Appendix F). This was done as suggested by the literature as a means to increase the availability of respondents participating in the survey at their preferable time (Zikmund 2007; Creswell 2008; Arnon 2009).

As suggested by the survey research literature (Conklin 1999; Bourque & Fielder 2003; Leon et al. 2005; Cahoon 2008), comprehensive stages are used to develop the survey interview instrument. The introduction was directed in a flexible manner according to the researcher’s impression of the way the preliminary contact had preceded. The researcher attempted to initiate a good opening to break the ice, including establishing trust and an image of competence. The interview started with demographic questions in order to provide easy questions to get the respondent talking and to establish rapport. For the survey questions, the word disruption was initially defined and the definition used explicitly so that it became very familiar and the following questions sounded like normal topics to be discussed.

Response cards were provided to assist with the respondent’s recall of some key answer patterns (see Appendix C). The use of response cards is suggested by Conklin (1999), Cahoon (2004; 2008), Fuse (2007), and Arnon (2009) if respondents may have
difficulties in providing their responses in relation to complex tables and figures. In addition, they recommend that in the response cards, similar answers should be categorised in exactly the same configuration so the similar information was always in the same place, with only the actual question differing. To follow the recommendation, five response cards from A to F were provided (see Appendix C).

Response Card A was provided to help respondents to rank the importance of transport modes in the wheat transport process, whilst Response Card B was used to assist respondents in selecting one of five frequency levels of a maritime disruption event. Similar to Response Card B, there were seven possible probability levels of a future disruptive event that a respondent needed to provide in Response Card C. To obtain the range of consequence values of maritime disruptions, Response Card D was utilised that included a “No Costs” option to accommodate the range of financial impacts of disruption consequences. Similar to Response Card D, Response Card E provides “Not Applicable” to include other option of response. Response Card F is utilised to identify how often disruption management strategies were applied. As suggested by Cahoon (2004; 2008) and Dracther (2007), the six response cards were sent to respondents by mail with the advance letter and printed on yellow paper in order to be easy recognised on the respondents' desk.

4.6.5 Administering the telephone survey

The telephone survey interview procedure consists of more than just asking survey questions. It also contains general directions, elaboration processes, and the discussion format to be used in the research interaction with the respondents. A good procedure should detail from whom or where different types of information should be gathered to achieve the aim of the research (Walton 1997; Zikmund 2007; Fowler 2008; Arnon 2009; Link et al. 2009; Saunders et al. 2009).

In essence, the primary content of the procedure is a set of specific questions to gather information and a checklist for the researcher to ensure that all questions and topics discussed have covered the research questions. The full survey instrument can be found in Appendix A. There are also examples of the survey questions used during the
telephone interviews. Given that this research proposed to cover at least 11 topics, the preparation of a well structured interview phase was extremely important.

In the telephone interview session, as suggested by Lavrakas (1993 in Cahoon 2004) and Zikmund (2007), a brief introduction was provided to explain again the purpose of the research as mentioned in the advance letters. As recommended by Cahoon (2004), Zikmund (2007), and Arnon (2009), it is important to record the interview in order to obtain an accurate response during the interview process. Therefore, in the current study, the researcher audio recorded the answers of respondents during the actual interview and the researcher ensured the questions were answered in the correct order and with the correct responses provided on the survey instrument to ensure data accuracy and completeness. However, prior to recording the interview, permission was first requested.

Further, to make them feel as comfortable as possible, respondents were encouraged to be able to speak in their own words and in the way they wanted to, not feeling forced by methodological structure. This technique was applied by Cahoon (2008) and Fuse (2007) to obtain an effective discussion in the telephone survey. By using this flexible approach, new and relevant, but unexpected topics could be discussed.

There was a logical sequence to the list of topics in the survey. The sequence considered the ‘brevity factor’ as recommended by Cahoon (2004, p. 213) in order to increase the ‘active involvement’ of the respondents (Lavrakas 1993 in Cahoon 2004, p. 213). For the first interviews a topic list was formulated, which consisted of several groups of questions because less was known at this stage about the information that would be forthcoming. In later interviews, a semi-structured list of questions was used, with some specific issues being central, but with open questions so as to elicit a broad range of answers.

Further, it was ensured that the subject matter of the research was important to the respondents with issues relating to losses or commercial impacts of maritime disruptions. It is understandable that it is difficult to be open about such problems, even more so when competitors and others in the chain upon whom they are dependent, were
also involved in the research. To enable the interviewer to delve deeply and thoroughly into their opinions and to gather data that was accurate as possible, a reasonably trusting relationship with the interviewees firstly had to be established (Walton 1997; Presser & Rothgeb 2004; Fowler 2008; Greckhamer et al. 2008).

A number of researchers such as (Naoya and Wen 2005; Fuse 2007; Drachter 2007; Arnon 2009) have recommended that explanation and clarifications need to be provided when conducting telephone surveys in order to avoid misperceptions of questions and discussion in the survey. To follow this, standardised explanations and clarifications were provided for questions that were unclear to the respondents and were only used to answer any respondent queries as they arose. Several simple definitions such delay, deviation, stoppage, disaster, mitigation, adaptation, and intervention were provided during the interview session as these words were asked frequently by respondents. In addition, it was stipulated that probing questions used completely neutral words such as “any more ideas?”, “could you provide more details”, “in what ways?”, and “anything else?”.

At the end of each interview, each respondent was formally thanked for their time and contributions (as suggested by Cahoon 2004; Leon et al. 2005; Zikmund 2007; Fowler 2008). Further, as another acknowledgment of their participation, each respondent was offered the results of the research survey when it becomes available. It was up to respondents whether they wanted to accept this offer by replying during the interview or by email.

4.7 The error control process of the telephone interview

In relation to possible errors in the data collection process, this section first discusses how potential bias was anticipated, followed by an explanation of the interviewer and respondent effect when undertaking the telephone interviews. This section also describes measures used to avoid and minimise these errors.
4.7.1 Measurement error

Measurement error usually results when the sample being surveyed does not reflect the general population (Zikmund 2007; Cooper and Wakefield 2008). This type of error may occur in the sample frame of entities of the wheat supply chain under investigation. The measurement error is different from sampling error. Measurement error results mainly from the manner in which the observations are made by the researcher, while sampling error may be produced by participants, the sampling tools, or telephone survey procedure (Zikmund 2007; Baruch and Holtom 2008).

In this research, the respondents may consider disruption consequences on different scales according to various states of disruption, with poor calibration. To follow the suggestion by Beer and Katz (2003), Cicyota and Harrison (2006), and Dracther (2007), some clues are utilised both to avoid measurement error and to have accurate responses. For example, this included questions such as “Is the observation of a disruption likely or probable?”. Further, if respondents wanted to state a different unit of scale, then some clues were provided in order to obtain a correct answer such as “50 per cent means once in two months” or “one hundred thousand dollars is equal to eight billion of Australian dollars”.

Inconsistency in an individual’s weighing may affect the response (Zikmund 2007). The scale reading of a Likert scale will also vary with the respondents’ experiences. Responses therefore, will not have a comparable validity unless all persons’ answers were measured according to the same circumstances. In addition, biased observations due to inaccurate measurement can be the case in providing responses. In responding to this, the same measurement units and items used in the survey were applied consistently in order to get the precise values from the opinions of respondents. For example in relation to consequence values in Question E1, the cost items were related to three main factors such as infrastructure, equipment and opportunity costs.

4.7.2 Induced bias

In this study, to decrease the non-response rate, three measures were taken. Firstly, a reminder email was sent to respondents if there was no response from them after two
weeks from receiving the advance letter. This technique was effective in increasing the response rates of senior managers. Secondly, approaching and requesting other contact person within similar companies or institutions of respondents was used to find alternate respondents when necessary. This approach found six alternate respondents (17.6 per cent) within the same organisations and in similar positions to the original respondents.

Thirdly, to minimise the non-response sample particularly on respondents who may have a major market share in the wheat business between Australia and Indonesia, the survey requested the assistance of a wheat association both in Australia and Indonesia to inform their members about the participating the research survey. In addition, this approach was also supported by posting advance letters (Cahoon 2004; Drachter et al. 2007) and explaining the importance and benefit of the study to their companies (Cahoon 2004; Arnon 2009)

4.8 Summary

This chapter has discussed the research methodology and survey procedures appropriate for the study. The research design selected was one that attempts to explore the subjective experiences of maritime disruptions in the wheat supply chain and gauge the implementation of effective and efficient mitigation strategies in response to 20 maritime disruptive events.

The chapter has documented the processes used in selecting the participants and collecting data in the Australian and Indonesian wheat supply chain. The research method chosen was a combination of qualitative and quantitative approaches that collected primary data via a telephone survey that included a mitigation scenario assessment. The research questions were prepared to address the research questions in the telephone survey interview, which basically aimed to assess the awareness and existence of maritime disruptions including the previous and current risk management practices in the wheat supply chain.
The sample for the study included senior managers from entities which provide maritime services in the wheat supply chain in eight locations across Australia and Indonesia. Multi-cluster sampling is applied as the main approach to constructing the sampling frame due to the various classifications of targeted respondents, mainly wheat farmers through to grain farmer associations, buyers, transport operators, and supply chain or distribution providers.

A two stage pre-test was applied to clarify the content of the survey question and for polishing the survey process. The pre-testing was also utilised to ensure the advance letter and confirmatory telephone interview were properly prepared and able to increase the response rate of the survey. Other approaches to minimise error and bias during the survey were also included. In the next chapter, the results of the research survey is discussed and presented.
CHAPTER FIVE

RESULTS OF
THE RESEARCH SURVEY
5.1 Introduction

This chapter discusses the results of the research survey process as explained in the previous chapter. Thirty-four interviews were conducted with senior managers from various stages of the Australian-Indonesian wheat supply chain including farmers, handlers, processors, shippers, ship and port operators, and consignees. Each respondent was asked their opinion on a variety of maritime disruptive events including the probabilities and consequences of those events, current mitigation responses, and partnership collaboration with other entities in the wheat supply chain. Eight different supply chain links (West Australia, South Australia, New South Wales, Queensland, Java, Sumatera, Sulawesi, and Borneo) were examined during the data collection phase which forms the basis of the analysis in this chapter. This chapter consists of eight main sections.

After the introduction, the second section explains the general characteristics of the sample and reports the response rate of the telephone interviews. The third section discusses the risk perception of disruptive events and describes the framework of maritime disruption in the wheat supply chain from various perspectives. The fourth section provides the descriptive data of maritime disruptions in terms of frequency rate, operational impact, and consequence levels. The fifth section presents the general process of disruption management applied by respondents. The sixth section explores mitigation strategies applied by respondents including statistical methods to test the reliability and significant differences of those mitigation strategies and measures the correlation factors of key variables in managing disruptions. The seventh section explains the roles of third and fourth party logistics in the wheat supply chain included in the maritime disruption management identified in the chain. The eighth section summarises the chapter.
5.2 The characteristics of survey respondents

This section describes the characteristics of the research sample, response rate and respondent profiles.

5.2.1 The response rate of the telephone interviews

Table 5-1 indicates that with the exception of groups A and H, the sample and population is proportionally stratified across each category with a mean difference of less than 1.5 per cent. This is an indication that the sample may adequately represent the pattern of the survey population.

<table>
<thead>
<tr>
<th>Descriptive</th>
<th>Sample (No. %)</th>
<th>Population (No. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers in Australia (A)</td>
<td>2 (5.8%)</td>
<td>7 (4.4%)</td>
</tr>
<tr>
<td>Handlers to collectors in Australia (B)</td>
<td>2 (5.8%)</td>
<td>8 (5.0%)</td>
</tr>
<tr>
<td>Processors in Australia (C)</td>
<td>2 (5.8%)</td>
<td>8 (5.0%)</td>
</tr>
<tr>
<td>Shippers to forwarders in Australia (D)</td>
<td>3 (8.8%)</td>
<td>13 (8.1%)</td>
</tr>
<tr>
<td>Port operators in Australia (E)</td>
<td>3 (11.2%)</td>
<td>18 (11.3%)</td>
</tr>
<tr>
<td>Shipping operators in Australia (F)</td>
<td>4 (11.7%)</td>
<td>19 (11.9%)</td>
</tr>
<tr>
<td>Shipping operators in Indonesia (G)</td>
<td>5 (14.7%)</td>
<td>23 (14.4%)</td>
</tr>
<tr>
<td>Port operators in Indonesia (H)</td>
<td>6 (17.6%)</td>
<td>22 (13.8%)</td>
</tr>
<tr>
<td>Forwarders in Indonesia (I)</td>
<td>3 (8.8%)</td>
<td>16 (10.0%)</td>
</tr>
<tr>
<td>Consignees in Indonesia (J)</td>
<td>1 (2.9%)</td>
<td>4 (2.5%)</td>
</tr>
<tr>
<td>Wholesalers in Indonesia (K)</td>
<td>2 (5.8%)</td>
<td>9 (5.6%)</td>
</tr>
<tr>
<td>Retailers to consumers in Indonesia (L)</td>
<td>1 (2.9%)</td>
<td>4 (2.5%)</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>151</td>
</tr>
</tbody>
</table>

Statistical Tests

- Pearson Correlation: 0.9427
- Hypothesised Mean Difference: 1.5
- df: 11
- Alpha: 0.05
- t Stat: -7.2001
- p (T<=t) one-tail: 8.76086E-06
- t critical one-tail: 1.7958
- p (T<=t) two-tail: 1.75217E-05
- t critical two-tail: 2.2009

Source: Appendix A section A1

A response rate of 68 per cent or 34 interviews from the sample of the 50 targeted respondents was achieved. Of the remainder, about 16 per cent were unwilling to
participate due to commercial in confidence issues relating to their companies, 12 per cent were busy due to the harvesting period, and five per cent provided no reasons. The acceptable correlation between these two groups is confirmed by the Pearson correlation factor (94.27 per cent), t Stat (-7.20), as well as p and t values which comply with the statistical requirements. Further, the heterogeneous nature of the sample complied with the confidence level (α = 0.05) and the generalisability of the results (Vaus 2002; Zikmund 2007). These statistical variables indicate that the number and characteristics of the research sample adequately represents the population of the selected wheat supply chain. A finding of this study in relation to the data collection method is that a telephone survey is an effective means of gathering data from senior managers. In particular, the telephone survey enabled the impact of maritime disruptions, the significant factors in managing the disruptions, and the cycle process of maritime disruptions to be investigated in depth. The success of using telephone interviews is evidenced by a response rate of 68 per cent with the average interview being 32 minutes with a range of 15 to 90 minutes. The response rate compares favourable to previous studies on senior managers that have used telephone interviews (as shown in Table 5-2).

Table 5-2. Response rates for previous telephone interviews on senior managers

<table>
<thead>
<tr>
<th>Study</th>
<th>Industry/Scope</th>
<th>Response rate (%)</th>
<th>Average time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conklin (1999)</td>
<td>Education</td>
<td>94</td>
<td>10</td>
</tr>
<tr>
<td>Kleifner et al. (2003)</td>
<td>Energy</td>
<td>26</td>
<td>Not provided</td>
</tr>
<tr>
<td></td>
<td>Government</td>
<td>30</td>
<td>Not provided</td>
</tr>
<tr>
<td></td>
<td>Finance</td>
<td>6</td>
<td>Not provided</td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
<td>9</td>
<td>Not provided</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>9</td>
<td>Not provided</td>
</tr>
<tr>
<td></td>
<td>Lumber</td>
<td>3</td>
<td>Not provided</td>
</tr>
<tr>
<td>Cahoon (2004, 2008)</td>
<td>Seaport marketing</td>
<td>100</td>
<td>62</td>
</tr>
<tr>
<td>Naoya and Chern (2005)</td>
<td>Agricultural</td>
<td>29</td>
<td>18</td>
</tr>
<tr>
<td>Drachter et al. (2007)</td>
<td>Mutual fund</td>
<td>75</td>
<td>40</td>
</tr>
<tr>
<td>Bonsal and Shirez (2009)</td>
<td>Travel</td>
<td>76</td>
<td>Not provided</td>
</tr>
<tr>
<td>Perks et al. (2009)</td>
<td>R &amp; D marketing</td>
<td>50</td>
<td>Not provided</td>
</tr>
</tbody>
</table>

Source: Author
Although some of the studies have very high response rates that are in excess of 70 per cent (Conklin 1999; Dracther 2007; Cahoon 2008; Bonsall & Shirez 2009), most of the studies have response rates of below 60 per cent. This confirms that the response rate for this study is acceptable in comparison to previous studies. The unsolicited comments from respondents indicating their preference for a telephone survey are in Table 5-3.

Table 5-3. Comments from respondents concerning telephone survey

<table>
<thead>
<tr>
<th>Flexibility of time and place</th>
<th>Open-ended question is preferable</th>
</tr>
</thead>
<tbody>
<tr>
<td>...telephone survey makes you easier to contact me right? and also very much flexible in terms of time (Port General Manager)</td>
<td>It's boring if you ask me those multiple choice questions, but quite challenging with open-ended question ones (Terminal Manager)</td>
</tr>
<tr>
<td>With a telephone survey you may contact me while I'm at home after coming back from office. So it's more relaxed (Operation Manager)</td>
<td>It was great and I like to discuss a lot of range of global topics to be discussed especially for me here in a rural area (Distribution Manager)</td>
</tr>
<tr>
<td>Telephone survey is a relative adaptable tool for us as managers who are quite mobile in the field. So you may get me easily (Port Manager).</td>
<td>I like the stimulating points you put in the survey in order to get active discussions over the telephone survey (Risk Manager)</td>
</tr>
<tr>
<td>Telephone survey is simple, flexible in time and place, and can explain a lot of rationales behind my statements (Shipping manager)</td>
<td>Telephone survey is fairly OK for open questions and discussions rather than the choices (Port Manager)</td>
</tr>
<tr>
<td>...through this survey you may get me while I'm in the car waiting for this congested traffic (Wheat CEO)</td>
<td>I like the discussion questions rather than the probing ones (Shipping Manager)</td>
</tr>
<tr>
<td>Survey over the telephone may give me a suitable time to start, stop, and continue the discussion with you (Supply Chain Manager)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Free expressions and discussions</th>
<th>Suggestions in relation to preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>...being interviewed over the telephone gives me a free choice to express many things (Distribution Manager)</td>
<td>It would be better if you ask me to prepare more documents rather than these respondent cards (Terminal Managers)</td>
</tr>
<tr>
<td>It is more comfortable to answer and discuss compare to directly having face to face discussions (Port Manager)</td>
<td>...the other thing, I'm not so prepared to answer your question, if you informed me a bit about the questions you want to ask in regards to numbers probably I should have prepared better for you (Operation Manager)</td>
</tr>
<tr>
<td>It is a good tool for survey, I am more relaxed in expressing ideas both pros and cons without knowing you over there (Distribution Manager)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author
Their comments highlight the benefits of using a telephone survey when compared to mail and face to face interview, thus further validating the selection of a telephone survey when gathering data from senior managers. Another major advantage of using a telephone survey to interview senior managers for collecting both qualitative and quantitative disruption data is the flexibility of time and place provided to the interviewer and respondents when undertaking interview sessions, especially for active and mobile senior managers. Further, as all respondents have in-depth knowledge of the wheat supply chain, including maritime operations, a telephone interview enabled greater discussion on open-ended questions when compared to what may be expected from mail surveys.

5.2.2 Respondent profiles

Table 5-4 shows the profile of the survey sample by titles, years of experiences, and qualifications. Thirty-two per cent were port managers, 20 per cent were supply chain managers, 24 per cent were shipping and operations managers and 18 per cent were owners and general managers. Therefore, all respondents were relevant participants for the purpose of this research.

<table>
<thead>
<tr>
<th>Job titles</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port manager</td>
<td>11</td>
<td>32</td>
</tr>
<tr>
<td>Supply chain manager</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Shipping manager</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Operations manager</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>General managers/Director</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Owner</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Marketing manager</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>New (5 years or fewer)</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>Intermediate (between 6 and 10 years)</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>Seasoned (over 10 years)</td>
<td>15</td>
<td>44</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Business or logistics related qualifications</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>24</td>
<td>71</td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>27</td>
</tr>
<tr>
<td>Unsure</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Appendix A section A2-A6 and section M1; Appendix G section E, G, and H.
In addition, of all respondents, 35 per cent of the senior managers have less than five years of experience, 44 per cent were “seasoned” (more than ten years of experience), and the remaining 21 per cent had between six to ten years of experience, thus indicating the senior managers should have sufficient experience and expertise to answer the questions. Seventy-one per cent of respondents had business or logistics related qualifications, 27 per cent had no qualifications in logistics and two per cent were unsure as their qualifications were vocational-related. This data suggests respondents have a significant role in the decision making process when managing and responding to maritime disruptions in the wheat supply chain, and therefore were able to provide sufficient insights into their organisation for the purposes of the current study.

5.2.3 Question routing

Table 5-5 shows the item response rates in relation to survey questions (section A to L) by all categories of respondents from farmers to retailers.

Table 5-5. Profile of question responses

<table>
<thead>
<tr>
<th>Items of research questions</th>
<th>Total responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in Australia</td>
</tr>
<tr>
<td>A. Demographic questions</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>B. Disruptions process</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>C. Major maritime disruptive events</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>D. Indemnifying potential disruptions</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>E. Consequences (costs and lead time)</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>F. Rerouting in the wheat supply chain</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>G. Single wheat marketing board</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>H. Maritime disruptive events at port</td>
<td>2 (5.8%)</td>
</tr>
<tr>
<td>J. Operational factors of maritime disruptions</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>E. Mitigation process</td>
<td>1 (2.9%)</td>
</tr>
<tr>
<td>L. Propagation effect on supply chain</td>
<td>1 (2.9%)</td>
</tr>
</tbody>
</table>

Source: Author

Note:
Far : Farmers  Dis : Distributors  MarOp : Maritime operators
Col : Collectors  Ret : Retailers  Proc : Processors
Mil : Millers
Complete responses by 34 respondents were given in section A to D. While in section E to L, the total response rate was less than 34. This is due to question routing being applied during the telephone survey where only related respondents provided their detailed perception and assessment on particular questions. For example, for questions in section J, only maritime operators in Australia and Indonesia answered some questions in this section as specific port and shipping-related information was required.

5.3 Risk perception of maritime disruption risk

This section explores respondents’ risk perceptions of maritime disruptions arising from responses to questions in section B of the survey questionnaire (see Appendix A). As part of the triangulation approach, qualitative analysis in the interview process confirmed the quantitative data in the survey. Qualitative data obtained through eight open-ended questions (see Appendix A) were categorised into four data groups: (i) maritime disruptive risk perception, (ii) management responses along the supply chain, (iii) the propagation effect of maritime disruptions, and (iv) strategic managerial actions executed. These four data groups were individually analysed and combined in relation to the characteristics specific to their positions along the wheat supply chain. As an analytical technique, comments were categorised and listed to assist the use of pattern matching. As suggested for an iterative approach, statements were recombined to develop case-specific findings (Drongelen 2001; Douglas & Craig 2007) on risk categories and perception.

5.3.1 Risk categories and stages in the wheat supply chain

Table 5-6 shows the respondents’ risk perceptions in terms of where disruptions occur in the wheat supply chain. In terms of risk categories, 35 per cent responded that operational risks were evident in their business followed by market risks (22 per cent), financial (15 per cent), environmental (11 per cent) and technical risks (nine per cent); whilst, legal (six per cent) and security (two per cent) risks were considered as low categories of risks. The level of experience of the respondents with operational, market,
financial, environmental, and technical risks provides additional support for the validity of the existence of maritime disruptive risks in the wheat supply chain.

In terms of which stages maritime disruptions occurred in the wheat supply chain, as shown in Figure 1-1 in Chapter One, the senior managers indicated that 68 per cent of disruptive events existed in the maritime leg operations of the wheat supply chain (from stage C to K as shown in Appendix A).

Table 5-6. Risk categories in the wheat supply chain

<table>
<thead>
<tr>
<th>Categories of disruptive related risks</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>19</td>
<td>35</td>
</tr>
<tr>
<td>Market</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>Financial</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Environmental</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Technical</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Legal</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Security</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Points where disruptive events occur

<table>
<thead>
<tr>
<th>Events</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port operations in Indonesia</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Port operations in Australia</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Shipping arrangements in Indonesia</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Shipping arrangements in Australia</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Forwarding operations in Australia</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Farmers to handlers in Australia</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Operations to shippers in Australia</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Flow to processors in Australia</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Forwarding operations in Indonesia</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Consignees’ premises in Indonesia</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Wholesalers’ premises in Indonesia</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Retailers’ premises in Indonesia</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Terminology of a disruptive event

<table>
<thead>
<tr>
<th>Events</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interruptions</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>Delays</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>Disturbances</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>Deviations</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Stoppages</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Disasters</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: Appendix G section E, section G, and section H

Of this percentage, port operations in both countries contributed to 29 per cent of the maritime disruptions, followed by shipping operations (22 per cent), and forwarding
operations (17 per cent). These percentages provide evidence of the extent that maritime operations contribute to the disruptions in the wheat supply chain. In addition, although those disruptions could also be caused by other processes in the chain, the category of operational risk reported by 35 per cent of respondents may indicate that the maritime leg operations are critical links where disruptions occur in the wheat supply chain.

Table 5-6 also shows the range of terminology used (provided in the survey questions) by senior managers when referring to a disruptive event. Twenty-six per cent of respondents had experienced and defined ‘interruptions’ as being the event of service unavailability in the wheat supply chain. Logistics or supply chain managers define ‘interruptions’ in line with the definition presented in this research (see Appendix G section F). This is similar to delays (23 per cent) that are reported by operations managers and shipping managers. Alternatively, about 21 per cent of respondents, mainly marketing managers and GMs/Owners used the word ‘disturbances’ to describe conditions of service unavailability, whilst mainly port managers used either ‘deviations’ or ‘stoppages’ in the wheat supply chain in regard to the unavailability of maritime services. The final seven per cent of respondents (operations managers) used the word ‘disasters’ to refer to the disruptive events they had experienced. While the perception of maritime risks in the area of port and shipping operations were alluded to through the terms of disturbance or interruption, it seems apparent that all delays, deviations of plans, and unavailability of services were ultimately referred to as operational disturbances.

The respondents were asked to indicate which transport modes contribute to increasing risks (ranked from 0 to 6, where 6 is the most important) along the wheat supply chain from Australia to Indonesia (see in Appendix G section K). Shipping transport was selected as the mode (5.68 points) contributing greatest to operational risks for international transport links, whereas in Australia, rail service (3.58) is the major common transport mode for wheat transport domestically. Trucking (3.35) and multimodal transportation (3.62) were viewed as more important in Indonesia as they are mostly used for wheat distribution both for major islands and inter-island destinations. Given the high level of importance to shipping transport, this is further
evidence that maritime operations are major contributors to the disruptions in the wheat supply chain.

5.3.2 Instigating factors

Instigating factors or disruptors are the driving forces of maritime disruption risks. Twenty instigating factors are identified in the literature as discussed in section 3.3 of Chapter Three and categorised into five basic causes of maritime disruptions, namely security and safety, service and infrastructure, market, organisation, and environment (see Figure 5-1).

<table>
<thead>
<tr>
<th>Security and safety</th>
<th>Service and infrastructure</th>
<th>Market</th>
<th>Organisation</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship accidents</td>
<td>Equipment breakdown</td>
<td>- Uncertain bunkering</td>
<td>- Port strikes</td>
<td>- Severe weather</td>
</tr>
<tr>
<td>Political events</td>
<td>Electrical outages</td>
<td>- Shortage of dry bulk ships</td>
<td>- Slow cleanliness checking</td>
<td>- Earthquake</td>
</tr>
<tr>
<td>Piracy</td>
<td>Communication failures</td>
<td>- Traffic imbalance (insufficient empty containers)</td>
<td>- Long customs process</td>
<td>- Tsunami</td>
</tr>
<tr>
<td>Terrorist attack</td>
<td>Insufficient rail facilities</td>
<td>- Port congestion</td>
<td>- Shipping port disputes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Port congestion</td>
<td>- Lack of inland access</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5-1. The comparison of instigating factors in the literature and the survey**

Source: Author

However, in the survey, only 17 instigating factors were mentioned by respondents (see Appendix G section N). Factors such as the failure of communication facilities, uncertain bunkering costs and tsunami were not recognised as disruptive events in the wheat supply chain. Each of the 17 instigating factors in the survey is discussed below.

5.3.2.1 Security and safety related factors

In the security and safety group, ship collisions, riots due to political unrest and theft at the port have occurred in the wheat supply chain. One respondent explained “ship
collisions were the biggest disruptive events at the port” (Port Branch Manager). Similarly, two respondents noted that “violent riots due to the land disputes and the removal of cultural graveyard by the local government” (Terminal General Manager) and “theft at the terminal” (Operation Manager) are three disruptive events that may delay and stop grain terminal operations.

The need to focus on safe, secure, and supply chain risk-proof practice was also recognised by some respondents. One respondent discussed how the port increases the awareness of security and safety related factors:

*We actually struggle to make our staff, and port users, including entities of the maritime community aware about maritime risks in terms of security and safety matters. By regularly practicing those risk management protocols within our company it may heighten the awareness of our staff and the port community to have a minimum understanding of those standards.*

- Port Branch Manager in Indonesia

Imposing risk minimisation strategies (as they were required for maintaining safe, secure and risk low practices) were necessary to build up an awareness of maritime disruptions, for example one respondent commented:

*Risk awareness of the maritime community in Indonesia is still minimal as they rely more on destiny. This is why maritime risk management needs to be established from the point of view of increasing maritime service risk awareness.*

- Safety and Risk Manager in Indonesia

### 5.3.2.2 Service and infrastructure related factors

Service and infrastructure at ports and inland road accessibility were seen as the dominant factors contributing to disruptive events in the wheat supply chain both in Australia and Indonesia. Similarly, infrastructure was recognised as one of the important instigating factors, because it can create disruptions due to five inter-related problems; (i) frequent equipment breakdown; (ii) electrical outages; (iii) insufficient rail facilities; (iv) port congestion; and (v) the lack of inland accessibility.
Frequent equipment breakdown was considered as a significant disruptive event in the wheat supply chain. For wheat handling in Indonesia, it became apparent, as one respondent commented “the old handling equipment in Indonesia may be the main factor for the slow service operation or low performance of ports in Indonesia” (Shipping Manager in Indonesia). In addition, one senior manager in Australia viewed that the lack of loading equipment availability recurrently occurred due to inadequate maintenance programs.

Further, in the words of a Port General Manager in Indonesia “inland accessibility is the real problem for supporting the increasing growth of maritime operations in the islands (of Indonesia)”. The impact of these factors has created recurrent maritime disruptions in Indonesia, as observed by a Distribution Manager in Indonesia “not only in the main strategic ports in Java but also frequently in other major ports in Sumatera, Kalimantan, and Sulawesi”. Due to these problems, port users or transport operators in Indonesia expect that the capacity and availability level of transportation assets in the wheat supply chain have increased. As commented by a Mill Manager in Indonesia “port infrastructure and inland accessibility need to be further expanded and modernised”.

More specifically for wheat handling at ports, some respondents mentioned electrical outages, insufficient storage and warehouse facilities as factors that may create delays, and deviations in the wheat supply chain. As a consequence, waiting time for delays has been a common outcome for wheat handling operations of the port users. These outcomes are evident in the following comments of three respondents:

The insufficient and stability of electrical power capacity for our grain terminal has been creating a significant delay in operation as we are unable to provide our own electrical generator.

- Mill Manager in Indonesia

The shortage of grain storage facilities may significantly impact and deviate the operations of shipping and ports.

- Bulk Shipping Manager in Australia

Insufficient warehouse facilities for LCL operations contribute to the delay of port operations for wheat commodities.
In Australia, the problems of the domestic wheat supply chain creating delay and deviation events, as commented by a Distribution Manager, are generally due to “insufficient rail facilities and capacities”. Similarly, another claimed “the inadequacy of rail services may be the biggest cause of disruptions in Australia” (Supply Chain Association General Manager in Australia).

This research confirms that port congestion is the most significant event occurring in the Australian and Indonesian wheat supply chain (see appendix G section N, P, and S). Out of 27 potential causes of port congestion in the literature, a tsunami was not confirmed as it was not applicable for respondents in their wheat supply chain (see Table 5-7).

Table 5-7. Potential causes of port congestion in the wheat supply chain

<table>
<thead>
<tr>
<th>Literature</th>
<th>Before port channel</th>
<th>Waterways</th>
<th>Port berth</th>
<th>Port platform</th>
<th>Port inland access</th>
<th>Port SCM network</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Problems in nearby port</td>
<td>- Ships accidents</td>
<td>- High wind</td>
<td>- Power failure</td>
<td>- Clearance of quarantine checks</td>
<td>- Flooding</td>
<td></td>
</tr>
<tr>
<td>- Port state control boarding and clearance</td>
<td>- Sedimentation</td>
<td>- Lack of pilotage</td>
<td>- Heavy wind and rain</td>
<td>- Customs clearance</td>
<td>- Downstream</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Hazardous spill</td>
<td>- Port strikes</td>
<td>- Immigration process</td>
<td>- Lack of roads, bridges, and access lanes</td>
<td>intermodal problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Low tide level</td>
<td>- Crane disabled</td>
<td>- IT system down</td>
<td>- Overloaded yard</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Severe waves</td>
<td>- Shortage of chassis</td>
<td>- Cargo verification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Earthquake/tsunami</td>
<td>- Shortage of handling equipment</td>
<td>- Overloaded yard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survey</td>
<td>Confirmed</td>
<td>Tsunami not applicable</td>
<td>Confirmed</td>
<td>- Wheat cleanliness checking</td>
<td>- Transport contractual disputes</td>
<td>Confirmed</td>
</tr>
</tbody>
</table>

Source: Author

Two additional new factors of port congestion reported by respondents are wheat cleanliness checking (at port platform) and transport contractual disputes (at port inland access) that recurrently occurred in the wheat supply chain. Thus, there are 28 potential causes that may generate port congestion in the wheat supply chain. The impact of port congestion significantly increases the supply chain time and costs. The impact is evident in the following comments:
Waiting time at Tanjung Emas, Perak, and Belawan is really a serious problem as ships have to add one to three days as waiting time to enter those ports.

- Dry Bulk CEO in Indonesia

I should say that port congestion is the real problem in the Australian wheat chain. Due to this, Australia may lose its competitiveness in the global wheat market.

- Mill Manager in Australia

Port infrastructure problems that frequently generate congestion in small ports of Indonesia may be the driving factor of the higher basic food prices.

- Mill manager in Indonesia

5.3.2.3 Market related factors

Market related factors of the wheat supply chain are another cause of accessibility problems for maritime transports that subsequently generate maritime disruptions. Uncertainty of the availability of dry bulk fleets and fluctuation of dry-bulk shipping freight are evident for maritime disruptions as wheat shipments could be delayed or even deviated to be loaded and transported to unloading ports. Higher shipping costs of dry bulk ships have influenced shippers to change the shipments from dry bulk to containerised wheat shipments. This was supported by 62 per cent of respondents as part of their business continuity plan (see Appendix G section AD). This consequence is evident in the following comments of two respondents:

As wheat importers are applying both containers and dry bulk shipments for their transport, consequently this may create more maritime (disruptions) risks in our transportation flows.

- Shipping Manager in Australia

There is a trend of arranging a dry-bulk shipping contract but utilising containerised transport in the actual shipment of COA (contract of affreightment). This may contribute to the emergence of maritime disruption as grain consignees here are not used to it.

- Terminal Manager in Indonesia

As indicated in Chapter Three, a maritime disruption is also influenced by traffic imbalance including the availability of empty containers. This was supported in the survey by 73.3 per cent of respondents (see Appendix G section N) who agreed that the
imbalance of empty containers has generated further disruption in the wheat supply chain. One respondent replied that:

The imbalance of empty containers in wheat transport may significantly affect the freight costs as well as the availability of ships in the market especially for grain transport. In many cases, the insufficient number of containers will push the freight level up proportionally.

- Distribution Manager in Australia

Market distortion in terms of price dumping and monopoly practice was also viewed as an important consideration in generating maritime disruptions with an example given of accessing a ship or terminal space primarily for same group business. Four respondents of Australian wheat distributors, millers, Indonesian buyers and millers confirmed this factor. The practice of dumping to establish better market penetration or coverage by Australian sellers was evident as a factor of supply uncertainty in the wheat supply chain among entities in Australia and Indonesia during the period 2008-2009 (Loppies 2010).

However, given the higher domestic wheat price in Australia (in the post-AWB era) and lower selling price in Indonesia (in the period 2009-2010) there is clear evidence that the claims by Indonesian buyers of Australian sellers dumping on the Indonesian market were not well proven as the Indonesian anti-dumping agency found no provable injuries to the Indonesian wheat market. This issue was discussed in the words of one respondent:

The dumping policy of Australian wheat contributed to the supply uncertainty between entities the wheat supply chains. This is because the AWB covered the demurrage costs and other additional shipping costs but not now. Accordingly, we know that in relation to this, KADI (the Indonesian Anti-Dumping Committee) has publicly affirmed that there was no evidence of injuries in the Indonesian market.

- Wheat CEO in Indonesia

Further, despite being able to get the different sources of wheat available in Australia through wheat marketing agencies associated with wheat growers associations and pool-based agencies, there remained a problem, as informed by a respondent that “wheat cargo readiness in Australia affects maritime disruptions due to a better value of Australian dollar against the American dollar” (Millers). Similar to this, another
respondent commented that “the lack of guarantee of supply contributes to the disturbances of wheat transport” (Collectors and Millers). As a consequence of the lack of guarantee supply is explained as:

*Market price may significantly affect the freight costs as well as the availability of ships in the market. In many cases, higher wheat prices will push the freight level up proportionally.*

- Port Operation Manager in Indonesia

### 5.3.2.4 Organisation related factors

It was also suggested by respondents that organisation-related factors in the maritime leg may impact on the original plan of maritime operations considerably and independently. This includes port strikes, slow cleanliness checking, long custom process and disputes among institutions at ports that may create significant delays, and deviations along the wheat supply chain. A port strike was considered as an essential disruptive event in the wheat supply chain by 66.7 per cent of respondents (see Appendix G section N). For example, one respondent confirmed that “*port strikes had forced us to close our terminal for about two to three days in a year. That’s why, we are really concerned about this factor*” (Terminal Manager in Australia). Administrative problems such as customs and quarantine processes were other disruptions identified by 80 per cent of respondents as being activities that caused frequent delays, particularly in Indonesian ports (as described in Table 5-8).

### Table 5-8. Customs and quarantine problems

<table>
<thead>
<tr>
<th>Customs related problems</th>
<th>Quarantine related problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customs procedures at port are terrible but now they are getting better due to tight inspections of the Corruption Eradication Watch Agency (Stevedoring Manager)</td>
<td>Quarantine procedures in relation to the new inspection procedures of AQIS and not enough staff to handle products or shipment inspections are problems that we experienced at this terminal (Freight Forwarding Manager)</td>
</tr>
<tr>
<td>In relation to customs, the overbrengen yard (the temporary inspection area) is insufficient (Distribution Manager)</td>
<td>Quarantine checks may create major impacts to the process of transporting wheat to Indonesia (Wheat Pools Manager)</td>
</tr>
<tr>
<td>The combination of customs operations and export clearance from the Trade Department of Indonesia may contribute to the additional time that ships wait at port (Port Manager).</td>
<td>What we see here, the number of quarantine officer is not sufficient to do the checking procedures efficiently (Port Manager)</td>
</tr>
</tbody>
</table>

Source: Author
Further, 73.3 per cent of senior managers considered the lack of skills of port workers (stevedoring companies) as factors generating disputes, while the remaining 26.7 per cent mentioned contractual disputes at terminals (see Appendix G section AH). These two factors lead to incidents and the potential consequences of low handling performances as reflected by slow productivity at the port or wheat terminal. The impact of unskilled port workers is evident in the words of the following respondents:

*The lack of skills of port workers may contribute significantly to the low handling rate at port and the interruptions of handling operations will probably happen if the availability of berths here is limited.*
- Land Transporter in Indonesia

*Disputes between trade (purchasing) agencies and shipping companies are actually the dominant disputes in the maritime chain. The impact of this was quite serious as delays and alterations of plans came out through this practice.*
- Millers/Distributors in Australia

### 5.3.2.5 Environmental related factors

The impact of environmental factors such as severe weather including strong winds, and high wave levels was confirmed by 73.3 per cent respondents (see Appendix G section P) as natural factors causing stoppages and losses of service platform in the maritime leg of wheat supply chains particularly at both ports and wheat terminals. In addition, earthquakes were confirmed by five Indonesian respondents (14.7 per cent of total respondents) as occurring recurrently in Indonesia in the period 2008-2009. These two factors (severe weather and earthquakes) are evident in the following comments of five respondents:

*The policy to temporarily close the local ports has contributed to delays in wheat and flour distribution to domestic distribution centres and markets in Indonesia.*
- Shipping Manager in Indonesia

*Weather is a natural risk factor that frequently creates disturbances for handling ships at ports.*
- Port Manager in Indonesia

*Severe wave levels and navigational warnings by the harbour master have disrupted our short sea shipping service particularly on main basic commodities such as rice, flour, and others.*
- Shipping Manager in Indonesia
Topping up our inventory level in our regional warehouses in Sumatera is a strategy we applied as the consequence of several earthquakes there sometime ago.

- Distribution Manager in Indonesia

When the earthquake occurred in our port, some areas of port infrastructure were damaged such as the access road to port, damage of our grain unloader unit as well as the storage buildings and consequently interrupted our port services for one month.

- Port Branch Manager in Indonesia

Subsidiary question one (SRQ1) of this study, as explained in Chapter One, asked whether shippers and consignees in the wheat supply chain are fully aware that disruptions occur in the maritime leg of the wheat supply chain? This question has been addressed by the above findings in this section.

5.3.3 Interdependent factors

Interdependent factors incorporate two dynamic issues that exist as operational risks propagating along the supply chain process, namely (i) access to loaders and (ii) collective risks. In order words, these two factors are risks that emerge due to the interactions of entities in the supply chain (as shown in Figure 5.3.3). This section discusses points under the two dynamic issues.

There are three aspects under the factor of access to loaders which are competition, terminal selection, and service preference (as listed in Figure 5-2). Competition is a commercial risk factor that has emerged within the wheat supply chain particularly with regard to having easy access to grain terminals and shipping services especially dry bulk and containerised shipping, both for international routes (from various Australian sources to Indonesia) and domestic Indonesian shipping, mainly inter-island and ferry shipping. This issue is evident in the words of one respondent:

Access to vessels between the grain and mining industries also contributes to the shortage of vessels. The bulk vessels issue revolves around the expanding mining trade as well. So competition,... again the issues of competition in terms of how I get access to bulk vessels.

- Port Manager in Australia
A more dominant position controlling the selection of terminal and ships held by the individual along the wheat supply chain played an important part in determining the power of the individual regarding accessibility to loaders. As one respondent commented:

*Access to loaders between small and big wheat traders may generate problems in maritime operations. The question is about how they allocate grain (wheat) to the belts for loading to vessels when they are giving priority to their own or other exporters.*

- Port Manager in Australia

In this situation, it was in the context of a bigger business scale being prioritised in the arrival sequence of wheat cargo rather than a small scale company viewed as being less significant due to having small parcels of wheat to transport. The small scale company had less influence in controlling the access to loaders and unloaders or as a wheat CEO in Australia stated “the important factor is the guarantee of shipment as shipping companies prioritise their own group or business partners first”. The preference of the shipping companies leads to a monopoly issue as reported by one respondent “the monopoly of wheat collectors may also create problems with the port operations in Australia” (General Manager of Freight Council in Australia). Consequently, as commented by one respondent “the bigger the company the more surety it has in its grain supply chain” (Port Manager in Australia). In addition, it was stated that the competition between the grain and mining industries in controlling dry bulk ships has contributed to the shortage of dry bulk fleets particularly in the global credit crisis during 2008-2009.
The other disruption risks that may exist are collective risks. These risks occur as an accumulated risk along the supply chain processes and thus amplify from one entity to the next. Events such as propagating risks (transferring risks), changes in supply chain performances, and limited coordination among entities are typical risks under this definition. However, from the survey, the measurement of risk attitudes and the impact of different levels of propagation risk on maritime services of the Australian-Indonesian wheat supply chain are considered as interrelated risks in the supply chain by 55.8 per cent of respondents (see Appendix G section AE). The factors of interrelated risks are evident in the following comment of one respondent:

*Again...port congestion, inefficient rail capability and insufficient empties in Australia may lessen the competitiveness of Australian wheat to the Asian market. Those are interrelated risks for the Australian wheat industry.*

- Grain Distribution Manager in Australia

According to respondents, the effect of maritime disruptions implies a primary consequence concerning supply chain performance (this might be a delay or even the voiding of a shipment contract) as related by one respondent who stated:

*Disruption at a port can affect the whole supply chain performance in terms of lead-time, when a container or a pack is unloaded at port can impact the contract of transport. So, if there is a delay in shipping and goods are not received on time then it would make the contract void.*

- Supply Chain Manager in Australia

### 5.3.4 Leadership factors

An essential point of maritime disruption risk is that the effective outcome of risk mitigations relies on the interaction and risk perception of the decision maker in identifying, preparing for, and responding to various disruptive risks. When interacting with the risk-related situation, 90.0 per cent of respondents (see Appendix G section AD) indicated that the lack of information and collaboration in managing supply chain risk were important factors that may influence the effectiveness of the decision making process when risks occur. Moreover, through the survey it was also found that senior managers were reluctant to make independent decisions. They indicated that decision making needed to be monitored or assessed, and confirmed the notion that all risk related decisions need to follow standardised guidelines. This was discussed in the words of one respondent:
...there is a lot of quality and risk documentation here. There are a lot of documents in our office in relation to commerce, safety, and security. So quite often I am thinking and getting confused about various risk matters as I’m not sure whether the guideline I referred to was correct. Therefore, frequently I would call a special meeting to gain information and inputs from other senior managers.

- Port Branch Manager in Indonesia

More specifically, this means that the probability of a disruption consequence being lower is proportional to the acquired skills of the decision maker being applied in mitigating various disruptions in the wheat supply chain. Clearly, the outcome of disruption mitigation plans may be completely different for two decision makers handling the same kind of disruptive event at the same point along the wheat supply chain if one senior manager has more experience and detailed risk perceptions, including sufficient information on the selected wheat supply chain rather than the other senior manager who does not have any experiences handling disruptions at all. One respondent commented that “as we become more experienced in making decisions the risk assessment process we implemented when severe disturbances occurred may result in low consequences than it was estimated before” (Distribution Manager in Indonesia).

In addition, in relation to the need of information to support operational judgement, one respondent stated that “we decided to top up our wheat product at certain ports or terminals due to information we got from our partners, either carriers or sellers” (Grain Supply Manager in Australia).

It was also suggested that the business specialisation of entities impacted on decisions that senior managers were willing to make independently. Areas of each entity, such as services in the area before or after the maritime leg or in the upstream or downstream sectors, were identified as areas where each senior manager felt comfortable making decisions. The concern was also expressed that specialisation by each entity contributes to the effectiveness of risk management when maritime disruptions occur in the wheat supply chain. One respondent discussed that:

..I’m really pleased to see that we are connected in the chain with a variety of expertise. But in reality it is quite difficult for all entities to make a decision at the chain level. What we can do is to make an assessment within our area unless we have a wide role in the chain, such as third party logistics that may control some dominant part of the wheat chain.

- Mill Manager in Australia
In relation to leadership risk, senior managers of entities in the wheat supply chain may have a direct effect on the likelihood of certain maritime disruption consequences in an uncertain environment. Hence, it is essential for senior managers in managing disruptions to distinguish between risk cultures and objectively measurable parameters (such as costs and time parameters) when facing various maritime disruptions. The survey found that effective measurable resolutions with low probabilities of negative consequences are related to wide collaborations of one entity with others including close collaboration within the supply chain community thus avoiding various disruptive events. Effective collaboration can be influenced by resources (such as budget, facility, and risk education) allocated by the decision makers when unpredictable conditions happen. Thus, mitigation actions of a particular senior manager have an impact on the probability distribution of the consequences of each disruption.

5.3.5 Progressive factors

Risk perception concerning maritime disruptions was explored in the context of events generating delays, deviations, stoppages and losses of service platform consequences during the process of wheat transport along the wheat supply chain. The survey provided detailed insight into events that impacted the flow of wheat transport in maritime services such as at port or during shipping or inland operations. From a total of 34 respondents surveyed, 88 per cent (see Appendix G section G) confirmed that maritime disruptive events occurred in their wheat supply chain whilst three per cent stated that disruptive events occurred within tolerable limits and nine per cent declared that disruptive events did not occur at all in their wheat supply chain. Important disruption susceptible operations such as port and shipping operations were confirmed by respondents as the primary maritime disruption events in the Australian and Indonesian wheat supply chain.

There was a sufficient indication to confirm that maritime disruptions were a recurrent problem in the wheat supply chain. For example, one respondent in Indonesia who was clearly frustrated with the disruptions confirmed that 17 events given in the telephone interview have occurred in the respondent’s supply chain and the number of
occurrences has increased in the period 2007 to 2009. The occurrences of maritime disruptions are evident in the following comments:

Almost all the (disruption) risks you mentioned have occurred here.
- Port Branch Manager in Indonesia

I think maritime disruptions are really a major issue for Indonesian logistics nowadays.
- Ship Owner in Indonesia

Domestic distribution within Indonesia may be the victim worst affected by maritime disruptions in Indonesia.
- Port Branch Manager in Indonesia

All respondents in the survey were questioned regarding operational risks during the period 2007-2009 and 54.8 per cent of respondents confirmed that delays occurred in the wheat trade especially in the maritime leg (see Appendix G section R). The remaining 45.2 per cent of the total respondents stated that deviations, stoppages, and services being unavailable have occurred in wheat their supply chain.

The disruptive events in terms of delay, deviation, stoppage, and loss of service platform were explained in the comments of two respondents:

The period 2007-2009, was the toughest time for the wheat business in Australia and Indonesia as a variety of factors such as drought, the global credit crisis, the change of the role of the AWB in Australia, and a significant increase of wheat crops in Australia have influenced the maritime operations of wheat commodities. We often revise our shipping schedule and reroute the cargo from one port to others.
- Shipping Operation Manager in Australia

...around 20% of our facilities especially for grain products were destroyed and 60% of port services in general were interrupted when we had that earthquake.
- Port General Manager in Indonesia

In contrast, maritime disruptions were viewed as a minor risk event along the wheat chains of two respondents who considered that they did not create a significant effect on their chain. Two respondents commented that:

Maritime risks (disruptions) exist but are probably not the biggest risk. The delay and deviation of schedules and operations are still tolerable.
- Logistics Manager in Australia
Maritime disturbances created low impact to supply chains.

- Port Manager in Australia

Furthermore, the instigating, inter-dependent and decision risks factors of the maritime leg contribute to the disruption events in the wheat trade between Australia and Indonesia. These findings partially address the primary research question (PRQ) of this study. Two major situations as consequences of maritime disruptions are changes, and unpredictable conditions in the wheat supply chain. To explain the wide scope of maritime disruptions, a comprehensive framework of disruptive events is depicted in Figure 5-3.

![Figure 5-3. The analytical framework of maritime disruptions](source)

Source: Author

Various unwanted internal and external factors creating uncertainty and severe negative consequences in the maritime leg can be defined as maritime disruption risks. The four
significant aspects of (a) instigating factors, (b) inter-dependent factors, (c) leadership risks, and (d) progressive factors are fundamental items that may contribute to the occurrence of maritime disruptions in the wheat supply chain, each of which are discussed below.

5.4 Descriptive data on maritime disruptions

Senior managers were asked a number of question (see appendix A: sections C1, D3, E1, F2, and F3) to determine whether maritime disruptions in the Australian-Indonesian wheat supply chain reflected the descriptions prescribed by the studies discussed in the literature review chapter. Respondents were asked to provide (i) an estimation of the frequency rate of maritime disruptive events; (ii) the consequences of previous disruptive events, and (iii) the probability index of future occurrences. The purpose was to seek data that may assist in developing a framework summary of maritime disruptions.

5.4.1 Frequency of maritime disruptive events

Each respondent was asked to provide information regarding the frequency of 20 given potential maritime disruptive events in the period of 2007-2009 (see Appendix A: section C1). Table 5-9 shows the frequencies of maritime disruptive events both in Australia and Indonesia in detail. In the Australian section of the supply chain, security threats, riot or wars due political events, earthquake and tsunami did not occur during 2007-2009.

As port strikes, severe weather, electrical outages, equipment breakdown and problems of inland transports occurred once a year, they are categorised at the level of low frequency. Further, events such as unavailability of rail services, long customs and quarantine processes, insufficient empty containers, port congestion and shipping port disputes, occurred on average once in three months.
Table 5-9. Frequencies of maritime disruptions

<table>
<thead>
<tr>
<th>Location</th>
<th>Never</th>
<th>Once a year</th>
<th>Once in three months</th>
<th>Once a month</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Australia</strong></td>
<td>Security threat</td>
<td>Port strikes</td>
<td>Rail services</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Riots/wars</td>
<td>Severe weathers</td>
<td>Long customs and quarantine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Earthquakes</td>
<td>Electrical outages</td>
<td>Insufficient empty container</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tsunami</td>
<td>Equipment breakdown</td>
<td>Port congestion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Communication failures</td>
<td>Ship accidents</td>
<td>Port and shipping disputes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uncertain fuel cost</td>
<td>Shortage of bulkers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Problems of inland transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Indonesia</strong></td>
<td>Uncertain fuel cost</td>
<td>Security threat</td>
<td>Rail services</td>
<td>Long customs and quarantine</td>
</tr>
<tr>
<td></td>
<td>Communication failures</td>
<td>Riots/wars</td>
<td>Equipment breakdown</td>
<td>Severe weathers</td>
</tr>
<tr>
<td></td>
<td>Tsunami</td>
<td>Port strikes</td>
<td>Ship accidents</td>
<td>Port congestion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earthquakes</td>
<td>Shortage of bulkers</td>
<td>Problems of inland transport</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Insufficient empty containers</td>
<td>The cleanliness checking</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electrical outages</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Port and shipping disputes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shortage of shipping services</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Appendix G section N

In Indonesia, the frequency of various maritime disruptive events that occur along the wheat supply chain is relatively higher and more varied. The event of electrical outages did not occur during 2007-2009. In contrast, four disruptive events such as long customs and quarantine, severe weather conditions, port congestion, and problems with inland accessibility occurred on average once in a month. The lack of rail facilities, equipment break-downs, ship accidents, cleanliness checking, and shortage of dry bulk ships were events that occurred once in three months. The other remaining ten events occurred once a year on average. These frequency levels experienced by the senior managers during 2007-2009 provide strong evidence suggesting that the maritime leg was becoming more involved in affecting the performance of the wheat supply chain, but not in the short term in Australia.

5.4.2 The operational impact of maritime disruptive events

The disruption consequences propagate upstream and downstream along the wheat supply chain. The concerns of growers (farmers) and consumers were confirmed in
terms of demurrage costs, higher level of transport costs and time problems that were included as additional costs for farmers and final consumers (especially for noodle makers and the flour consumers in Indonesia). The propagation issue was discussed in the words of three respondents:

*In the past, demurrage was a cost that was passed on to the AWB, but now the ship loading costs are transferred along the chain or to every participant, including the growers. So, as part of their business, demurrage now is fully paid by the growers.*

- Supply Chain Manager

*I would think that particularly the supply chain blockages that are on the Australian side would apply to whatever market we send out the product to. So supply blockages in Australia apply to both chains (up and downstream).*

- Distributors/Millers

*Of course, consumers in rural areas and on smaller islands are groups that suffer much from the maritime disruptions that happen along the wheat chain especially for our noodles and flour consumers who are mainly located in the remote islands of Indonesia.*

- Mill Manager

In terms of propagating stages of disruptions, the impact of maritime disruption is transferred in the chain involving a number of events for the entities along the wheat supply chain. Each event represents a direct (or an indirect) threat to every other entity in the supply chain area (upstream or downstream). One respondent confirmed the impacts by explaining that:

*We as port operators realised that due to this equipment breakdown carriers and shippers have suffered valuable losses in terms of demurrage, more transport costs, higher inventory time and costs, delays to their production processes, and finally the distribution costs to their customers. The consequences were beyond our expectation. But we had established and discussed this matter with our users and maritime entities to minimise direct and indirect impacts to the higher commodity price of flour for home buyers of flour for noodles makers as reported before.*

- Port Branch Manager

Thus, as all the links in a chain are connected, the total supply chain performance (in terms of price differences and additional lead times experienced by buyers and sellers in the Australian-Indonesian wheat supply chain) confirms the extent of the consequences
in terms of geographical propagation, price differentiation and operational time effects of maritime disruptions. In relation to the consequences, three respondents provided comments that:

Maritime disruptions created higher distribution costs and transferred them as an extra cost to consumers, specifically final consumers.

- Distribution Manager

Despite supply guarantee and the price level of wheat fluctuating during these two years, disturbances, delays, and interruption in shipping operations have been occasions that push the supply chain costs up from usual.

- Millers/Distributors

But, we can’t easily raise the flour price due to higher freight levels or problems in the maritime operations because of the low buying power of consumers, particularly in Indonesian rural areas. So basically we are the ones who may have to rationalise our costs of production.

- Miller Manager

Operational impact is other evidence of maritime disruptions in the wheat supply chain. Table 5-10 shows two main operational impacts of disruptive events at a port.

Table 5-10. The profile of causes of port congestion and their impacts

<table>
<thead>
<tr>
<th>Reduced port operations</th>
<th>Stoppages of port services</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delays</strong></td>
<td><strong>Deviations</strong></td>
</tr>
<tr>
<td>Ship waiting in anchoring area</td>
<td>Ship collisions</td>
</tr>
<tr>
<td>Port state inspections</td>
<td>Hazardous spill</td>
</tr>
<tr>
<td>Low tide period</td>
<td>Port strikes</td>
</tr>
<tr>
<td>Severe waves</td>
<td>Crane disabled</td>
</tr>
<tr>
<td>Strong winds</td>
<td>Straddle disabled</td>
</tr>
<tr>
<td>Lack of pilotage services</td>
<td>Shortage of choppers</td>
</tr>
<tr>
<td>Fire accidents on a ship while at port</td>
<td>Insufficient unloading equipment</td>
</tr>
<tr>
<td>Failure of water provision</td>
<td>Insufficient empty containers</td>
</tr>
<tr>
<td>Heavy rain</td>
<td>Failure of information system</td>
</tr>
<tr>
<td>Cleanliness of wheat product</td>
<td>Shortage of storage area</td>
</tr>
<tr>
<td>Custom clearance</td>
<td>Insufficient container yard</td>
</tr>
<tr>
<td>Delay of immigration process</td>
<td>Clearance of quarantine check</td>
</tr>
<tr>
<td>Inland congestion</td>
<td>Insufficient road access to and</td>
</tr>
<tr>
<td></td>
<td>from port</td>
</tr>
<tr>
<td></td>
<td>Transport contractual disputes</td>
</tr>
</tbody>
</table>

Source: Appendix G section AF.
Regarding the operational impact, respondents indicate that 31 possible maritime event disruptions are becoming more prevalent particularly in a port area. Those 31 events comprise 20 events in the supply chain and another 11 events at a port. Three possible consequences examined were port stoppages, reduced port operations, and no impacts at all (or not applicable) as seen in questions H1 and H2 of the survey (see Appendix A).

In general, respondents indicate that maritime disruptions significantly reduce the level of port services (due to delays and deviations from planned operations), and stop port services (due to port closures and loss of port service platform). Events such as congestion (as 52 per cent of respondents reported), earthquakes (48 per cent), and severe weather (42 per cent) generated port closures. Moreover, 13 per cent of respondents (particularly those in Indonesia) experienced the loss of service platform of their ports due to earthquakes. There are 13 events that created delays and 14 events that generated deviations at ports. Those findings are consistent with previous discussions where individual maritime disruptions were correlated with short-term consequences (such as delays and deviation) and extensive unavailability of port services with a long-term orientation (Vanags 2002; Bearing-Point & Hewlett-Packard 2005; Pinto & Wayne 2006; Pettitt 2007; Garcia 2008; Guerrero et al. 2008; Gurning & Cahoon 2009).

To compare overall responses, t-tests with p, and mean values are used to test the independence of the overall response rate when possible disruption events occurred. The null hypothesis for overall response rate (R), where Ho: $R_{\text{Australia}} \neq R_{\text{Indonesia}}$ (significantly different), with the alternative being they are not different where Ho: $R_{\text{Australia}} = R_{\text{Indonesia}}$. Statistical results from the t-tests method shown in Table 5-11 demonstrate that some entities in the wheat supply chain such as collectors (pools), millers, and third party logistics were more important than others in controlling supply chain risks, such as supply volumes and transport availability. Considering that all stages in the chain have an equal probability risk in creating maritime disruptions including the wheat retailer’s prices, there are statistically significant differences between the main risk performance of similar entities in Australia and Indonesia regarding maritime disruptive events ($p = 0.04$ and $p = 0.043$).
Table 5-11. The results of t-tests for the impacts of maritime disruptions

<table>
<thead>
<tr>
<th>The impacts of maritime disruptions</th>
<th>t-stat</th>
<th>P two tail</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>All stages along the chain have an equal risk probabilities in creating maritime disruptions</td>
<td>0.985</td>
<td>0.040*</td>
<td>4.9/Agree</td>
</tr>
<tr>
<td>Inability of your company to fulfil its wheat supply chain performance create maritime disruptions for company further down the supply chain</td>
<td>1.527</td>
<td>0.202</td>
<td>4.9/Agree</td>
</tr>
<tr>
<td>The maritime disruptions affect the wheat retailers’ prices</td>
<td>2.915</td>
<td>0.043*</td>
<td>4.4/Agree</td>
</tr>
<tr>
<td>Stages prior to maritime service (such as handlers) may initiate maritime disruptions</td>
<td>2.776</td>
<td>0.080*</td>
<td>4.1/Agree</td>
</tr>
<tr>
<td>All stages along the chain have an equal risk probability to suffer from maritime disruptions</td>
<td>2.979</td>
<td>0.041*</td>
<td>3.3/Unsure</td>
</tr>
</tbody>
</table>

Note: * there is a significant difference between respondents in Australia and Indonesia
Source: Appendix G section AE

This is mainly because Australian entities are more concerned about international wheat transport processes compared to entities in Indonesia that are involved with inter-island or local distribution processes. Moreover, the fundamental shift to a deregulation of the wheat business in Australia after the era of the AWB means that risks, including shipping transport or maritime services may be allocated equally to all entities in the wheat industry by sharing the additional costs to players both downstream and upstream along the chain. In relation to supply chain performance, the respondents also agree that the inability of their entity to fulfil its service may create disruptions further down the supply chain compounding the consequences (t = 1.527, mean = 4.9). On the other hand, as indicated by the associated insignificant difference level (p = 0.202), Australian and Indonesian respondents note an important similarity in relation to the impact of their organisations to other entities further down the supply chain. Entities in Indonesia do not expect sellers or millers in Australia to plan cancellations or deviations of their supply volumes as agreed in their business or shipment contracts. On these particular issues, wheat sellers such as farmers or millers in Australia should match their perceived performance of wheat pools and third party logistics to the expectations of their Indonesian partners. Thus, senior managers in Australia agreed that the role of third party logistics may reduce the problem of supply uncertainty in the process of flour production in Indonesia. It was also found that respondents were unsure whether
all stages along the chain have an equal probabilistic risk level due to maritime disruptions (mean = 3.3 / unsure). This directly indicates that there is a difference in the risk probability level that all entities have when maritime disruptions occur. Entities in both Australia and Indonesia confirmed this as a significant difference was found in the p value (p = 0.041 which is less than 0.1). This means respondents agree that maritime disruptions affect the wheat retailers’ prices (with different level of prices), especially for the market in Indonesia.

5.4.3 The consequence value of maritime disruptive events

The predicted consequence values of maritime disruptive events from respondents through this research survey are presented in Figure 5-4. From the 34 respondents, 30 responses confirmed the previous results of maritime disruptive events from the period of 2007-2009 (see Appendix G section P). The descriptive statistics provide a starting point for the interpretation of the consequences of maritime disruptive events. As the data was interval scaled, the measures of central tendency (mean and standard deviation) are reported for 17 maritime disruptive events (see Appendix G section AG).

![Figure 5-4. Ranking of consequences of maritime disruptions (in $A)](source: Appendix G section P)
From the survey data, it can be summarised that the distribution of each maritime disruptive event has a relatively accepted range of standard deviation level (less than 10 per cent) based on the maximum and minimum value of each risk event data. Similar to this, the disruption research of Elkins et al. (2008), MacDonald (2008) and McCormack (2008) in measuring the impact costs of disruptions along the supply chain of manufactured products may have a wide range of standard deviation value due to the variety of cases which occurred.

The other possibility is that the majority of research respondents, including those from this maritime disruption research, were unable to provide an accurate value of the impact costs or of the financial impact to their organisation as a consequence of a maritime disruption. However, when the level of consequences was given through response cards, then respondents predominantly were able to estimate the total costs that they had to spend for maritime disruptions that had occurred previously. There were only three respondents willing to provide information regarding the real level of costs associated with maritime disruptions due to related risk reports being available when the interviews were conducted.

Respondents indicated and estimated that three maritime disruptive events namely earthquakes, equipment breakdown, and port congestion were events with the highest consequences in terms of costs to be compensated both for anticipating and recovering from these events. This is due to the relatively large scale of investment needed (at about $A1.1 million for earthquakes in Indonesia, $A0.80 million for equipment breakdown in Australia and $A0.650 million for port congestion in Indonesia) either to totally rebuild or revitalise the slow performance of pilot services, storage services in grain terminals or silos and warehouse facilities, as well as insufficient berth capacity at terminals.

Telecommunication failures and lengthy customs and quarantine processes were considered by respondents as the lowest maritime disruptive events and had minimal financial impacts (at $A115,000 for telecommunication failures and $A135,000 for lengthy customs and quarantine process) in terms of delaying the flow of wheat through
ports. These delays were tolerable for both shippers and consignees in the wheat supply chain between Australia and Indonesia.

5.4.5 Probability level of maritime disruptive events

The predictive probability level was collected from respondents through research question D3 (see Appendix A). Of the 34 respondents, there were 30 responses that provided a prediction of future maritime disruptive events (see Appendix G section S). The descriptive statistics provide a starting point for the interpretation of these probabilities of maritime disruptive events (as applied in Gaonkar & Viswanadham 2007; Handfield et al. 2008).

Respondents suggested three maritime disruptive events have a high future probability level of occurrence; port congestion (probability = 0.35) followed by equipment breakdowns (0.26) and insufficient rail facilities (0.23). However, the standard deviation values of the first and last events (as seen in Appendix G section AG) are relatively dispersed (20 per cent for port congestion and nine per cent for insufficient rail facilities).

The lowest risk probability with a risk value of two per cent in Indonesia is earthquakes, and political events (in Indonesia). Most of the respondents (83 per cent) experienced port congestion once in three months, both in Australia and Indonesia. Generally, respondents confirmed that port congestion is the event with an average probability of 35 per cent (in Indonesia).

The second most probable disruptive event is equipment breakdown, which is given a 26 per cent chance (in Indonesia) by the respondents of occurring in the future. In relation to the probability level of 13 major grain terminals in Australia and six main grain terminals in Indonesia, respondents indicate that three ports in Indonesia, namely Belawan (in Medan), Banjarmasin (in South Kalimantan) and Makassar (in South Sulawesi) as having a port risk index of less than ten per cent.
In Australia, there are nine ports mentioned as terminals with a risk probability level of less than ten per cent. In addition, ports or terminals with a risk probability level of less than ten per cent were regularly impacted on by operational delays in their services. Similar to this, ports rated by respondents with a probability index in the range of ten per cent to 25 per cent, were defined as terminals where delays and deviations of services in terms of scheduling and service capacity or through-put occurred repeatedly, such as in Kwinana, Albany and Esperance.

Further, grain terminals with a risk probability level more than 25 per cent and less than 50 per cent were considered by respondents as terminals with frequently occurring disruptions or interruptions. In these groups, the terminals in Priok (Jakarta), Perak (Surabaya) and Geraldton (WA) were mentioned. In addition, Tanjung Emas was predicted to have more than 50 per cent as its probability level as deviations occurred recurrently due to shortage of storage area, insufficient road access to the port, and a lengthy quarantine process.

For risk alleviation competency and risk evaluation of supply chains, the graph theory approach is applied (As per Faisal et al. 2006; Faisal et al. 2007). By applying this approach, the risk mitigation proficiency can be provided as single numerical values. This will help to compare and map maritime disruptions along the supply chains in these two dimensions namely financial consequence and probability. The use of graph theory can further be applied to model and analyse various types of risk management systems. Figure 5-5 provides the risk index analysis of the maritime disruptions in the wheat supply chain using a risk distribution matrix (Faisal et al. 2006; McCormack 2008).

The risk mapping in Figure 5-5 is constructed by plotting consequences of maritime disruptions versus the average risk probability of entities in the wheat supply chain. A visualisation was then created that categorises the impact by plotting consequences of maritime disruptions versus the average risk probability of entities in the wheat supply chain. A visualisation was then created that categorises the impact level of disruptive events as low, medium or high from the subjective assessment of respondents during the
telephone interview. The areas of the diagram are colour coded from green (low risk) to orange (high risk).

Figure 5-5. Graph of subjective disruption risk and consequences index
Source: Appendix G, section P and section S

Note:

**Low disruption risk events**

EQ: Electrical outages  
PE: Political events  
PS: Port strikes  
SA: Ship accidents  
SS: Shortage of shipping service  
ST: Security threats

**Medium disruption risk events**

EC: Empty container  
IA: Inland accessibility  
CQ: Lengthy customs process  
SDB: Shortage of dry bulks  
SD: Shipping disputes  
SW: Severe weather  
QRN: Quarantine process  
RF: Insufficient rail facilities

**High disruption risk events**

EA: Earthquake  
PC: Port congestion  
EB: Equipment breakdown

The high level of high disruption risk is identified on Figure 5-5 by a line connecting the points of 26 per cent of probability level and consequences at $A800,000, The medium level is formed by a line linking the probability of 15 per cent to 25 per cent and the consequences value ranging $A400,000 to below $A800,000. Lastly, the low disruption level is formed by the boundary line connecting any events with a probability lower than 15 percent and the consequences level less than $A400,000.
Figure 5-5 also enables the presentation of disruption risk profiles as a useful tool for prioritising and focusing on mitigation actions. The disruption risk should be considered as a tool to help prioritise and focus on mitigation actions.

5.4.6 The cycles of maritime disruptions

The output of a period analysis of maritime disruptions can provide a number of key values that recognises every stage of maritime disruptions from the phase of discovery to that of recovery. Accordingly, Handfield and McCormack (2008); Yu and Li (2004); Wu et al. (2007) further explain that understanding the critical components of disruption cycles can provide decision makers with the level of impact of a disruption and the approaches to dealing with it. Of interest is that, respondents continually referred to four main stages in maritime disruptions namely disruption discovery, initial recovery, intermediate recovery and final recovery stages rather than only one full recovery phase as suggested by Yu and Li (2004) and Handfield and McCormack (2008).

The survey obtained details of four major disruptive events as experienced by the respondents during the period of 2007-2009 namely congestion due to equipment breakdowns, port stoppages due to the influence of severe weather, disruption due to earthquake and disruption due to a shortage of dry bulk ships. However, all respondents in the survey contributed uniformly in providing information regarding the period of discovery and the recovery phase of the various disruptive events that they experienced in their wheat supply chain. The period duration of days and hours are used to measure the stage of discovery and the recovery interval of the different disruptive events.

5.4.6.1 General disruption process

Figure 5-6 below shows the general cycle of maritime disruptions as a finding of the maritime disruption survey. Fifty-three per cent of respondents suggested that they tend to discover various maritime disruptive events from somewhere along the supply chain seven days after the events have occurred. These events are usually discovered through shared information given to them by their business partners and agents. In addition, 52
per cent of respondents (see Appendix G section U, and V) stated that on average the maritime disruptive events added seven additional days to their lead times or service times. In terms of the time needed to return to their normal operational level (recovery), 18 per cent of respondents mentioned that they required about fourteen days after the disruption was discovered as an initial recovery phase to return to their limited operations.

Further, 27 per cent of respondents revealed that they required 15 days after the day of initial recovery to achieve partial normal operations (referred to as intermediate recovery) and three per cent needed about 90 days from the disruption to completely recover to their normal service operations (see Appendix G section V and X). Therefore, in general, maritime disruption in the wheat supply chain is a risk event which has a relatively long-term period of cycle from the stage of discovery to recovery.

5.4.6.2 Congestion due to equipment breakdown

Figure 5-7 details general cases of port congestion due to equipment breakdown that occurred in the operational area of respondents in Indonesia. The data was obtained through historical reports of the congestion cases of ten respondents. Analysis of the
data identified that the disruption, a breakdown of unloading or loading equipment, was initially indicated from a delay of port operations on the first day after the handling equipment partially failed. This further led to a deviation phase of the ports services (on the fifth day after the disruption happened) as unloading operations could not fulfil the operational contracts between stevedoring companies and shipping agents. By the 19th day, the capacity of the equipment was down to 70 per cent and consequently the main handling services of the ports were unavailable by the 22nd day.

![Diagram of port congestion due to handling equipment breakdown](image)

**Figure 5-7. Cases of port congestion due to handling equipment breakdown**

Source: Author

The port general managers ordered back-up equipment immediately; but it still took 15 to 16 days to get the back-up equipment on-site, set up and working. The respondents stated that the ports needed 38 days to initially recover to 50 per cent of normal operations, 72 days to achieve 70 per cent of normal port operations (intermediate recovery) and about 90 days to fully recover to normal operational level as they had to complete a retrofitting and replacement program of their broken unloading equipment.
5.4.6.3 Port stoppages due to weather factors

Figure 5-8 indicates the disruption cycle of port stoppages due to severe weather factors as explained by respondents particularly in Indonesia. This cycle is different from the other cases in that it was explained in an hourly-based period instead of day by day.

The cycle began with the operational delay discovered one to six hours after the severe weather occurred in the port of the respondents. Six hours after the start of the delay, the port managers found there was a significant deviation of port services. This notification was received from navigational warnings received by the port authorities from the Badan Meteorologi Klimatologi dan Geofisika (BMKG) of Indonesia, that ships and facilities at the port, including trucks, had to be shifted in order to avoid fatal injuries at the port.

Further, at the 24th hour, the majority of respondents in Indonesia stated that the port authorities closed their ports and consequently stopped operations of the ports along with those with changes in the weather by the 36th hour, the ports were initially opened

Figure 5-8. Cases of port stoppages due to severe weather
Source: Author
and recovered 30 per cent of their services; by the 48th hour the ports had recovered by 60 per cent and finally they had fully recovered by the 60th hour.

5.4.6.4 Disruption due to earthquake

Figure 5-9 denotes the cycle of cases of disruptions due to earthquakes as explained by particular respondents in Indonesia. One day after the earthquake destroyed a particular port, four port senior manager respondents indicated that 50 per cent to 60 per cent of the port facilities were damaged and dry bulk ships that were going to call at the ports had to reroute to other ports. On the 7th day, the port could not provide its main services as 70 per cent of their facilities were unavailable. After finding back-up supports, providing temporary facilities and new operational procedures, the port managed to recover with 30 per cent of the port facility ready for operation on the 50th to 62nd day. It took a further month until the 90th day for the port facility to be fully restored.

Figure 5-9. Cases of port disruptions due earthquakes
Source: Author

5.4.6.5 Disruptions due the shortage of dry bulk fleet

The cycle analysis of a disruption case due to dry bulk fleet shortage, as informed by respondents in both Australia and Indonesia in the period 2007-2008, is shown in
Figure 5-10. The figure indicates that the cycle started from the discovery of the shortage in the dry bulk fleet by supply chain partners on the 7th day after the disruptive events occurred. This event was driven by a rise in international bulk freight rates. Consequently, seven days later, significant delays in shipping operations were identified and experienced by shippers. In response, the respondents promptly decided to top up the wheat cargoes at the loading port while waiting for available ships to transport the cargoes to unloading ports assigned by buyers.

This response was followed by other immediate actions such as rerouting the cargoes to other nearby ports including revising shipping contracts with 3P/L (third party logistics) or 4P/L (fourth party logistics) partners. By implementing these actions, the respondents found that the initial recovery stage was achieved 50 days after the disruption occurred. Next, the intermediate recovery was attained 75 days after undertaking significant measures to change the transport mode from bulk to containerised shipment. Further, on the 80th day the full recovery stage was achieved after changing the unloading ports to those previously assigned by buyers.
The discussion of maritime disruption cycles experienced by respondents above may further partially address subsidiary question three (SRQ 3) of this study. The findings from the telephone interview may provide a general indication that existing mitigation responses applied by respondents were not efficient in terms of time required to manage maritime disruptions. This is due to taking seven days to discover the disruptive events and up to 90 days on average being needed to recover from the disruptions. Some new effective strategies are needed to shorten the cycle of maritime disruption which has occurred previously. The next section discusses how more insight into respondents’ views on responses and preparedness was gained as their previous mitigation strategies including various significant factors were required in the preparation of the mitigation strategies.

5.5 General maritime disruption management process

This section will discuss three responding steps namely detection, discovery, and recovery included in the maritime disruption management of senior managers in the wheat supply chain. The intention is to explore and assess how effective their responses when maritime disruptions occurred.

5.5.1 The detection period of maritime disruptive events

A major factor in determining the course of actions by entities in the supply chain disruption management (as suggested in Elkins et al. 2008) is the degree of understanding and detection of behaviours demonstrated when disruptions develop in the chain. Through the survey, it was confirmed that 54.8 per cent of respondents detected maritime disruptive events when significant delays happened in their own service operations (see Appendix G section R). Moreover, another 23.8 per cent of survey respondents stated that they had detected maritime disruptions when significant deviations occurred from previous plans, and 21.4 per cent of the remaining detected disruption when partial services of other stages along the wheat supply chain (before and after their location) were inactive. This result suggests the majority of respondents had the ability to detect the disruptions from the delay stage to the stages of deviation.
and stoppage of services and subsequently may control the impact of the maritime disruption. The quotation below gives one example of this indication:

*Delays are events that our team here in this operational division have to be aware of and respond to detect maritime disruptions as you mentioned as soon as possible, so the severe negative consequences mainly on our target and performance may be minimised to an acceptable level.*

- Port Manager in Indonesia

### 5.5.2 Approach to discovering maritime disruptive events

Of 34 respondents, 44.7 per cent rated their transactional relationship with other entities as being beneficial to them because of the significant information they receive in relation to various risks in the wheat supply chain (see Appendix G section M). Other large sources providing an indication on supply chain risks including for those events in maritime operations were news from findings within the organisation (23.4 per cent) and historical data or past experience (12.8 per cent).

Particular concerns about discovering disruptive events were information through operation problems (10.6 per cent) and from industrial association (8.5 per cent). These percentages suggest that the majority of the supply chain behaviours occur based on reactions to external events where strategies and decisions were exercised depending on the inputs of the partners in the wheat supply chain. These behaviours are quite unexpected whilst the ability of respondents to detect disruptions was generally accepted, it was surprising to realise that their reactions are dependent on external parties. Others indicated that reactions were executed based on the severe forms of maritime disruption that were prevalent in the supply chain. It means that the fundamental reactions of respondents in managing disruptions are based on how large the negative commercial impact would be on their organisation. This provides further support for the mitigation of maritime disruptions.

### 5.5.3 Maritime disruption recovery actions

At least two steps were confirmed in the recovery of maritime disruptions in the Australian-Indonesian wheat supply chain namely undertaking immediate action, and
revaluating emergency plans. Actions reported in the maritime disruption survey were coordinated actions with supply chain partners, establishment of an immediate replacement program for breakdown equipment, utilising back-up facilities, and allocating emergency funds to support various recovery actions.

Two important decisions mentioned in relation to the physical component or equipment by the majority of ports and shipping operators in implementing recovery actions were firstly to have equipment functioning as soon as possible and secondly to recover their service operations. In relation to actions taken to recover their handling services, two respondents explained that:

_Three things we took as our urgent actions at that time. Firstly, was to hire or to request similar equipment from our central office. Secondly, while waiting for the delivery of similar equipment, we tried to undertake retrofitting and replacement programs for our handling equipment such as cranes, conveyers and other lifting equipments as our high priority decision was to recover our handling system immediately._

- Terminal Manager in Indonesia

_When the earthquake occurred in our port, some areas of port infrastructure were damaged such as the access road to port, damage of our grain unloader unit as well as the storage buildings and consequently interrupted our port services for one month. Due to this we had to re-arrange our temporary service stage especially a new route to port and temporary storage areas and inform our grain shippers and consignees. And after two months, we started operating again._

- Port Branch Manager in Indonesia

The actions for each step and their positive outcomes will depend on the collaboration and support of maritime community entities. Due to this, respondents suggest that contingency plans at a port community scale or even for in an entire supply chain are required to significantly reduce the loss of users and stakeholders. One respondent confirmed this by arguing that:

_Collaboration with all port entities is a substantial endeavour. As the reason for our last port stoppage was due to natural forces, therefore port users were aware of this accident and understood about the situation. I also heard some complaints about our slow response in recovering from the situation on the first day after the earthquake. But later on in that day we received some support and inputs from shipping operators and dry bulk terminal operators from other companies to replace the damaged handling_
equipment. For roads that were exposed to high levels of damaged were rerouted to access road of our other partners in the same district. From this experience, I realised and should say that having and preparing a contingency plan for the entire port and maritime community together in the future is an essential initiative to be proposed for us here.

- Port Branch Manager in Indonesia

In addition, respondents re-evaluated their contingency plans but did not redesign the network and supply chain processes as suggested by the literature. Almost 28 per cent of respondents had experienced recovery actions along the chain as they had to deal with maritime disruptions starting from the time when the disruptions were detected until the time when recovery phase was completed. The majority of respondents experienced an understanding of re-evaluating the previous disruption risks by developing general incident cycles including estimating the consequences to benefit decision making when future disruptions occur.

A proactive decision making process by respondents in their companies based on a contingency plan was repeatedly used in relation to the risk management of various maritime disruptive events. Frequently this was still the case with decisions that were mostly not associated with a high degree of uncertainty. Three respondents supported this by commenting that:

*We always applied the contingency procedures set up by our mother company (central office) whenever operational risks occurred that partially or completely related to our negligence.*

- Port Manager in Indonesia

*Procedures of reporting, risk assessment based on risk matrix indicators, risk sharing responses, executing and monitoring processes were keys related to the risk actions that we performed.*

- Shipping Manager in Indonesia

*We estimate the potential consequences or losses that we could incur, provide some scenarios and discuss with the Board of Directors in terms of the best decision option that we can determine. ...but we sometimes were really unsure of taking that [certain action] on so on the one hand we are anxious that we didn’t have enough responsibility in decision making but on the other we actually, at every opportunity, we could get sorted it out.*

- Port Manager in Australia
When operational and commercial uncertainty along the wheat supply chain due to maritime disruptions occurred, there was also a reliance on others, particularly market agents, buyers, sellers and other related service users to provide considerations in the decision making process, particularly on the risk management process. For example, two respondents confirmed that:

*We decided to top up our wheat product at certain ports or terminals due to information we got from our partners either carriers or sellers.*

- Grain Supply Manager in Indonesia

*The decision to reroute the loading or unloading ports usually relied on information or input from our marketing agent or our sellers. Our shipping team will adjust their planning to the new shipment arrangement.*

- Supply Chain Manager in Indonesia

The need to comply with the established practices or guidelines for maritime disruptions was evident. However, consideration of how past experiences underpinned established contingency plans or guidelines was not well articulated and how practice applied to special maritime disruptive events was not routinely expressed in the risk management system of respondents. Two respondents discussed these common responses when delays or deviations occurred due to congestion problems:

*We used to deal with our customers when interruptions such as delays or disturbances due to congestion problems occurred at a certain port. But it was not really the standard risk protocol that we have been applying. The common procedure if we had such events was dealing with insurance or establishing better coordination with the port authority and operators.*

- Dry Shipping Manager in Indonesia

*As we become more experienced in making decisions, and we think what we are, is as part of our risk assessment….However, we found that coordination and flexible strategies were still essential decisions as we think that the probability of maritime risks was relatively low unless there is evidence that the prevalence of maritime disruptions is relatively high or something to worry about then we will formally include it in our contingency plan.*

- Distribution Manager in Australia

Through the general maritime disruption management process applied by respondents above, subsidiary research question two (SRQ2) of this study can be partially addressed and explored. The findings through the telephone survey are evidence that shippers and consignees in the wheat supply chain are applying supply chain risk
assessment as their mitigation strategies to minimise the maritime disruptions between Australia and Indonesia.

5.6 Strategies implemented in managing maritime disruptions

Not only does this study explore and descriptively measure maritime disruptions, it also attempts to measure the actual incidence of disruptive events. As the measurement instrument of risk combines the frequency, probability and actual consequences, the results tend to reflect the fact that the majority of respondents rated their interruptive events as more than mere disruptions. Thus, the process of disruptive events may be rated exclusively in the threat range from delay to the loss of service platform (disaster). However, the centralising tendency of a mean disguises the fact that some respondents actually reported their previous risk incidents as being inherently a process of maritime risk along one or more dimension of delays, deviations, stoppages and even disasters when no service platform is available. To investigate further, the strategies implemented in managing maritime disruptions are examined (as seen in Figure 5-11).

Figure 5-11. The structure of maritime disruption risk management
Source: Author

Figure 5-11 shows the structure of maritime disruption risk management found in the survey when various disruptive events occur. Despite the mitigation strategies, the following sub-sections discuss three other important strategies implemented by entities
in the wheat supply chain when a maritime disruption occurs, such as adaptation, coordination and intervention.

5.6.1 Mitigation strategies

The survey explored the issue of mitigating actions predominantly within the context of individuals or entities along the wheat supply chain using a maritime leg in their operations. By interviewing senior managers along the wheat supply chain, various problems and resolutions were reflected as empirical mitigation responses in three stages namely pre-disruption, disruption and post-disruption for 18 disruptive events in the maritime leg. In the pre-disruption stage, the existing mitigation strategy at this stage (as appears in Figure 5-12) identified that the dominant reactions of maritime users in the wheat supply chain were to apply contingency planning which principally consists of supply flexibility and insurance management (see Appendix G section AC). This is achieved through transferring risk or risk-sharing decision methods such as insurance plans (generally for marine cargo insurance) and outsourcing strategies.

Other entities along the chain may also apply reserved maritime routes, providing strategic stock (through agency service) and include providing back-up systems and optimum ordering policies in their contingency plans for responding to worst case scenarios of maritime disruptions. Those mitigations were taken especially when they have problems with the shortage of dry bulk ships in the market and port congestion problems particularly in some Australian grain terminals.

From the survey, it is found that 94 per cent of respondents (see Appendix G section AC) consider mitigation as factors that may reduce the occurrence level of maritime disruptions that may come one step after and before them in the wheat supply chain. To prevent the high occurrence of maritime disruptions occurring, contingency plans were raised by respondents as the basis to manage unwanted events of various maritime related operations in the pre-disruption stage.

One general manager of a port argued that “maintenance and replacement programs combined with our specific contingency plans such as provide back-up yard, port-trucks
“and handling equipment such as cranes are evidence in decreasing the probability of downtime due to equipment breakdown” (Terminal General Manager in Indonesia).

**Figure 5-12. Existing mitigation strategies of wheat supply chain from entities**
Source: Author

From Figure 5-12, contingency plans are used as a basis for further prepared adaptation responses such as insurance arrangement, various reserved routes, and supply flexibility actions. One respondent commented “implementing contingency plan and taking cargo insurance contract per unit cargo transported are quite common and effective measures we take to respond problems related to slow quarantine process” (Shipowner in Indonesia). Therefore in general, contingency response is a major mitigation action implemented by entities in managing maritime disruptions in the wheat supply chain.

The other important factor is how to get access to a loader. To have effective accessibility or control of a loader, entities in the chain find that three actions were
needed such as utilising their partner (agent) service to explore more supply points, apply optimum ordering policy, and arrange reserved routes. However, dominant purchasers of wheat in Indonesia decided to own their shipping fleet in order to have a certain level of transportation flow of wheat from Australia to Indonesia and domestically in Indonesia. This is similar in Australia where dominant wheat distributors and pools decided to provide their own shipping fleet or having a long term shipping contract with one dedicated shipping operator.

According to respondents, one effect of maritime disruptions in the wheat supply chain is a primary consequence for supply chain performance (this might be a delay or even a void of a shipment contract). In relation to anticipating the events of ship delay at the port and the distribution flow of wheat products (such as noodles and flour), some entities such as distributors and wholesalers provide a reserved warehouse at the port complex to guarantee back-up supply when disruptive events occur. For this reason, two respondents explained that:

*We provide a back-up warehouse to guarantee our storage capacity near to the unloading ports or grain terminal, it has successfully avoided the severe delay of our supply chain flow to our local distributors and retailers.*

*Supply Chain Manager in Australia*

*As you know that the serious congestion at severe major ports in Indonesia has forced us to establish our regional distribution centres in West, Central, and Eastern part of Indonesia in order to anticipate the interruptions of our distribution process that may reduce our competitiveness. This is one of our contingency responses due to maritime problems.*

*Distribution Manager in Indonesia*

Some entities that had experienced various disruptions in the maritime links perform a risk mapping activity in order to identify high critical nodes such as ports, grain terminals, shipping routes, and ships in their supply chain links in their previous supply chain flows. The risk mapping assists in having better visibility of the supply chain to prepare a contingency rerouting plan if delays, deviations and other stoppages occur in their supply chain process. In relation to this, for example, one respondent reported that:

*We used to have a risk map by which we can identify and estimate ports, terminals, routes, and even ships that we charter as critical nodes and links of our supply chain. By doing this, we may plan our rerouting plan in case we find problems with numerous maritime points.*
Out of the 34 respondents who were involved in the survey, 31 of them attributed their experiences to disruption mitigation. As a result, eight respondents (23.5 per cent of the total respondents) applied contingency plans combined with other strategies, which varied from insurance, flexible supply decisions to coordinating actions between entities in the supply chain (see Appendix G section AC). Table 5-12 describes quotations on contingency and other strategies implemented by senior managers.

Table 5-12. Combining a contingency plan with other strategies

<table>
<thead>
<tr>
<th>Viewpoints</th>
<th>Quotations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contingency plan and insurance</td>
<td>Implementing a contingency plan and arranging insurance contract for per unit cargo are strategies we use for risk sharing arrangement in maritime operations (Shipowner).</td>
</tr>
<tr>
<td>Contingency and risk matrix policy</td>
<td>What we do is to implement the contingency document and risk matrix policy from our mother company (Distribution Manager)</td>
</tr>
<tr>
<td>Contingency and supply flexibility</td>
<td>Make sure that a contingency plan, supply flexibility, and guarantee of supply are included in our purchase contract, and also insure all cargo as per marine cargo arrangements (Wheat CEO).</td>
</tr>
<tr>
<td></td>
<td>A contingency plan and supply flexibility strategies, I think are the resources available to prepare for the risks inherent in maritime operations (Supply Chain Manager).</td>
</tr>
<tr>
<td>Contingency, coordination and evaluation procedures</td>
<td>We always employ a contingency plan, coordination (good networking) and evaluation procedures especially for the working standard of our staff (Land Transporter Manager).</td>
</tr>
<tr>
<td></td>
<td>A contingency plan and coordination with operators and the community contributes to the low dust levels (Port Branch Manager).</td>
</tr>
<tr>
<td></td>
<td>A local port contingency plan and good coordination with port users (Regional Port Manager).</td>
</tr>
</tbody>
</table>

Source: Author
5.6.2 Adaptation strategies

In the disruption stage, adaptation strategies implemented by entities when maritime disruptions occur are inventory polling at ports, various changing of working practices, and applying the impact monitoring programs. Inventory pooling at ports is selected if problems such as the shortage of ships, the closure of unloading ports for various reasons, and the payment delay of cargoes in the country of buyers occur. The other essential strategies implemented as adaptation strategies on the disruption stage are to employ impact monitoring action. It is found that there are seven commercial impacts that entities in the wheat supply chain have experienced. These are discrepancies in maritime transport costs, loss of profit, poor business reputation, higher emergency costs, customers turning into other competitors, the decreased service tariff, and permanent stoppage of cargo delivery process (as shown in Appendix G section T). Entities in the survey then prepare their further adaptation responses to minimise these impacts. In many cases, adaptation strategies become a new consideration or input for the next mitigation strategies implemented when maritime disruptions occur in the future.

Changing to containerised shipment from grain transport is one important working practice as part of the adaptation responses to minimise the consequence level of maritime disruptions. Prior to changing the working practices, entities attempt first to employ impact monitoring evaluation and apply their contingency plans including inventory pooling, and get more accessibility to a loader. Other responses in relation to this include re-routing cargo flow, apply various business continuity plans (such as to utilise a flexible contract, short-term contract with wheat transporters including ship operators, joined shipment with other cargo owners in one consignment, use a swap cargo agreement, apply a price bridging clause in the trade contract, and chartering out the ships when the cargo levels make it difficult to reach the economics of scale of the ship).

Contingency rerouting was another typical response viewed by entities in the supply chain as a reserve plan when disruptive events occurred, involving changing the location of loading and unloading ports close to source and destination in the same
market. One respondent commented that “rerouting is a rational decision to avoid costly operations at port” (Grain Shipping Manager in Australia). This decision is related to the need for minimising the risk of waiting time, additional inventory costs and the potential consequences of cargo damage at port (particularly for containerised wheat cargo).

The limitations of various maritime infrastructures to anticipate the increasing growth of seaborne trade both in Australia and Indonesia have created disruptions in the wheat supply chain that impose rerouting their cargo from original plans. One respondent confirmed this by informing that “due to port problems both in Australia and Indonesia, we used to apply rerouting our loading and discharging ports. Rerouting is a rational decision to avoid costly operations at ports” (Grain Shipping Manager in Indonesia).

The strategy of flexible supply was also viewed as an important adaptation response with examples given of providing a flexible supply base of wheat to overcome various problems that may interrupt its transfer to the market such as drought, flood, and other natural factors. Three respondents confirmed the flexible supply strategy as an essential response in their words:

*Proper scheduling, flexible decisions, and adjustable supply base are strategies that we have applied so far if we found supply uncertainties due to drought in Australia for an example.*

- Distribution Manager in Australia

In addition, having an agreement of cargo swapping combined with price adjustments in order to maintain the guarantee of supply to buyers are also applied as adaptation strategies by wheat supply chain entities. One respondent, for example confirmed that:

*A cargo swapping agreement and price bridging are our strategic inventories actions to guarantee the supply to buyers. Consequently, we have to allocate several loading and unloading ports including inventory points to be decided when disturbances happen in the process of our business.*

- Dry Bulk Shipping Manager in Indonesia
Selecting loading ports as temporary inventory points were also other adaptation reactions applied according to the decision of wheat market agents in order to fulfil the supply contract from Australia to Indonesian buyers. This was known as inventory pooling at a port or buying port strategy. The following quotation confirmed the importance of inventory pooling at a port by one respondent:

_Altering the loading ports and assigning several inventory points were common decisions made on the instructions of our marketing agents. Following this, we also applied the inventory pooling or port buying action in order to consolidate our cargo at a certain terminal while waiting for the information about unloading ports from our buyers when disturbances occurred._

- _Mill Manager in Australia_

Providing immediate response when disruptions occurred at ports or grain terminals has been explained as a difficult adaptation reaction for many terminal managers, particularly when decision making should be provided immediately. To avoid any big losses or inaccuracies and misjudgements, respondents preferred to apply back-up support to facilities, particularly in anticipating urgent need of more capacity in the ports or terminals. The following two quotations were mentioned by two respondents during a discussion about back-up supports:

_Providing back-up service capacity at ports such as providing a reserved area especially for warehouse service was frequently requested by grain consignees when they have problems in their distribution chain._

- _Port Manager in Indonesia_

_To provide a back-up yard, stand-by port-trucks and handling equipment such as cranes are preferable rather than exploring possibilities and executing decisions when disruptions occur._

- _Port Branch Manager in Indonesia_

Supply flexibility and contingency plans were frequently applied by the majority of respondents in order to have a wide control of maritime access for loading terminals and unloading operations in a destination market. Further, another finding is that respondents developed an adaptation strategy for controlling and handling access involving the maintaining of acceptable logistical costs and a controllable wheat-marketing scheme. This applied to 18 per cent of respondents who insured international wheat cargo with marine cargo insurance companies.
At the disruption stage, it was found that 74 per cent of respondents had experienced significant active and flexible adaptation responses from port facilities and services (see Appendix G section AD). This was achieved by determining certain optimum costs including a specific level of wheat price based on the size and capacity of available ships and freight rates. Three main responses were identified by respondents such as inventory pooling at loading or unloading terminals, impact monitoring and also changing work practices for a temporary period when disruptive events occur. For the post disruption stage, in contrast to the literature, the current study found that actions to recover from disruptive events may include coordinated actions with supply chain partners, the application of an immediate maintenance program for equipment breakdown, utilising back-up facilities and allocating emergency funds to support various recovery actions.

5.6.3 Coordination strategies

Seeking coordination with other players in the wheat supply chain was seen as a way of managing various maritime disruptions and was also considered by respondents as a concrete effort to avoid the occurrence and minimise the consequences of maritime disruptive risks through collaborations in the wheat supply chain. In relation to the wide scale of the wheat supply chain, respondents (as shown in Appendix G section AD) indicated that coordination through effective and strong collaboration is one effective strategy to manage uncertainties in terms of maritime disruptions with other entities within the wheat supply chain networking.

Ninety per cent of respondents confirm this strategy with a major concern that the wheat supply chain including the maritime leg is a complex network in the supply chain. It is interesting to find that entities who always decide to reschedule the shipments have a strong correlation with the coordination strategies. This is because, coordination makes the decision of shipment rescheduling and rerouting able to be effectively implemented.

Table 5-13 shows comments by respondents considering coordination strategies in managing maritime disruptions, for example, these refer to collective actions of
managing problems between one entity and its partners both in downstream and upstream positions in the wheat supply chain.

Table 5-13. Coordination strategies implemented by respondents

<table>
<thead>
<tr>
<th>Coordination with:</th>
<th>Quotations</th>
</tr>
</thead>
<tbody>
<tr>
<td>User or direct customers</td>
<td>For our port, informal meeting (coordination) with users to respond to any maritime disturbances is really essential (Port Branch Manager).</td>
</tr>
<tr>
<td>Regional office</td>
<td>Coordination and agreed collective actions and support from our regional office (Stevedoring Manager).</td>
</tr>
<tr>
<td>3P/L or 4P/L</td>
<td>Coordinate and anticipate the numbers of LCL containers per B/L with companies or other storage areas are the solutions we are applying so far (Mill Manager).</td>
</tr>
<tr>
<td>Consignees</td>
<td>Coordination with consignees is essential especially in arranging and calculating the demurrage costs including the delay time needed to add to their flows (Shipping Manager).</td>
</tr>
</tbody>
</table>

Source: Author

Further, establishing coordinating links within the bulk operations including silo and millers were important for senior managers when managing maritime disruptions when disruptive events occur in the wheat supply chain. In relation to the coordinating links, one respondent argued that:

For bulk operations, coordination with silo operators will be the important action, while for the container it is the response to the imbalance of empty container availability at the Depot. An insurance package is applied both for cargo and third party (P&I club) arrangements.

- Shipping Manager in Indonesia

Coordination with the community, although not directly involved in the wheat supply chain, was mentioned by respondents as another mitigation response to prevent interruptive consequences in maritime operations. This mitigation action was particularly well articulated by port and terminal operators. One respondent described it as evident that productive coordination with the community contributed to their service performance levels due to positive participation and support by the community in the service operations of a port. The following quotation is the argument of that respondent who mentioned:
Long-term involvement with the community as corporate social responsibility as well as with port staff within our organisation and the port workers association have been a productive prime mover of our port in managing operational risks.

- Port Branch Manager in Australia

In addition, other environmental implications such as lower levels of pollution at a port was also confirmed as a result of better collaboration by one respondent who informed that:

Coordination with operators and the community contributes to the low levels of dust at our port.

- Port Business Development Manager in Australia

5.6.4 The intervention response

This study finds that the intervention response in the wheat supply chains is usually controlled by dominant agribusiness corporations in the chain rather than individual farmers. This finding confirms the argument of Trechter and Murray-Prior (2003) and Rubzen et al. (2005) that explained oligopolistic firms controlling various stages in the wheat supply chain both upstream (input suppliers) and downstream (food processors/manufacturers and retailers) are entities that farmers or growers have to deal with regarding their commodity especially for international trade.

The current study found that the structure of bargaining power in the wheat supply including the transportation process is controlled by 3P/L or 4P/L, wheat marketing bodies (such as Australian Wheat Board, and BULOG in Indonesia), and government agencies such as port authorities. Figure 5-13 shows the general roles and controlling power of 3P/L or 4P/L in dealing with the flow of wheat from Australia to Indonesia including the supply chain risk management of the chain as described through the telephone interviews.

Through the interviews it was found that there are third and fourth party logistics in the Australian-Indonesian wheat supply chain connecting and also controlling the bargaining power of loading accessibility to maritime operations. For example, one respondent confirmed that:
We really rely on the role of some export agencies. These agencies are the party that control and arrange the flow of our cargo from Australia to Indonesia including the transport or shipping process to load wheat from ports in Australia.

- Wheat CEO in Australia

![Figure 5-13. Existing supply chain entities controlling transport services](source: Author)

In addition, due to the insufficient maritime infrastructures in the wheat supply chain, wheat entities particularly producers and buyers rely on third party (3P/L) and fourth party (4P/L) logistics operators. However, 3P/L and 4P/L apply service preferences to their own business networks ahead of others. One respondent confirmed the dependency to 3P/L and 4P/L that:

> ....for our business here in Sulawesi, we rely on other parties for our inbound and outbound transportation links. Therefore, the important factor is the guarantee of shipment as shipping companies prioritise their own group or business partners first.

- Wheat CEO in Indonesia

Following the concerns already discussed, respondents related how these parties may have the roles of wheat collector, millers or the owner of pooling centres, export agencies, export authorities and wholesalers and they exist in both the Australian chain and the Indonesian chain. However, the majority of Indonesian wheat buyers, including...
large scale millers and distributors have their own shipping fleets to transport raw and manufactured wheat products from Australia to their domestic distribution centres in Java, Sumatera, Kalimantan and Sulawesi. This is different to entities in Australia where the 3P/L or 4P/L (who also act as millers and collectors) take the role of consolidators with their own shipping fleets.

In terms of their function in maritime operations, third party logistics have their own shipping fleets and control major grain terminals on each side of the market. Two respondents confirmed the strategy of owning dedicated shipping fleets by informing that:

In our case, the agencies decide the port of call and volume to load in one period. Sometimes, it is quite hard to get our schedule on time as we found that they frequently change the route of our ships. Their functions seem similar to the former AWB.

- Wheat CEO in Indonesia

We offer services for containerised shipment from Australia to Indonesia for raw wheat and vice versa with manufactured products of wheat to Australia. But, during these two years, we never had contracts with millers here (Indonesia) as they owned their own fleets but mainly dry bulk. We always had shipment contracts with third party logistics mainly from those in Australia. So the freight, additional shipping costs including risks of cargo and demurrage were arranged in our shipment contracts.

- Stevedoring Manager in Indonesia

In relation to channelling the markets in Australia and Indonesia, third party logistics in the wheat supply chain is connected with the fourth party logistics as marketing agent or wheat marketing bodies. A wheat CEO in Australia supported this response by explaining that:

In terms of the market channel, buyers in Indonesia are free to establish our business relationships not only through one single body like the AWB but sources may come through pooling centres, millers, collectors, or grower associations. On top of that, we still have to deal with several bigger players there which also control the supply chain process of the wheat from Australia. These companies are agencies who connect Australia distributors to us here. Or even, they are also the distributors and the buyers. So, once the cargo is unloaded in Indonesia, then we may control and monitor our chain here.
In order to be able to determine which dimensions are of critical importance to respondents in relation to 3P/L or 4P/L when arranging the wheat supply chain between sellers and buyers, a sample t-tests was conducted (refer to Table 5-14). As indicated by the sample t-tests statistics, respondents suggest that 3P/L or 4P/L are required to deal with variables related to five dimensions: the shipping contract including its risk, collaboration with the export agency, inland transport arrangements, and the selection of a terminal for loading and unloading, and shipping company selection. The most important one, according to respondents, relates to the provision of shipping arrangements including operational risks that may emerge along the supply chain.

**Table 5-14. T-tests for the role of the 3P/L or 4P/L**

<table>
<thead>
<tr>
<th>The role of third and fourth party logistics</th>
<th>t-stat</th>
<th>P two tail</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrange the shipping contract including its risks</td>
<td>-2.331</td>
<td>0.08*</td>
<td>4.9/Strongly agree</td>
</tr>
<tr>
<td>Consider and collaborate with the export agency</td>
<td>-1.759</td>
<td>0.153</td>
<td>4.6/Agree</td>
</tr>
<tr>
<td>Arrange the inland transport arrangements</td>
<td>-3.559</td>
<td>0.024*</td>
<td>4.3/Agree</td>
</tr>
<tr>
<td>Arrange the selection of loading/unloading ports</td>
<td>-2.484</td>
<td>0.068*</td>
<td>4.3/Agree</td>
</tr>
<tr>
<td>Select the shipping companies</td>
<td>-2.449</td>
<td>0.07*</td>
<td>4.2/Agree</td>
</tr>
<tr>
<td>Decide the selling price of raw wheat</td>
<td>-2.915</td>
<td>0.0043*</td>
<td>4.1/Agree</td>
</tr>
<tr>
<td>Decide the freight level of shipping arrangements</td>
<td>-3.302</td>
<td>0.03*</td>
<td>4.1/Unsure</td>
</tr>
</tbody>
</table>

Note: * there is a significant difference between respondents in Australia and Indonesia
Source: Appendix G section AB

The respondents’ views of export agencies (in arranging buy-sell agreements including shipping arrangements) emerged as another important dimension. Respondents’ evaluations about the role of 3P/L or 4P/L and its performance regarding market facilitation dimensions revealed that, on the whole, respondents were satisfied with the previous performance of the AWB. In relation to this, Indonesian respondents found that the function of this marketing and export agency provided a guaranteed supply to Indonesian buyers. Similarly, entities in Australia expected that the AWB would still perform its role in assessing and evaluating the performance of various export agencies, including factors related to maritime service risks such as demurrage, instability, higher
freight, and the availability of ships. Therefore, it appears, entities in both Australia and Indonesia have similar perceptions in favour of the export agency.

The role of a 3P/L or 4P/L in arranging inland transport operations is another important task that respondents expect to be provided. This is due to the many problems in inland transport stages such as insufficient rail and road facilities (particularly in Indonesia). In this regards, respondents in both Indonesia and Australia confirmed this with a significant p value in the t-tests (p = 0.024). In relation to selecting a shipping company including the selection of a terminal to load or to unload at, the respondents found that these are also necessary factors that the 3P/L or 4P/L should provide in dealing with transporting wheat commodities. However, there are a few different perspectives between entities in Australia and Indonesia in this regards (p = 0.068).

Unlike in Indonesia, competition and access to loaders and terminals are critical problems according to respondents in Australia, whilst in Indonesia, buyers including millers, collectors, and distributors have their own shipping fleets and grain terminals. It is also interesting to find that respondents agree that it is the role of 3P/L or 4P/L to decide the price of raw wheat when preparing buying and selling contracts. This comes as a result of the uncertainty of wheat prices due to various factors that both wheat supply chain entities in Australia and Indonesia have frequently come across, such as drought, higher unpredictable rising freight rates, unavailability of dry bulk ships and empty containers.

In contrast, freight is one substantial factor on which respondents in Australia and Indonesia were unable to give views with any level of conformity. In general, respondents did not want the shipping freight to impact their trade performance such as the profit they may obtain from the selling and buying contract. However, the majority of respondents expected that supply chain providers such as wheat marketing bodies (the AWB or WEA in Australia or BULOG) including 3P/L or 4P/L should cover the demurrage costs as the AWB did previously. In other words, respondents tend to be pragmatic in their evaluations in relation to this aspect in order to maintain their profits.
In relation to the intervention strategies, maritime authorities including port authorities (especially in Indonesia) have essential roles in managing maritime disruptions due to severe weather conditions. Normally maritime authorities received navigational warnings from maritime climate and meteorology offices. The maritime authority persistently applies deterrent actions including random checking of ships and cargoes ensuring the seaworthiness standards are fulfilled, particularly in relation to stability issues of the ships. This response was supported with active route observation, limiting the voyage of small vessels (wooden boat shipping commonly referred to as *pelayaran rakyat*) and the delivery of marine notices to prohibit the operations of inter-island shipping such as ferries, general cargo and dry bulk ships, wooden and fiberglass-made ships during the period of severe weather conditions. Further responses taken in this stage were continuous monitoring and active coordination with ship agency and inland transport operators such as hauliers or truck operators.

Whilst in the disruption stage, authorities mainly focused on proposing a broad business continuity reaction which employed three main responses such as closing ports (port stoppage), prohibiting ships to sail during severe weather situations, and minimizing the impact of congestion in the terminal, including the monitoring of implications of port and shipping services being terminated due to severe weather situations such as tropical cyclones. In the post disruptions phase, the current study found that actions to recover from disruptive events may include prioritising ships carrying nine basic commodities including wheat products for inter-island shipping operations and preventing unseaworthy ships from voyages until some modification has been undertaken.

### 5.7 The analysis of disruption management strategies

In this section, two main variables namely preference strategies and correlation factors are employed to assess the effective and efficient results of maritime mitigation responses. Preference strategies include twelve main important factors in managing maritime disruptions. For the correlation factor analysis, three major aspects are explored such as supply chain performance, market and operational impacts.
5.7.1 The preference strategies for managing maritime disruption

Based on the survey results, the common disruption management strategies taken by respondents are listed in Table 5-15 based on the preference of strategies that may be efficiently and effectively applied when maritime disruptions occur. In order to assess the effectiveness of the disruption management strategies applied, the univariate method was used to rank eleven common management responses which were important in the wheat supply chain in the range of six frequencies values (from six to one).

Table 5-15. The preference of mitigation responses

<table>
<thead>
<tr>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rescheduling the shipment process</td>
<td>Effective and strong coordination</td>
<td>Increase inventories at ports</td>
<td>Controlling product exposure</td>
</tr>
<tr>
<td></td>
<td>Flexible rerouting to other ports</td>
<td>Utilise supply networks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Employing supply incentives</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Real time decision support</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Redundancy system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Business continuity plan</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bottom up approach of mitigation plan</td>
<td></td>
</tr>
</tbody>
</table>

Source: Appendix G section AD.

As seen in Table 5-15, the most preferable response from managers is rescheduling the shipment process (adaptation strategy) as it is always applied, while an effective and strong coordination with other players in the wheat supply chain and flexible rerouting to other loading/unloading ports are two strategies that are often implemented by respondents as their managerial decisions. Some management responses included increasing inventories, utilising supply networks, supply incentives, real time decision support, business continuity plan, and a bottom up approach of disruption management planning are strategies that are sometimes applied. Controlling product exposure is one strategy that is never taken as a mitigation action when a maritime disruption occurs.

When interviewing respondents, it was noted that in general, there are some significant differences in the implementation of the 12 important factors (as shown in Table 5-16) when managing or responding to various disruptive events in the wheat supply chain. These factors are a contingency plan, flexible transport arrangements, International
Security for Port Security (ISPS) Code implementation, improving port capacity, the active efforts of customs and quarantine, a repositioning plan for empty containers, back up support for bunkering, and support for insufficient rail facilities. In relation to 12 factors assessed in Table 5-16, a contingency plan was the most preferred strategy \( (t = -1.372, \text{ and mean } = 4.9) \) with significantly different applications both in Australia and Indonesia \( (p = 0.0242) \).

**Table 5-16. Statistical t-tests for maritime operators in managing maritime disruptions**

<table>
<thead>
<tr>
<th>Factors to manage maritime disruption</th>
<th>t-stat</th>
<th>P two tail</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your organisation always uses a contingency plan</td>
<td>-1.732</td>
<td>0.242</td>
<td>4.9/Agree</td>
</tr>
<tr>
<td>A flexible transport arrangement in the wheat supply chain management</td>
<td>-1.647</td>
<td>0.175</td>
<td>4.7/Agree</td>
</tr>
<tr>
<td>ISPS Code reduces maritime security threats</td>
<td>-1.719</td>
<td>0.161</td>
<td>4.6/Agree</td>
</tr>
<tr>
<td>Improving port capacity is the best way to deal with port congestion</td>
<td>-1.324</td>
<td>0.256</td>
<td>4.6/Agree</td>
</tr>
<tr>
<td>Customs and quarantine agencies are inactive in reducing longer and costly processes</td>
<td>-2.201</td>
<td>0.093*</td>
<td>4.4/Agree</td>
</tr>
<tr>
<td>Your organisation prepared a pre-disaster plan for natural disasters that may impact your facilities</td>
<td>-3.096</td>
<td>0.036*</td>
<td>4.3/Agree</td>
</tr>
<tr>
<td>Your organisation is implementing a risk sharing plan with your business partners when disruptive events occur</td>
<td>-3.068</td>
<td>0.037*</td>
<td>4.3/Agree</td>
</tr>
<tr>
<td>Applying a good repositioning plan for empty containers</td>
<td>-2.202</td>
<td>0.092*</td>
<td>4.1/Agree</td>
</tr>
<tr>
<td>Your organisation is employing a backup system for bunkering supplies</td>
<td>-1.744</td>
<td>0.156</td>
<td>4.1/Agree</td>
</tr>
<tr>
<td>Your organisation is adopting a reliable maintenance and repair system</td>
<td>-3.508</td>
<td>0.025*</td>
<td>3.6/Unsure</td>
</tr>
<tr>
<td>Rail service supports your service appropriately</td>
<td>-1.909</td>
<td>0.129</td>
<td>2.9/Disagree</td>
</tr>
<tr>
<td>Labour strikes have occurred in your organisation</td>
<td>-3.608</td>
<td>0.037*</td>
<td>2.9/Disagree</td>
</tr>
</tbody>
</table>

Source: Appendix G section AC

Three operational strategies considered as similar important actions both in Australia and Indonesia were flexible transport arrangements \( (t= -1.647, \text{ p } = 0.175, \text{ and mean } = 4.7) \), ISPS Code implementation \( (t = -1.719, \text{ p } = 0.161, \text{ and mean } = 4.6) \), and improving
port capacity ($t = -1.324$, $p = 0.256$, and mean = 4.6). In contrast, there were three factors in managing disruptions that contribute to the easing of disruptions only insignificantly. Those were unreliable maintenance and repair systems ($t = -3.508$, $p = 0.025$, and mean = 3.6), rail service ($t = -1.909$, $p = 0.129$, and mean = 2.9) and labour strikes ($t = -3.068$, $p = 0.037$, and mean = 2.9). However, there were six factors considered by senior managers that had different implementations (either in Australia or Indonesia) in managing disruptions in the wheat supply chain such as active customs and quarantine agencies ($p = 0.093$), pre-disaster plans ($p = 0.036$), risk sharing or insurance plans ($p = 0.037$), empty container repositioning plan ($p = 0.092$), unreliable maintenance systems ($p = 0.025$), and labour strikes ($p = 0.037$).

Subsidiary research question three (SRQ3) of this study was investigated through assessing the preferred maritime mitigation responses supplied by the above respondents who are maritime operators or other entities in the wheat supply chain. The findings through the telephone survey provide evidence that current mitigation responses applied by respondents in the wheat supply chain were limited to minimising maritime disruptions internally for each entity along the wheat supply chain between Australia and Indonesia and not effective at the network scale of the chain.

### 5.7.2 Correlation factors of managing disruptions on commercial impacts

The reactions of respondents in managing maritime disruptions were investigated by analysing the correlation factors of parameters utilised in their management actions. Correlation analysis gives a correlation coefficient (CR) that determines the strength of the relationship between two parameters or factors. A correlation coefficient that is close to 1 means that there is a near perfect correlation between two variables. Moreover +1 means that there is a perfect positive correlation whilst -1 means that there is a perfect negative correlation. The CR can indicate any point along the continuum between 0 and 1 (both positive and negative), with a CR of 0.1 being a weak correlation, 0.5 being a moderate correlation and 0.7 being a strong correlation. (Groves et al. 2004; Presser & Rothgeb 2004; Zikmund 2007; Creswell 2008; Fowler 2008).
Two aspects of mitigation responses are explored: first, the impact of disruptions resulting in variations in the supply chain performance, market, and operational processes, and second, the key factors that were commonly implemented by senior managers when responding to maritime disruptions in their wheat supply chain. Key factors tested comprised of risk perception in identifying disruptions, responses in managing maritime disruptions and strategies to deal with 3P/L or 4P/L. Thus, within these contexts, the general performance of managing maritime disruptions can be identified by following the respondents’ basic framework of risk management.

As summarised in Table 5-17, the survey results seem to indicate that the implications of maritime disruptions on supply chain performances and the wheat market between the two countries was more evident than impacts to operational processes or services.

<table>
<thead>
<tr>
<th>The commercial impacts of maritime disruptions</th>
<th>N</th>
<th>Correlation factors</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply chain performances</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue losses (from buyers to sellers) due to the decrease in traffic demand</td>
<td>34</td>
<td>0.40</td>
<td>0.06</td>
</tr>
<tr>
<td>Poor business reputation due to unreliable services</td>
<td>34</td>
<td>0.33</td>
<td>0.08</td>
</tr>
<tr>
<td>Discrepancies in maritime transport costs</td>
<td>34</td>
<td>0.27</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Market</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply guarantee (buyers deciding to explore other sources)</td>
<td>34</td>
<td>0.52</td>
<td>0.07</td>
</tr>
<tr>
<td>Higher wheat retailers’ prices</td>
<td>34</td>
<td>0.48</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Operational processes / services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower tariff and higher costs in order to attract customers back</td>
<td>34</td>
<td>0.47</td>
<td>0.04</td>
</tr>
<tr>
<td>Risk of permanent stoppages in the cargo delivery process</td>
<td>34</td>
<td>0.35</td>
<td>0.06</td>
</tr>
<tr>
<td>Higher emergency costs due to immediate response</td>
<td>34</td>
<td>0.27</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Source: Appendix G section T

Details show that supply guarantee (CR = 0.52) as one market factor was the highest correlating factor considered by supply chain entities compared to lower tariff and higher costs (CR = 0.47) and revenue loss (CR = 0.40). Respondents found, in responding to maritime disruptions, discrepancies in maritime transport costs and emergency costs to have minimal commercial impacts (CR = 0.27).
In relation to supply chain performances, respondents were more likely to consider discrepancies in maritime costs as the lowest consequence in terms of costs when compared to others \( t = -3.773, \) mean value = 4.2, \( p \) value = 0.020 with a significantly different application both in Australia and Indonesia. This is probably reflective of respondents having foresight and being more aware of and sensitive to their business and market certainty in general. Appendix H (section A) shows a summary of the correlation factors considered essential by respondents when dealing with mitigation plans during maritime disruptions.

As recommended by Tomlin (2006), Yu and Qi (2004) and McCormack (2008), the success of having disruption management depends on the perception and understanding of the risk profile along the supply chain. In relation to this, risk perception in this study reveals two interesting points. First, in weighing the probability level of entities that create and suffer from maritime disruptions, generally respondents consider there is a variety of risk level distributed to all parties along the chain rather than one entity having the same risk level along the supply chain. The risk level CR of 0.4-0.6 confirms this view. Second, the input from respondents that gives the CRs indirectly indicates that some entities have a large probability of suffering from a disruption while others have a smaller risk level. Thus, the second observation confirms the first. To determine whether these CRs indeed have a similar pattern on the risk level across stages in the supply chain, the CR of each entity was checked to see if the general value of risk level was statistically significant when compared to each entity across the chain.

In comparing the CRs of entities along the wheat supply chain, three entities with roles as processors, retailers and industrial consumers have a slightly different idea about the contribution level of risks across the wheat supply chain. Next, the survey examined the responses towards strategies taken in managing maritime disruptions by exploring and ranking the correlation coefficient of eleven factors across the entities in the wheat supply chain. The seven higher correlation factors in Table 5-15 above are even more encouraging and indicate that respondents in the sample are more likely to apply those seven strategies (with CR in the range of 0.6 to 0.8) than other the four (with CR value from 0.2 to 0.50). Further, from this point of view, the three factors of back-up systems for bunkering supplies, maintenance and repair systems, and rail facilities are confirmed
as the main problems or hindrances for all entities when dealing with maritime disruptions in the wheat supply chain.

In relation to strategies in coordinating with 3P/L or 4P/L, respondents across the chain indicate that five items are considered as highly correlating strategies when dealing with marketing bodies, logistics providers, and export agencies. The five items include the negotiations of raw wheat selling prices, shipping contracts, the arrangement of inland transport, the selection of shipping companies and the inclusion of additional shipping costs. The only item that is not very significant (with CR = 0.5) is arranging the selection of loading and unloading terminals.

In Australia, alternatives of grain or wheat terminals are available, whilst in Indonesia, the majority of buyers including collectors and flour millers in Indonesia operate their own grain terminals. Thus, using correlation data from the survey, the study has found the importance of various actions or responses taken in managing maritime disruptions either as grouped initiatives or as individual response across the wheat supply chain. Therefore, it can be concluded that overall, through the statistical t-tests and CRs, respondents as key players in the chain are more responsive to the consequences of the market and supply chain performance on their wheat business rather than the operational services within their organisation as these are probably less important when it comes to managing maritime disruptions.

5.8 Summary

In this chapter a detailed analysis of research survey results in the Australian-Indonesian wheat supply chain was provided. The survey results form the basis for the theoretical assessment of maritime disruptions presented in this study. The findings of this study confirm the various unwanted internal and external factors creating uncertainty and severe negative consequences in the maritime leg as maritime disruption risks. The four significant aspects of (a) instigating factors, (b) inter-dependent factors, (c) leadership
risks, and (d) progressive factors are fundamental items that may contribute to the occurrence of maritime disruptions in the wheat supply chain.

The current study also relates to perceptions, responses, risk management and decision making processes used by senior managers, shippers, and consignees in the wheat supply chain. The information used to support disruption management decision making is described and the preference for personal responses is identified. Based on the characteristics of disruption and managerial behaviour, propagation and recovery actions taken by the respondents were also important aspects of managing maritime disruptions.

Through the telephone survey, the study found a process of maritime disruption risk management implemented by entities in the Australian-Indonesian wheat supply chain when various disruptive events occur that addresses the second subsidiary research question two (SRQ2). The main strategy applied by all entities is mitigation strategy. The other three important strategies implemented are adaptation, coordination and intervention strategies. The dominant reactions of maritime users in the wheat supply chain were to apply contingency planning which principally consists of supply flexibility and insurance management. This is achieved through transferring risk or risk-sharing decision methods such as insurance plans (generally for marine cargo insurance) and outsourcing strategies. Other entities along the chain also apply reserved maritime routes, provide strategic stock (through agency service) and back-up systems, and optimum ordering policies in their contingency plans for responding to worst case scenarios of maritime disruptions. These mitigations were adopted when they have problems with the shortage of dry bulk ship in the market and port congestion problems particularly in some Australian grain terminals.

Adaptation strategies which are mainly implemented in the disruption stage by entities are inventory polling at ports, various changes of working practices, and applying impact monitoring programs. Inventory pooling at ports is selected if problems such as the shortage of ships, the closure of unloading ports for various reasons, and the payment delay of cargoes in the country of buyers occur. The other essential strategies
implemented as adaptation strategies in the disruption stage are to employ impact monitoring action.

In terms of intervention strategies, the current study found that the intervention response in the wheat supply chains is usually controlled by dominant agribusiness corporations in the chain rather than individual farmers. In addition, the structure of bargaining power in the wheat supply including the transportation process is controlled by 3P/L or 4P/L, wheat marketing bodies (such as Australian Wheat Board, and BULOG in Indonesia), and government agencies such as port authorities.

To address SRQ3, the findings through the telephone survey suggest that current mitigation responses applied by respondents in the wheat supply chain, such as rescheduling the shipment process, using effective and strong coordination, and flexible rerouting to other ports, were limited to minimising maritime disruptions internally for each entity along the wheat supply chain between Australia and Indonesia and were not effective at the network scale of the chain. The values of the correlation factor (CR) of those three strategies were lower than 0.5 which indicate that the benefits and outcomes of these three strategies to manage maritime disruptions were not sufficient.

From the discussion above, in relation to SRQ1, SRQ2 and SRQ3 of this study, this chapter confirms that maritime disruptions exist and significantly influence the wheat supply chain between Australia and Indonesia, through changes in supply chain performance in terms of time and costs.

In general, respondents of the survey determined that efficient and effective responses or strategies have been provided in managing disruptions mainly through contingency, flexible supply, and business continuity management responses between entities along the chain. Through the commercial and operational consequences when maritime disruptions occurred, it was found that there is uncertainty in the practice of providing actions to manage disruptions. As a result, mitigations and responses of entities along the chain rely upon external factors to their organisation such as 3P/L or 4P/L, wheat marketing body, and government agencies. Thus, the resulting actions were relatively passive rather than providing an active certain response within their organisation.
Despite all research questions of this study being addressed, in order to further explore the aspect of disruption management efficiency as a value added outcome of the study, the next Chapter will explore and discuss various disruption management scenarios using the Markov chain method to optimise the outcomes of the decision making process during maritime disruption risk events.
CHAPTER SIX

DISRUPTION MANAGEMENT SCENARIO
6.1 Introduction

This chapter discusses the assessment of various disruption management scenarios based on the Markov decision process (MDP) approach. The Markov probabilistic theory examines the estimation processes for which the knowledge of previous outcomes influences predictions for future experiments (Loury 1983; Jong & Greig 1984; Chao 1987; Parlar et al. 1995; Mundt 2008). This assessment enhances the results of Chapter Five and provides more value added outcomes for the current study as suggested in the literature to optimise the results of the decision making process during maritime disruption risk events. Further, the scenario assessment in this Chapter explores real time optimisation techniques in supply chain networks in transport such as maritime service operations. The reasons for this are provided by the research respondents who suggest there is an urgent need to apply quick and adaptable solutions when an operational disruption occurs in the maritime leg. The 2006-2008 dry bulk ship shortage in the Australian-Indonesian wheat supply chain will be employed as a tool to assess previous disruption management scenarios of relevant supply chain entities.

The Markov chain is used to provide a comprehensive network scale assessment of a disruptive event when compared to traditional maritime risk analysis which is mainly aimed at providing detailed problem insights within small scale interactions of entities in the supply chain (Yu & Qi 2004; Blackhurst et al. 2005). In addition, the existing risk mitigation processes are not set up to work early in conceptual design with limited information. Therefore, by using the Markov chain approach, potential responses and preparedness may be quantified and optimised earlier in the planning process of a supply chain before spending a significant amount of the risk management budget to examine them.

In relation to the assessment process of multi-mitigation scenarios using the Markov Chain, the supply chain network of the Australian-Indonesian wheat supply chain is used to generate empirical responses and preparedness that attempt to assess the consequences of maritime disruptions in various streams of the wheat supply chain. These responses and preparedness are then applied to the single-entity during the
process of transporting wheat, to improve the accuracy of the supply chain performance. This stochastic approach is applied as a result of a non-proactive method implemented by supply chain entities when managing maritime disruption. The non-proactive assessments that were tried and proposed as revised plans were mostly applied as worst cases of small probability, and thus made the operational plans and resolutions applied by entities too conservative and passively implemented when maritime disruptions occurred.

After the introduction, the second section of this chapter explains the general assessment process followed by the third section which explores the data required for the assessment process collected from secondary and primary resources. The fourth section discusses the assessment framework risk perception of disruptive events including the analysis of transition probabilities, algorithm process and the optimisation process. The fourth section provides the descriptive data of maritime disruptions in terms of frequency rate, operational impact, and consequence levels. The fifth section discusses the propagation effect of maritime disruptions in terms of propagation matrix, probabilities, and evaluation. The sixth section presents the assessment results in an empirical case of Australian-Indonesian wheat supply chain. The seventh section summarises the chapter.

### 6.2 The general assessment of the Markov chain process

The assessment process by Markov chain approach begins with performance indicators including the source of wheat and instigating factors by which the wheat supply chain is interrupted when maritime disruptions occur. The process is followed by specifying the decision framework of disruption management such as mitigation, adaptation, and intervention which can be applied with 16 disruption actions, 14 states, and 4 progressive factors of maritime disruptions as found in Chapter Five. Further, the strategic actions are assessed by analysing the optimised values of a transition matrix, transition costs, and reward value. As suggested in the literature, sixteen disruption management scenarios used in the assessment process are determined from four major risk management approaches: inventory and sourcing mitigation, contingency rerouting, recovery planning, and business continuity planning. These scenarios will be provided
as options of disruption management strategy for 14 entities of the wheat supply chain with four different disruptive events: delay, deviation, stoppage of maritime service, and loss of service platform. The system will simulate the optimised decision for various routes and operation scenarios (see Figure 6-1).

**Figure 6-1. The general flow-chart of maritime disruption assessment**

Source: Author
Basically, there are three main indicators which should be fulfilled; S/S’ (shipper preferences before and after maritime disruptions occur), Te/Te’ (the acceptance level of consequences), and M/T (the correlation of risk management plans and supply chain performances on costs and time). The assessment should have these three indicators being larger than the existing values.

The location of the ports determines the operational risks of the supply chain relative to alternative options and therefore affects the strategy choices. Once the planned performance is achieved and the port-dependent decision is known, a future disruption management scenario can be calculated for every alternative port of call. In addition, the ports of call for wheat shipments can be determined and selected in order to apply the most effective disruption management strategy. Within the framework of this research, a number of choices are made and a number of constraints imposed on the disruption management scenarios in three stages namely pre-disruption, disruption, and post-disruption. Strategies such as contingency plans, developing a warning system, supply flexibility, utilising agency service, having an optimum ordering policy, critical nodes mapping, reserved routes, and insurance plans are responses implemented in the pre-disruption stage. However the disruptions level should be in the acceptable range, which is realistic to be implemented, based on various disruption management scenarios and their operational requirements. In addition, the simulation of multi-disruption management scenarios will deliver recommendations and disruption management strategies when solving the problems encountered.

6.3 Data collection for the assessment process

Primary and secondary data for the assessment process is categorised into six parameters as listed in Table 6-1. In the initial stage of the assessment, the wheat supply chain performance data (from the empirical case of the 2006-2008 dry bulk ship shortage in the Australian-Indonesian wheat supply chain), including the maritime disruption survey of this study are collected from secondary and primary sources (the telephone survey).
Table 6-1. The source of data required for Markov chain process

<table>
<thead>
<tr>
<th>NO.</th>
<th>ASSESSMENT PROCESS</th>
<th>SOURCE OF COLLECTED DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SECONDARY</td>
</tr>
<tr>
<td>1</td>
<td>Performance indicators</td>
<td>* Source of wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* The type of wheat cargoes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* The origin and destination of wheat supply chain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Port facilities of selected port or dry bulk terminal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Operational logistics performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Ship traffic and routes</td>
</tr>
<tr>
<td>2</td>
<td>Transportation objectives</td>
<td>* The export volume of the Australian wheat to Indonesia (million tonnes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Shipping terms used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Transportation time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Shipping freight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* The increase value of wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* The inflation rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Inventory costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Port handling costs</td>
</tr>
<tr>
<td>3</td>
<td>Risk state definition</td>
<td>* Drought factor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Severe weather</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Shortage of dry bulk ships</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Probabilities scenario</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Disruption management strategies</td>
<td>Mitigation scenarios such as:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Contingency plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Containerised transport</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* Insurance policy</td>
</tr>
<tr>
<td>6</td>
<td>Expected future probabilities, frequency, and consequences</td>
<td>Not available</td>
</tr>
</tbody>
</table>

Source: Author

Collected data and parameters of the assessment process require six variables, which consist of parameters of performance indicators, transportation objectives, risk state definition, probabilities scenario, disruption management strategies, and expected future
probabilities and consequences. The assessment also includes multiple management plans, even though the disruption management assessment is based on the assumption of a single decision making approach. Primary data is gathered from the maritime disruption survey which has been collected both quantitatively and qualitatively combined with the triangulation method. The secondary data is collected from various databases, previous research outcomes, and operational reports of entities in the wheat supply chain.

Choices such as inventory pooling at ports, changes to working practices, applying other chain links, postponement delays, risk formal assessment, maximum allowable interruption, risk implication monitoring, and reevaluating contingency plans are considered as strategies taken when disruptions occurred and in the post disruption stage collected from primary sources. These choices, including constraints, are assessed in five different maritime consequences as conditional events such as normal, delays, deviation, stoppages, and loss of port services. Any input data included in calculating parametric variables will vary between scenario objectives. However, the way in which parametric variables are calculated from historical data and the way they are applied in the estimating process are still consistent within individual estimating systems.

There are 16 disruption management scenarios and all need to have ranges of costs attached to them. These ranges will be the same across all entities in the Australian-Indonesian wheat supply chain. The disruption management scenarios which can be applied by senior managers when maritime disruptions occur, are inventory polling, agency utilisation, using other chain links, applying optimum ordering, postponement delays, using supply flexibility, reserved routes, mapping out the critical nodes, containerised shipment (as one of business continuity responses), changes of working practices, allowable interruptions, using warning systems, implication monitoring, and purchasing insurance packages. These scenarios then are categorised as the list of actions with the ranges of consequences and probabilities, which were collected from telephone interviews, as shown in Table 6-2.

Risk mitigation strategies that can be applied by supply chain entities in detecting the instigating factors of maritime disruptions include the development of a warning
system, insurance planning, contingency planning, formal risk assessment, and critical nodes mapping.

Table 6-2. List of alternatives of strategies, probabilities and consequences

<table>
<thead>
<tr>
<th>STATE</th>
<th>ALTERNATIVES</th>
<th>PROBABILITY</th>
<th>CONSEQUENCES PER TONNES</th>
<th>EXPECTED IMMEDIATE RESP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DEL</td>
<td>DEV</td>
<td>STOP</td>
</tr>
<tr>
<td>Pre-disruption</td>
<td>Supply flexibility</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Develop warning system</td>
<td>0.1</td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Insurance arrangement</td>
<td>0.4</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Reserved routes</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Optimum ordering policy</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Control access to load</td>
<td>0.2</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Utilise agency service</td>
<td>0.4</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Critical nodes mapping</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>On disruption</td>
<td>Inventory pooling</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Containerised shipment</td>
<td>0.3</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Implication monitoring</td>
<td>0.4</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Postponement delays</td>
<td>0.1</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Maximum allowable interruption</td>
<td>0.2</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Apply other chain links</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Post disruption</td>
<td>Re-evaluating contingency plan</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Network and procedure redesign</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Note: Consequence and expected immediate response (resp) values in US$. Del: Delay; Dev: Deviation; Stop: Stoppage of the service; Dis: Disaster

Source: Author

Interdependent factors due to the competition of loading accessibility and collective risks, have been important aspects generating disruptions in the wheat supply chain between Australia and Indonesia in the total scale of supply chain links. The disruption management should focus on commercial collaboration among entities in the supply chain including possible coordination and risk adjustment in the shipment and shipping contracts.

Coordination may consistently contribute to entities when all entities fully accept responsibility for various maritime disruptive events that may occur. Accepting a certain maximum level of disruption consequences on the other hand may be another factor to help prepare for the worst impacts of maritime disruptions. This is realised when specific reserved resources are allocated for future potential disruptive events.
The self provision of ships and dedicated grain terminals by either having long-term shipping contracts and ship chartering may minimise the impact of higher maritime costs. These are possible actions for decision makers in the wheat supply chain when a shortage of dry bulk ships occurs.

6.4 Markovian approach of disruption management assessment

In the assessment process, the objective is to determine optimal disruption strategies for events that recurrently and severely impact on maritime services and the supply chain process using the example of empirical case of a wheat supply chain from Australia to Indonesia. The roles of the wheat supply chain entities surveyed through the maritime disruptions study are taken and prepared as input for the disruption management assessment. The subjective perspectives of respondents on the flexibility factors and real-time responses to maritime disruptions are appraised in terms of total costs and time.

6.4.1 Basic framework of disruption management assessment

The maritime disruptions that occurred in the Australian-Indonesian wheat supply chain varied both in frequency and severity. Some disruptions had a high probability and low consequence whereas others were of a low probability and high consequence. Specifically, the existence of the latter leads to difficulties in the disruption analysis process. Due to the rare occurrence of such disruptions, there is a lack of available data to determine the contribution of various situational attributes to disruption risks. Therefore, the study constructed a maritime disruption management framework, which incorporates wheat supply chain simulation and available data as well as topic specific professional judgments in order to quantify disruption level through the estimation of the contribution of situational attributes to maritime disruptions.

In the maritime disruption assessment, attributes contributing to disruption occurrence from stage A to M (as shown in Figure 6-2) are quantified in order to estimate the future
risk level. Therefore, in this study, maritime disruption risks are quantified based on the maritime disruption survey including professional judgment, elicitation and disruption management assessment of the wheat supply chain in the Australian-Indonesian trade link.

The disruption risk at various stages of the wheat supply chain is denoted as $s$, $R_s$ is calculated based on the snapshot of the traffic in that stage every time a wheat consignment enters it. The orientation of wheat cargo starts from local farmers in Australia and then enters the stages in Indonesia’s direction. The observed wheat flow when entering the stages, first (A) calculates its own contribution to the stages disruption and then may contribute to the geometric mean of disruption value of that stage after being accumulated with other wheat at the same stage.

In estimating the level of maritime disruptive risks quantitatively, there are three factors that should be considered namely i). What are the driving factors of maritime disruptive events? ; ii). How likely is it to occur?; iii). If it does occur, what are the consequences? To answer these questions, a list of scenarios is constructed as shown in Table 6-3. Let $s_i$ be the $i$-th scenario, and $p_i$ and $x_i$ be its probability and consequence (either in costs and time), respectively.
where $S_N = \mathbb{R}^+$; $P_N = 1$; $X_N = \mathbb{R}^+$ is the risk value of a severe disruptive event or the highest risk value of a set of disruptive events. Thus, the triplet $(s_i, p_i, x_i)$ represents an answer to the above questions. Consequently, disruption is defined as the complete set of triplets including all possible scenarios.

$$R = \{(s_i, p_i, x_i)\}, \quad i = 1, \ldots, N$$

The scenarios are sorted in an increasing order of severity of consequence such that

$$x_1 \leq x_2 \leq \ldots \leq x_N$$

Table 6-4 is obtained by adding a column representing the cumulative probabilities calculated starting with the most severe scenario $s_N$.

### Table 6-4. List of scenarios with cumulative probability

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Probability</th>
<th>Consequence</th>
<th>Cumulative Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s_1$</td>
<td>$p_1$</td>
<td>$x_1$</td>
<td>$P_1 = P_2 + p_1$</td>
</tr>
<tr>
<td>$s_2$</td>
<td>$p_2$</td>
<td>$x_2$</td>
<td>$P_2 = P_3 + p_2$</td>
</tr>
<tr>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>$s_i$</td>
<td>$p_i$</td>
<td>$x_i$</td>
<td>$P_i = P_{i+1} + p_i$</td>
</tr>
<tr>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td>$\ldots$</td>
</tr>
<tr>
<td>$s_{N-1}$</td>
<td>$p_{N-1}$</td>
<td>$x_{N-1}$</td>
<td>$P_{N-1} = P_N + p_{N-1}$</td>
</tr>
<tr>
<td>$s_N$</td>
<td>$p_N$</td>
<td>$x_N$</td>
<td>$P_N = P_{N+1} + p_N$</td>
</tr>
</tbody>
</table>

Source: Author

In the case of maritime disruption, disruption risks can be defined as unexpected events that can be driven from instigating, interdependent, and decision maker
factors resulting in four progressive factors such as delays, deviations, stoppages, and loss of maritime services. The quantity risk level of a maritime disruption risk can be formulated as follows:

\[
R = \text{Disruption Probability} \times \text{Consequence Impact} \quad (3)
\]

A Markov chain of a wheat supply chain has a set of states in the wheat supply chain process denoted as \( S = (s_1; s_2; \ldots s_n) \). The process starts in one of these states and moves successively from one state (farmer) to another (until final consumers). Each move is called a step. If the wheat supply chain is currently in state \( si \), then it moves to state \( sj \) at the next step with a probability denoted by \( p_{ij} \), as probability level, this probability does not depend upon which states the chain was in before the current state. The probabilities \( p_{ij} \) are called transition probabilities.

The process can remain in the state it is in, and this occurs with probability \( p_{ii} \). An initial probability distribution, defined as \( S \), specifies the starting state. Usually this is done by specifying a particular state as the starting state. In general, if a Markov chain has \( r \) states, then the following general theorem is easy to prove by using the above observation and induction. Therefore a Markov model may contain \( S, A, T, R \) consisting of a set of environment states \( S \), a set of actions \( A \), a transition function denoted as \( T \) and can be defined as

\[
SxAxS' \xrightarrow{TF} \[0,1]\]

then

\[
T(S,A,S') = \Pr (S'| S,A) \quad (5)
\]

A reward function \( R \) can also be defined as

\[
SxA \xrightarrow{R} \mathbb{R}^+ \quad (6)
\]

In addition, a disruption management policy is a function \( \pi: S \rightarrow A \) and its expectation as a cumulative reward value function
The TF as defined in a MDP is Markovian, that is, the probability of reaching the next state depends only on the current state and action, and not on the history of earlier states. Inclusion of the TF allows MDPs to model and reason with non-deterministic (uncertain) actions. Furthermore, the horizon may be either finite or infinite. If a MDP is solved over a finite horizon, then the resulting policy is non-stationary, since the best action to perform may depend on the remaining time. If the horizon is infinite, then the resulting policy is stationary.

The four intervals of disruption management can be implemented in one particular wheat supply chain when facing one maritime disruptive event both to reduce the likelihood of the occurrence of a primary disruptive event, and to lower maritime risk after being in normal (initial) state, \( \mu_0 \). To depict the different approaches of disruption management measures and its processes, a diagram of disruption management formalism is used in disruption management assessment and is shown in Figure 6-3.

![Figure 6-3. Markovian process from disruptive events to normal state](image)

Source: Author

Figure 6-3 shows the sequence of disruption management events and the process from normal (initial) state to their possible consequences. Disruption management measures
denoted by \((\lambda)\) that reduce the probability of entering a disruptive state are referred to as single or multi-disruption scenarios as appears in Figure 6-4 below.

![Figure 6-4: States in wheat supply chain and Markov structure](image)

**Note:**
- Far: Farmers
- Han: Handlers
- Proc: Processor
- Aspr: Shippers
- Afwr: Forwarders in Australia
- Ashp: Shipping operations in Australia
- Aprt: Ports in Australia
- Ishp: Shipping operations in Indonesia
- Iprt: Ports in Indonesia
- Ifwr: Forwarders in Indonesia
- Cos: Consignees
- Whl: Wholesalers
- Rtl: Retailers
- Fcon: Final consumers

**Figure 6-4. States in wheat supply chain and Markov structure**

Source: Author

The event sequence begins with the initial risk state to a disruptive state that may come from one or more potential disruptive events. Maritime stages such as port and shipping operations have more than one probable disruptive event (from 1 to N) which may occur from a normal state to failure mode (\(\lambda\)) and may be recovered again due to responses or proper disruption management strategies (\(\mu\)). For example, in terminal or port areas, events such as port congestion resulting from equipment breakdown may change the normal operation level of a port to a sub-optimal or failure mode condition. In managing this situation, two common stages of risk management responses are taken by senior managers namely implementing the reserved existing plans (such as a contingency plan), and preparing a disruption management plan that may minimise the congestion event. The management of disruptive events can be a single strategy (\(\lambda 1\)) or multi-disruption management strategy (\(\lambda 1+\lambda 1+\ldots N\)). One way to decide whether a set of disruption management alternatives is effective or not, can be obtained by assessing the impact probability of disruption management options in enabling optimal consequences in terms of costs and time.
In order to obtain the initial probability, the most recent disruption-occurrence data is used, which can be divided by the time periods of three, six, and nine months and one year. By analysing the most recent data, the initial probability vector is calculated using formula (9).

\[
V_{j,i} = X_i DM_{j,i}
\]  

(9)

For this analysis, the mitigation functions are combined to simplify evaluation of mitigation measures that typically couple detection and recovery functions. Each decision node has a set of conditional probabilities that describe the probability of occurrence of each branch, conditional upon the previous states. The overall likelihood of each outcome is determined by multiplying conditional probabilities through the branch, and the risk level is aggregated along potential consequences in different branches as shown in the formula (9) where: \(V_{j,i} = \) strategy value index for type \(j\) disruptive event for scenario \(i\); \(X_i = \) probability of occurrence of scenario \(i\); \(DM_{j,i} = \) type managed consequences of type \(j\) related to the scenario \(i\).

The matrix combining scenarios with types of consequences shows all possible indexes \(V_{j,i}\) representing impacts based on the 2009 maritime disruption research survey. The managed consequence is evaluated from the potential consequence that is mitigated by the susceptibility and coping capacity of the strategy.

The consequences of disruption management \(j\) relative to the scenario \(i\) (\(DM_{j,i}\)), which is calculated through the formula (10), is the sum of all consequences referred to as the intensity threshold value \(m\). \(V_{j,i,m}\) is the vulnerability related to intensity \(m\) of the \(j\) type of consequence and related to the scenario \(i\), \(DX_{j,i,m}\): is the potential consequence type \(j\) related to scenario \(i\) to consequences \(j\) and to intensity \(m\) (Yu and Qi 2007).

\[
DM_{j,i} = \sum_m (DX_{j,i,m}V_{j,i,m})
\]  

(10)
On the basis of the disruption management strategies implemented previously, a business continuity concept was implemented by wheat chain players in the Australian-Indonesian wheat supply chain. This generic wheat supply chain case with the scenario of changes to working practices can be denoted with $i = 10$ (as shown in Table 6-5).

Table 6-5. The $i$-scenarios of (A) disruption management scenarios and $j$-consequences indicators proposed by author.

<table>
<thead>
<tr>
<th>Scenario $i$</th>
<th>Type of disruption management scenarios</th>
<th>$J=1$ (delay)</th>
<th>$J=2$ (deviation)</th>
<th>$J=3$ (stop)</th>
<th>$J=4$ (Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i=1$</td>
<td>Inventory pooling ports (A)</td>
<td>S11</td>
<td>S21</td>
<td>S31</td>
<td>S41</td>
</tr>
<tr>
<td>$i=2$</td>
<td>Utilising agency service (A)</td>
<td>S12</td>
<td>S22</td>
<td>S32</td>
<td>S42</td>
</tr>
<tr>
<td>$i=3$</td>
<td>Control access to load (A)</td>
<td>S13</td>
<td>S23</td>
<td>S33</td>
<td>S43</td>
</tr>
<tr>
<td>$i=4$</td>
<td>Optimum ordering policy (M)</td>
<td>S14</td>
<td>S24</td>
<td>S34</td>
<td>S44</td>
</tr>
<tr>
<td>$i=5$</td>
<td>Postponement delays (A)</td>
<td>S15</td>
<td>S25</td>
<td>S35</td>
<td>S45</td>
</tr>
<tr>
<td>$i=6$</td>
<td>Supply flexibility (M)</td>
<td>S16</td>
<td>S26</td>
<td>S36</td>
<td>S46</td>
</tr>
<tr>
<td>$i=7$</td>
<td>Reserves routes (M)</td>
<td>S17</td>
<td>S27</td>
<td>S37</td>
<td>S47</td>
</tr>
<tr>
<td>$i=8$</td>
<td>Critical nodes mapping (M)</td>
<td>S18</td>
<td>S28</td>
<td>S38</td>
<td>S48</td>
</tr>
<tr>
<td>$i=9$</td>
<td>Apply other chain links (M)</td>
<td>S19</td>
<td>S29</td>
<td>S39</td>
<td>S49</td>
</tr>
<tr>
<td>$i=10$</td>
<td>Containerised shipment (A)</td>
<td>S110</td>
<td>S210</td>
<td>S310</td>
<td>S410</td>
</tr>
<tr>
<td>$i=11$</td>
<td>Maximum allowable interruption (A)</td>
<td>S111</td>
<td>S211</td>
<td>S311</td>
<td>S411</td>
</tr>
<tr>
<td>$i=12$</td>
<td>Develop warning system (M)</td>
<td>S112</td>
<td>S212</td>
<td>S312</td>
<td>S412</td>
</tr>
<tr>
<td>$i=13$</td>
<td>Implication monitoring (A)</td>
<td>S113</td>
<td>S213</td>
<td>S313</td>
<td>S413</td>
</tr>
<tr>
<td>$i=14$</td>
<td>Insurance arrangement (M)</td>
<td>S114</td>
<td>S214</td>
<td>S314</td>
<td>S414</td>
</tr>
<tr>
<td>$i=15$</td>
<td>Re-evaluating contingency plan</td>
<td>S115</td>
<td>S215</td>
<td>S315</td>
<td>S415</td>
</tr>
<tr>
<td>$i=16$</td>
<td>Network and procedure redesign</td>
<td>S116</td>
<td>S216</td>
<td>S316</td>
<td>S416</td>
</tr>
</tbody>
</table>

Note: A: Adaptation; M: Mitigation
Source: Author

6.4.2 Transition states of wheat supply chain of the case

As indicated in Figure 6-4 earlier, wheat from Australian farmers is transported by handlers and processors by road or rail via self discharging wagons to a hopper and then by means of conveyors is transported into storage tanks (silos) at ports or dedicated grain terminals. The transportation of wheat from loading ports to unloading ports uses international shipping operations consisting of bulk and containerised shipments which allows the transfer of wheat cargo through ports (labelled as maritime distributors and handling) under the control of shippers, freight-forwarders and consignees. The detail
interaction of entities of the case is explained by the Figure 6-4. Given the stages in the Australian-Indonesian wheat chain, the Markov transition matrix is provided in Figure 6-6. Maritime stages such as port and shipping operations have more than one probable disruptive event (from 1 to N) which may occur from a normal state to failure mode (λ) and may be recovered again due to responses or proper disruption management strategies (μ).

### 6.4.3 Multi-state scenarios of maritime disruption management

A further explanation of the maritime disruption assessment in relation to normal and internal states, particularly for the states of $S_6$ ($P_{66}$), $S_7$ ($P_{77}$), $S_8$ ($P_{88}$), $S_9$ ($P_{99}$) is shown in Figure 6-5. Let $p_c(t)$ be the state probability of $X(t)$ at time $t$, so probability of event at time $t$ can be defined as

$$p_c(t) = P[X(t) \geq C] \text{ where } C \in X$$

where C is an acceptable level of costs or time.

$$
\begin{bmatrix}
P_{11} & P_{12} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
P_{21} & P_{22} & P_{23} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & P_{53} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & P_{54} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & P_{55} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\end{bmatrix}
$$

**Figure 6-5. Markov transition matrix in the wheat supply chain**

Source: Author

The following system of differential equations for finding the four states probabilities (from normal to delay, delay to deviation, deviation to stoppage including loss of service) $p_i(t)$ for the Markov process can be written as:
\[
\frac{dp_i(t)}{dt} = \sum_{j=i}^{v} p_j(t)\lambda_{ji}(t) - p_i(t)\sum_{j=i}^{v} \lambda_{ij}(t)
\] (12)

These four stages (Kumamoto & Henley 1996; Yu & Qi 2004; Xiao et al. 2009) as shown in Figure 6-6, where \(\lambda_{ij}\) is the transition probability from state I to state j, can be explained in detail below:

\(\lambda_{32}\): the transition probability from state 3 to state 2;
\(\lambda_{31}\): the transition probability from state 3 to state 1;
\(\lambda_{30}\): the transition probability from state 3 to state 0;
\(\lambda_{21}\): the transition probability from state 2 to state 1;
\(\lambda_{20}\): the transition probability from state 2 to state 0;
\(\lambda_{10}\): the transition probability from state 1 to state 0;
\(\mu\): the transition probability from state 0 to state 3.

**Figure 6-6. Multiple maritime disruptive events**
Source: Author

**Figure 6-7. Maritime disruption stages and scenario**
Source: Author
The probabilities of internal stages for each risk event are further approached by using four different maritime disruption stages; these are indicated by states 3, 2, 1 and 0. A description of each stage is as follows:

i). State 3 – ensuring the normal level of the maritime service availability as planned.

ii). State 2 – the occurrence of delays along maritime services which creates a less efficient level of service performance.

iii) State 1 – the events of deviations as the results of further divergences of maritime services.

iv). State 0 – the conditions in which disruptions occur due to variable factors that result in various maritime services being unavailable.

These four stages as part of the Markov chain process can also be defined as the transitions of maritime disruptions of which the value will depend on the combinations of actions. Assume that the probability functions for the maritime disruptive stages 3, 2, 1 and 0 for any operational period t which is continuously changing with t are $F_3(t)$, $F_2(t)$, $F_1(t)$.

$F_0(t)$ respectively, where $F_3(t) + F_2(t) + F_1(t) + F_0(t) = 1$  

(13)

Therefore, to find the probability function for each stage, a system of differential equations is applied under the assumption that the transition rates are relatively constant and can be estimated from the historical record (Kumamoto & Henley 1996; Hermanns et al. 2003; Xiao et al. 2009). With reference to these scenarios, each stage may be formulated by the following equations:

$$\frac{dF_3(t)}{dt} = -(\lambda_{32} + \lambda_{31} + \lambda_{30})F_3(t) + \mu F_0(t)$$  

(14)

$$\frac{dF_2(t)}{dt} = -(\lambda_{21} + \lambda_{20})F_2(t) + \lambda_{32} F_3(t)$$  

(15)

$$\frac{dF_1(t)}{dt} = -\lambda_{10} F_1(t) + \lambda_{21} F_2(t) + \lambda_{31} F_3(t)$$  

(16)

$$\frac{dF_0(t)}{dt} = -\mu F_0(t) + \lambda_{30} F_3(t) + \lambda_{20} F_2(t) + \lambda_{10} F_1(t)$$  

(17)

Therefore, M(t) or total probabilities of some disrupted states is equal to
\[ F_2(t) + F_1(t) + F_0(t) \]  

When equation (11) is considered, consequently the value of state 3 becomes  

\[ F_3(t) = 1 - M(t) \]  

6.4.4 Formulating the optimised disruption management strategies

The assessment framework for maritime disruption strategies provides a preliminary reference of potential disruption management strategies using the Markov decision process that meets the objectives and requirements in company disruption responses; however, in this model, it is possible to select the lowest costs that may occur for each strategy and the combination of three disruption strategies taken. To do so, first, the value \( v_i \) of each disruption strategy at state \( i \) is formulated by the steady-state condition:

\[
V_i^* - \beta \sum_{j=1}^{N} p_{ij}^x v_j = q_i^x \text{ for } i = 1, \ldots, N
\]  

where the \( V_i^* \) is the cost for the policy solution.

The process of disruption policy evaluation is initially started by solving the steady state cost equation using \( X_k \) as the optimum disruption management policy. If \( v_i^* = v_i \) for all \( i \), then the calculation process which is finished as \( X_k \) has been achieved. Otherwise, increase \( k \) by 1 and let \( v_i = v_i^* \) and do the iteration process of:

\[
\left| V_i^* - v_i \right| \leq \epsilon, \text{ where } \epsilon = C \text{ (acceptable cost level)}
\]  

Therefore, the iteration process will stop if the condition of \( \left| V_i^* - v_i \right| \leq \text{tolerance value} \) is achieved.

In a steady-state condition, the value of \( v_i = \lim_{k \to \infty} V_i(k) \)

Then, the equation becomes  

\[
V_i = q_i^x + \beta \sum_{j=1}^{N} p_{ij}^x v_j
\]
or

\[ V_i - \beta \sum_{j=1}^{N} p_{ij}^X v_j = q_i^X \quad \text{for } i = 1, \ldots, N \quad (24) \]

Therefore, the steady-state disruption probability is \( \pi_i = \lim_{k \to \infty} \pi_i(k) \quad (25) \)

and then continued to \( \pi_i = \sum_{j=1}^{N} p_{ij}^X \pi_j \quad \text{for } i = 1, \ldots, N \quad (26) \)

As the set of equations has one redundant equation then \( \sum_{j=1}^{N} p_{ij}^X \pi_j - \pi_i = 0 \quad (27) \)

for \( i = 1, \ldots, N-1 \) where \( \sum_{j=1}^{N} \pi_j = 1 \quad (28) \)

where:

\( X_i \quad : \) Disruption management policy implemented in disruption state

\( i \) where \( P_i \subset A_i \)

\( P = (x_1, x_2, x_3, \ldots, x_N) \quad : \) Disruption management scenario

\( V_i(n) \quad : \) Cost value of state \( i \) at period \( n, n = 0,1, \ldots, N \)

\( V(n) \quad : \) \{\( V_1(n), V_2(n), \ldots, V_N(n) \)\} as vector of costs

\( \pi_i(n) \quad : \) Probabilities of disruption state \( i \) at period \( n, n = 0,1, \ldots, N \)

\( (n) \quad : \) \{\( \pi_1(n), \pi_2(n) \ldots \pi_N(n) \} \quad : \) Vector of probabilities

The initial cost of the disruption management policy \( n \) in disruption state \( i \) is \( V_i(n) \). By using the iteration solution, let \( k = 1 \) combined with the value of disruption management costs, then the minimum consequences can be calculated. The management formulation to address the minimum consequences (for example costs) at state \( i \) is given here:

\[ V_i^* = \min_{x_i \in A_i} \left\{ q_i^X + \beta \sum_{j=1}^{N} p_{ij}^X v_j \right\} \quad \text{for } i = 1, \ldots, N \quad (29) \]

where \( A_i \) is a set of disruption strategy / action. From (29), let the optimum disruption management policy be \( X_k \) as the disruption management costs for minimization can be estimated with \( V_i^* \). In supporting the process, an excel application created by Jensen
is applied as a tool to provide the iterations of disruption management policy on 16 maritime disruptive events both before, and during the delivery process and as generic optimal policy due to various factors in Australia and Indonesia. Additional information on average disruption costs, specific costs on several states, and cost level on each strategy considered in the system would thereby have the effect of narrowing the potential number of alternate optimal solutions, while perhaps better meeting the decision-makers’ preferences and needs. In this way, supply chain and logistics managers can anticipate both the effects of different threats to the wheat supply chain and the possible ways to utilize backup facilities to minimise maritime disruptions due various instigating factors.

6.4.5 Algorithm for optimised mitigation scenario

In Table 6-6, an algorithm for the optimised mitigation scenario is proposed. The solution method involves the following calculation: given a set of mitigation scenarios, in the first step, the number of entities in the wheat supply chain is incorporated into \( S \) (line 1) including the four categories of disruptions stages \( \lambda \) (line 2) and mitigation scenarios \( D_{ji} \) (line 3).

Next, the probability of mitigation scenario based on mitigation policy of entities in the chain is applied (line 4). This is what is also assessed in the next step of the algorithm to estimate the probability at time \( t \) and acceptable level of costs \( C \) (line 6 and 7). Due to the mitigation scenario taken, then the TP and transition costs can be calculated (line 10 and 11). The objective level of multi-mitigation scenarios is identified in 13: \( V_i^* \) corresponds to the minimal costs among various scenarios within available mitigation scenarios. If \( V_i^* \) is undefined because no contradiction could be obtained (line 14), the level of costs is equal to \( V_i \) represents a feasible disruption consequences (line 15). Otherwise, a recursive process is started (line 16-22): \( V_i^* \) is initialised (line 16) before the level of consequence (reward) of a scenario applied is identified (line 17). For each \( i \) scenario of a disruption \( j \) (line 18) the steady-state of disruption probability may be estimated (line 19 and 20). The set of all identified feasible scenarios is finally returned as the result of the algorithm (line 23).
Table 6-6. Algorithm of multi-mitigation scenarios

<table>
<thead>
<tr>
<th>Line</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$S \leftarrow$ SET UP THE NUMBER OF ENTITIES IN THE CHAIN ($s_1, \ldots, s_N$)</td>
</tr>
<tr>
<td>2</td>
<td>$\lambda \leftarrow$ APPLY FOUR DIFFERENT STAGE OF DISRUPTIONS ($\lambda_3, \lambda_2, \lambda_1, \lambda_0$)</td>
</tr>
<tr>
<td>3</td>
<td>$D_{ji}$ $\leftarrow$ SET UP MITIGATION SCENARIO $i$ WITH DISRUPTION $j$</td>
</tr>
<tr>
<td>4</td>
<td>$Pr(x,a) \leftarrow$ INCLUDE PROBABILITIES OF EACH ACTIONS</td>
</tr>
<tr>
<td></td>
<td>for each $C \in X$, do</td>
</tr>
<tr>
<td>5</td>
<td>$P_{ji}(t) \leftarrow P[x(t) &gt; C]$</td>
</tr>
<tr>
<td>6</td>
<td>$M_{ji} \leftarrow F_3(t) + F_1(t) + F_0(t)$</td>
</tr>
<tr>
<td>7</td>
<td>end for</td>
</tr>
<tr>
<td>8</td>
<td>for each $i$ and $j \in N$, do</td>
</tr>
<tr>
<td>9</td>
<td>$p_{ij} \leftarrow$ Transition probabilities</td>
</tr>
<tr>
<td>10</td>
<td>$DM_{ji} \leftarrow$ Transition costs</td>
</tr>
<tr>
<td>11</td>
<td>end for</td>
</tr>
<tr>
<td>12</td>
<td>$V_i \leftarrow \min { q_i^- + \beta \sum_{j \neq i} p_{ij} v_j }$</td>
</tr>
<tr>
<td>13</td>
<td>If $V_i$ is undefined then</td>
</tr>
<tr>
<td>14</td>
<td>$V_i = q_i^- + \beta \sum_{j \neq i} p_{ij} v_j$</td>
</tr>
<tr>
<td>15</td>
<td>Else, $V_i \leftarrow \Phi$</td>
</tr>
<tr>
<td>16</td>
<td>end if</td>
</tr>
<tr>
<td>17</td>
<td>$V_{j'} \leftarrow V(X, DM_{j'}, V \in R$ (reward)</td>
</tr>
<tr>
<td>18</td>
<td>for each $i=1, N$, do</td>
</tr>
<tr>
<td>19</td>
<td>$\pi_i \leftarrow$ probabilities of disruption $j$ at period $n$</td>
</tr>
<tr>
<td>20</td>
<td>$\pi_i \leftarrow \pi (P_{ij}, \pi_j)$</td>
</tr>
<tr>
<td>21</td>
<td>end for</td>
</tr>
<tr>
<td>22</td>
<td>end if</td>
</tr>
<tr>
<td>23</td>
<td>return $S$</td>
</tr>
</tbody>
</table>

Source: Author

6.4.6 Optimised strategies of the case

The recommended and optimised disruption management plan is calculated using Markov’s disruption transition matrix that is based on the minimum cost of actions. Inventory planning is recommended to be applied for entities as farmers, handlers, Australian forwarders, retailers, and final consumers. This can be achieved by increasing the inventory level until the supply chain condition may recover to normal state again. In addition, the strategy of postponement delays is suggested by the Markov decision process to be implemented by Australian shippers and forwarders when the case of dry bulk ship shortage happens due to the freight increase of dry bulk shipping.

On the maritime operation side, it is recommended that containerisation (or changes to working practice) is a supply chain key solution particularly for Australian shipping, Indonesian shipping, Indonesian ports, consignees and forwarders in Indonesia.
Table 6-7 shows the results of the assessment of multi-disruption management scenarios of the case (see Appendix H section A to section G). The table shows the results of the assessment of multi-disruption management scenarios of the study when mitigating maritime disruptions on the Australian-Indonesian wheat supply chain. MDP proposes strategies (in the column of action name) that may be implemented by entities (state name column). State value is a contractual cost required by each entity when a disruption occurs to handle the total wheat shipment (Table 6-6, line 15). The value is calculated from the total tonnage of monthly wheat shipment (8,333 tonnes) and contractual costs allocated by entities.

<table>
<thead>
<tr>
<th>DP Solver</th>
<th>Index</th>
<th>State Name</th>
<th>State Cost</th>
<th>Final Cost</th>
<th>Step Value</th>
<th>Action Name</th>
<th>Last Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td></td>
<td>Farmers</td>
<td>1,766,596</td>
<td>1,775,429</td>
<td>2,868,913</td>
<td>Inventory polling</td>
<td>0.215</td>
</tr>
<tr>
<td>Title</td>
<td></td>
<td>Case 2006-2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal</td>
<td></td>
<td>Min</td>
<td>124,995</td>
<td>125,620</td>
<td>1,096,495</td>
<td>Postponement delays</td>
<td>0.099</td>
</tr>
<tr>
<td>States</td>
<td>14</td>
<td>Australian Shippers</td>
<td>1,833,260</td>
<td>1,842,426</td>
<td>2,449,760</td>
<td>Postponement delays</td>
<td>0.054</td>
</tr>
<tr>
<td>Actions</td>
<td>14</td>
<td>Australian Forwarders</td>
<td>1,999,920</td>
<td>2,009,920</td>
<td>3,102,237</td>
<td>Inventory polling</td>
<td>0.042</td>
</tr>
<tr>
<td>Actions/State</td>
<td>14</td>
<td>Australian shipping</td>
<td>999,960</td>
<td>1,004,960</td>
<td>1,124,955</td>
<td>Containedisled</td>
<td>0.039</td>
</tr>
<tr>
<td>Events</td>
<td>5</td>
<td>Australian ports</td>
<td>666,640</td>
<td>669,973</td>
<td>1,768,957</td>
<td>Other chain links</td>
<td>0.011</td>
</tr>
<tr>
<td>Events/Action</td>
<td>5</td>
<td>Indonesian shipping</td>
<td>708,305</td>
<td>711,847</td>
<td>1,533,300</td>
<td>Containedisled</td>
<td>0.110</td>
</tr>
<tr>
<td>Iteration Type</td>
<td>Policy</td>
<td>Indonesian ports</td>
<td>374,985</td>
<td>376,860</td>
<td>1,199,980</td>
<td>Containedisled</td>
<td>0.046</td>
</tr>
<tr>
<td>Policy Steps</td>
<td>365</td>
<td>Indonesian forwards</td>
<td>1,666,600</td>
<td>1,674,933</td>
<td>2,491,595</td>
<td>Containedisled</td>
<td>0.031</td>
</tr>
<tr>
<td>Stop Diff.</td>
<td>1E-05</td>
<td>Consignees</td>
<td>2,083,200</td>
<td>2,093,666</td>
<td>2,938,245</td>
<td>Containedisled</td>
<td>0.024</td>
</tr>
<tr>
<td>Value Error</td>
<td>3.00E-06</td>
<td>Wholesalers</td>
<td>2,124,915</td>
<td>2,135,540</td>
<td>3,024,915</td>
<td>Implication monitoring</td>
<td>0.004</td>
</tr>
<tr>
<td>Prob. Error</td>
<td>6.30E-09</td>
<td>Retailers</td>
<td>2,166,580</td>
<td>2,177,413</td>
<td>2,588,897</td>
<td>Inventory polling</td>
<td>0.001</td>
</tr>
<tr>
<td>Time Measure</td>
<td>Days</td>
<td>Final Consumers</td>
<td>2,208,245</td>
<td>2,219,296</td>
<td>2,616,562</td>
<td>Inventory polling</td>
<td>0.215</td>
</tr>
<tr>
<td>Economic Measure</td>
<td>Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount Rate</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount Factor</td>
<td>99%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step Interval</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author

The value of contractual costs is collected from the 2009 maritime disruption survey interview of 34 senior managers in the Australian-Indonesian wheat supply chain. Final cost is a maximum acceptable cost (C) of all companies (column 6, Table 6-7). The level of this cost is obtained from the value of state costs and the sensitivity factors ranging from 0.1% - 1%. In this case, 0.5% (the middle value) is applied. While the step value is actually the minimum costs occurring from 14 alternatives of scenarios given (see Table 6-6, line 13-21). The function of this value is dependent on action costs, decision value, probabilities, decision index, and discount value of costs applied across one year period or 365 days.
Applying other chain links is recommended for a new shifting of shipping service from dry bulk operation to containerised shipment. This also consequently requires the use of a container terminal rather than a grain terminal. The outputs of probabilistic level of each entity from the scenario assessment find that farmers in Australia and final consumers in Indonesia are entities with the same consequences at the end of the disruption period (for about 365 days). Following this, the higher probabilistic level of commercial and operational consequences due to maritime disruption will severely impact on Australian handlers and wheat processors and Indonesian shipping companies. It is estimated that retailers in Indonesian will have no commercial consequences as the risk affecting this entity probably may be passed over to final consumers.

6.5 Propagation effect in the wheat supply chain

In this section, the maritime disruption propagation effect model based on the Markov process is explored which continues the previous works of Kim et al. (2006, 2007), Kim and Lim (2007), and Blackhurst, Wu and O’Grady (2004). This propagation model proposes four steps as a comprehensive process: disruption state definition, disruption-state transition matrix, initial disruption management scenario with its results of the expected frequency and probabilities, and finally the disruption propagation evaluation. A more detailed description will be presented in the following subsections.

6.5.1 Propagation state definition

The discussion is started by defining the events that may trigger maritime disruptions as causal factors called instigators. Various instigators of the case include higher shipping freight, long customs and quarantine processes, severe weather conditions, and earthquakes, electrical outages, equipment down, shortage of dry bulk ships for grain, long customs and quarantine processes, lack of inland accessibility, insufficient port facilities, insufficient rail facilities, and drought in Australia. While a wheat consignment flows in the wheat supply chain, there is a possibility that entities in the
supply chain can find various uncertainties including disturbances during the supply chain process.

6.5.2 Formulating the propagation matrix

In the first stage, three processes are explored in defining the maritime disruptive-states: the gathering of occurrence data of disruptions, disruption analysis, and the defining of a set of disruption-states for a fixed mitigation policy are applied. That is, in this stage, various disruptive risks are assessed, the disruption-occurrence data is collected and analysed in a database system, and then the possible disruption-states can be defined. If $S$ is a set of disruption states, $S$ can be defined as formula (30) where:

\begin{align*}
T & = \text{a set of maximum risks or consequences (thresholds), } \{T_1, T_2, \ldots, T_n\} \\
T_i & = \text{a specific maritime disruption such as congestion, or delay or deviation} \\
S & = \text{a set of disruption-states, } \{S_1, S_2, S_i, \ldots, S_n\} \\
S_i & = \text{a pair of maximum risks or consequences (thresholds), } \{T_\alpha, T_2, \ldots, T_\gamma\},
\end{align*}

where $\alpha, \beta, \text{ and } \gamma$ are each a different threat.

In the second stage, the disruption-state transition matrix is arranged, which is a square matrix describing the probabilities of transforming from one major disruption-state in the network to another. In order to obtain the transition matrix, three processes are performed. First, disruption-states are listed by mapping the disruption-occurrence data of each disruptive event into the disruption-state, as defined in the previous step. Second, the number from one disruption-state to another is calculated. Finally, the matrix is composed. The function mapping each state $S$ to a set of maximum $T$ is as follows:

\begin{equation}
\text{Disruption-states: } S \rightarrow 2T
\end{equation}

as a function mapping each state $S$ to a set of maximum $T$.

As in stage one, the creation of a transition matrix is divided into two approaches according to the dependency among disruption risks. When a disruption occurs independently, the transition matrix can be created simply with the two tasks mentioned previously. However, when a disruption occurs that is related to others, the size and
complexity of the disruption-transition matrix are increased, depending on the number of related disruptions and the disruption-state defined in stage one. Therefore, in order to reduce the complexity and size of the transition matrix, it is essential to decide the appropriate number of disruption-states in state one. If $P$ is the transition probability matrix which is created in this process, then the entries of the matrix $P$ are specified as follows:

$$P = \begin{bmatrix}
P_{11} & P_{12} & P_{13} & \cdots & P_{14} \\
P_{21} & P_{22} & P_{23} & \cdots & P_{24} \\
P_{31} & P_{32} & P_{33} & \cdots & P_{34} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
P_{141} & P_{142} & P_{143} & \cdots & P_{144}
\end{bmatrix}$$

(32)

where $\sum_{j=1}^{n} P_{ij} = 1$, $\sum_{j=1}^{n} P_{xj} = 1, \ldots, \sum_{j=1}^{n} P_{nj} = 1$. That is, $\sum_{j=1}^{n} P_{ij} = 1$, $i=1,2,\ldots,n$

(33)

Therefore, the steady-state propagation as a result of a mitigation action $k$ at state $i$ becomes:

$$IV_x - \beta P_x V_x = [I - \beta P_x]V_x = q_x$$

(34)

Then the solution for the $i$-state

$$V_x = [I - \beta P_x]^{-1} q_x$$

(35)

Where:

$P$ : Transition probability matrix for all disruption management actions and all disruptive states

$P_x$ : Square matrix achieved from alternatives in the matrix rows of $P$ corresponding to the current actions

$q_x$ : Direct returns for the current disruption management actions

$V_x$ : Steady-state worth costs associated with the current disruption management action

$I$ : Identity matrix
6.5.3 Probabilities prediction of propagation of maritime disruption

The formulations indicating the steady-state probabilities of propagation state for disruptive events: 

\[ \Pi_i = \sum_{j=1}^{N} p_{ij}^N \pi_j \quad \text{for } i = 1, \ldots N \quad \Pi_x [Q_x - I] = u \quad (36) \]

then the probability steady-state solution, is 

\[ \Pi_x = u [Q_x - I]^{-1} \quad (37) \]

The policy values obtained for a fixed policy with a discount factor of worth values of the disruption management costs:

\[ V_i(n) : \text{Vector total costs after } n \text{ steps starting in state } i. \quad (38) \]

Recursive equations for total cost for a fixed policy with the recursive equations:

\[ V_i(n+1) = q_i^N + \sum_{j=1}^{N} p_{ij}^N v_j \quad \text{for } i = 1, \ldots N, \text{ n } = 0,1,2.. \quad (39) \]

where \( g \) is the expected cost per step of disruption responses. Whilst for large number of steps and \( V_N = 0 \), then the expected costs or \( g \) are:

\[ g + v_i = q_i^N + \sum_{j=1}^{N} p_{ij}^N v_j \quad \text{for } i = 1, \ldots N \quad (40) \]

\[ q + \sum_{j=1}^{N-1} (\xi_j - p_{ij}^N) v_j = q_i^N \quad \text{for } i = 1, \ldots N-1 \quad (41) \]

then with \( N-1 \) the formulation becomes

\[ q - \sum_{j=1}^{N-1} p_{(N-1)}^{N-1} v_j = q_N^N \quad \text{for } \xi_j = 1, \text{ if } i=j \text{ and } \xi_j = 0 \text{ if } i \neq j \quad (42) \]

While for transient systems when the mitigation state values converge to a finite value then the immediate cost for action \( k \) in state \( i \) becomes:

\[ q_i^k = c_i^k + \sum_{j=1}^{N} p_{ij}^k r_{ij} \quad (43) \]

where:

\[ N : \text{ Number of states} \]
$A_i$ : Set of disruption management actions available for state $i$

$c^k_i$ : Cost of action $k$ in state $i$

$t_{ik}^k$ : Cost for transition from state $i$ to $j$, due to action $k$

$p_{ij}^k$ : Probability of transition from state $i$ to state $j$, due to the disruption management action

By the Markov decision process, the iteration of disruption management policy which creates the recursive equation for disruption management value iteration is:

$$V_i = \min_{x_i \in A_i} \left\{ q_i^x + \beta \sum_{j=1}^{N} p_{ij}^x v_j(n) \right\} \text{ for } i = 1, \ldots, N, \text{ and } n = 0, 1, 2 \quad (44)$$

Then the optimum decision results in a value smaller than all others where

$$v_i(n+1) \leq q_i^x + \beta \sum_{j=1}^{N} p_{ij}^x v_j(n) \text{ for } x_i \in A_i, i=1 \ldots N, n=0,1,2,\ldots \quad (45)$$

Take the limit of various stages of the inequalities as $n \to \infty$ then

$$v_i \leq q_i^x + \beta \sum_{j=1}^{N} p_{ij}^x v_j \text{ for } x_i \in A_i, \ i = 1 \ldots N \quad (46)$$

The number of constraints for a given disruption state is equal to the number of management decisions:

$$v_i \leq q_i^x + \beta \sum_{j=1}^{N} p_{ij}^x v_j \text{ for } k \in A_k \quad (47)$$

or

$$v_i - \beta \sum_{j=1}^{N} p_{ij}^x v_j \leq q_i^x \text{ for } k \in A_k \quad (48)$$

or

$$(1-\beta p_{ij}^k)v_i - \beta \sum_{j=1}^{N} p_{ij}^k v_j \leq q_i^k \text{ for } k \in A_k \quad (49)$$
Then the objective is to minimise the expected costs or time of maritime disruption management over an infinite time horizon of a propagation which is:

\[ Z = \text{Min} \sum_{i=1}^{N} \delta_{i}v_{i} \]  \hspace{1cm} (50)

Where \( \delta_{i} \) is the probability of wheat supply chain operating in state \( i \).

The third stage is to obtain the initial probability vector, which represents the occurrence possibility of each disruption-state when one particular mitigating plan is implemented. In order to obtain the initial probability, the most recent disruption-occurrence data are used, which can be divided by the time period such as three, six, and nine months and one year. By analysing the most recent data, the initial probability vector is calculated using formula (51) satisfied by condition (52).

\[ P(S_1, S_2, \ldots, S_{k}, \ldots, S_n) = \left( \frac{\alpha_1}{F}, \frac{\alpha_2}{F}, \frac{\alpha_3}{F}, \frac{\alpha_4}{F} \right) \]  \hspace{1cm} (51)

Where \( \alpha \) represents the number of disruption occurrence for each state \( S_i \). Moreover, the initial (mitigating plan) probability \( P(S_i) \) of each state \( S_i \) satisfies the formula (52), as the total value of the initial probability must be one in total.

\[ \sum_{i=1}^{n} P(S_i) = 1 \]  \hspace{1cm} (52)

### 6.5.4 Propagation evaluation of the case

In this process, the probability and frequency of the disruption-occurrence that will occur in the future are estimated, using the transition matrix created and the initial probability vector. Formula (53) depicts the computation of the probability of disruption-occurrence.

\[
\begin{bmatrix}
P_1 & P_{12} & P_{13} & \ldots & P_{14} \\
\vdots & \ddots & \ddots & \ddots & \ddots \\
\vdots & \ddots & \ddots & \ddots & \ddots \\
\vdots & \ddots & \ddots & \ddots & \ddots \\
P_{n1} & P_{n2} & P_{n3} & \ldots & P_{nn}
\end{bmatrix} = P(S_1, S_2, \ldots, S_{k}, \ldots, S_n) \]  \hspace{1cm} (53)
where \( n \) is the number of threat-states, \( P(S_i) \) the initial probability of each disruption-state, and \( P'(S_i) \) the next probability of disruption-occurrence. Finally, the Expected Frequency (\( EF \)) of threat-occurrence is estimated using the probability of disruption-occurrence and the median for each disruption-state, as formula (54).

\[
EF = \sum_{i=1}^{n} P(S_i) \cdot M(S_i)
\]  

(54)

where \( n \) is the number of disruption-states, \( P(S_i) \) the probability of disruption occurrence for disruption-state \( i \), and \( M(S_i) \) the median of each disruption-state \( i \). In that figure, the list of disruption management actions is recommended for each transport step starting from farmers to final consumers from zero to 360 days (steps).

### 6.6 The assessment result

In general, by applying multi-strategy scenarios, business entities on the maritime leg may be affected with relatively low levels of risk probabilities ranging from three to five per cent; whilst farmers and final consumers may experience maritime risk probabilities in the range of 21-22 per cent as the expected frequency (\( EF \)) of the entities. This is different from handlers and processors who may have 10-11 per cent of maritime disruption risks. The outputs of transition probabilities of the case are presented for 360 days. From day zero to the 20\(^{th}\) day, farmers are estimated to have transition probabilistic levels ranging from 55 per cent to 18 per cent as an entity in the chain that may experience the highest level of risk consequences. Similarly, handlers in the chain may have 50 per cent to 18 per cent as a probabilistic level; whilst processors in Australia and Indonesian shipping companies (25 per cent to 18 per cent) and wholesalers are in the range with the transition probability level at 0.4 per cent.

If the maritime disruption event is continuing, in the range of 21-40 and 40-60 days, the amplitude of transition probabilities is decreased for all entities (except wholesalers which still remain at 0.4%) to get 18-21 per cent for farmers, and 10 per cent for handlers, processors and Indonesian shipping companies. After the period of the 60\(^{th}\) day, the transition probabilities pattern takes a similar configuration with a constant level of values. Thus, transition probability outputs from days 342 to 360 have a
constant level for all entities (see Appendix H section B). The result of detailed calculation of disruption propagation effect appears in Figure 6-8.

**Figure 6-8. The transition probabilities of one year wheat supply chain**  
Source: Author

Figure 6-8 shows the expected frequencies (EF, formula 54) of entities from the period of day 0 to 360th. The figure also shows four different periods of EF which is defined as transition probabilities or probabilities in different steps in time, pij, between the normal period of day 0 to various disruptive states and constantly attain the last EF at the day of 342nd to 360th.
Further, in the constant level of transition probability, there are three groups of transition probabilities. One is the group of two entities namely farmers and final consumers (in Indonesia) that may be clustered in a similar probability value. Moreover, farmers and final consumers are entities that may experience a high likelihood of disruption consequences (21.5 per cent).

In detail, the unavailability of ships due to higher freight level costs including the competition with other industries such as mining, creates uncertainty of loading and transporting accessibility of Australian farmers to the Indonesian market. Due to the impact of the supply uncertainty from Australia to Indonesia (due to the problem of ship shortages), final consumers in Indonesia may suffer by paying a higher price for flour and other manufactured wheat commodities due to a higher level of shipping freight.

The second groups that may receive a medium level of disruption consequences are handlers and processors in Australia and Indonesian shipping companies in Indonesia. These three entities with their value added services such as pooling and processing semi-finished products, international and domestic shipping will have the disruption risk consequences of approximately ten per cent in the wheat supply chain. This probability level is calculated by the Markov chain process based on the service output of these three entities creating parallel services, including the transportation process which includes the transfer of maritime disruption risks. Therefore, these entities applied adaptation approaches rather than implementing mitigation actions. Thus, in principal, the application of multi-disruption management scenarios using the Markov chain decision process in maritime disruption may minimise the consequences of the risks in the wheat supply chain by applying adaptation strategies rather than mitigation and intervention actions. The selling price of wheat commodities may be one piece of evidence in which the maximum increasing price of wheat products is in the range of 21-25 per cent rather than 250 per cent as occurred in 2007-2008.

In the Australian-Indonesian wheat supply chain, there can be a deviation process in wheat transport if one selected unloading port is having problems due to the shortage of dry bulk fleet or high shipping freight situations. These events that may trigger a disruption are referred to as instigators (Jason et al. 2002). The occurrence of a
stimulator depends on the circumstances which is the vector of situational attributes. Obviously, some system states are more likely at risk than others. Similar to this, ports in Australia operating with a variety of multimodal transport for its inland access are at a lower risk than ports operating in Indonesia with an insufficient road or inland transport capacity. Figure 6-9 shows the consequences of different situation attributes on the various steps of the maritime disruption propagation in the case of Australian-Indonesian wheat supply chain (as confirmed in Appendix G section P, T, and AE). A stimulator may lead to one disruptive event at both the 1st and 2nd layer of disruptions.

![Diagram](image-url)

**Figure 6-9. The framework of propagation effects of maritime disruptions**
Source: Author

Entities such as Australian shipping companies, forwarders, ports and shippers, and Indonesian forwarders, ports, consignees and wholesalers are estimated to have the same probability level of 0.5 to five per cent. As a group, the likelihood of future maritime disruption risks will fall to low level as the consequence of the maritime disruption risks will be passed on to farmers and final consumers in the wheat supply chain.

The 1st layer disruption types occurring as a result of the stimulators include shortage of shipping services, shortage of storage services at ports, disputes between port operators
and shipping companies, and insufficient empty containers. The 2\textsuperscript{nd} layer disruption types that may occur following 1\textsuperscript{st} layer disruptions include delays, deviations, and unavailability of maritime services such as port stoppages and no shipping services for particular routes. The potential consequences of maritime disruptions include cargo rerouting, poor business reputation, higher logistics costs, loss of profit, and higher prices of wheat commodities including flour and noodles. Since the system state influences the likelihood of a disruption at every step starting from the occurrence of a stimulator up to the consequences of the maritime disruption, the response preparation needs to utilise the effect of the dynamic nature of the wheat supply chain on the maritime disruption. The situational attributes are divided into four categories: attributes influencing disruption scope, consequences, attributes influencing characters, and processes.

The first step of a propagation analysis is the identification of the scope of disruptive events leading to a disruption and its consequences. A disruption is not a single event, but the result of a series of events. In the case of the Australian-Indonesian wheat supply chain, the deficiency of shipping services is the main problem on the maritime leg internally and reduces the shipping transport capacity in the wheat supply chain externally. Those internal and external scopes can be explained as serial and parallel processes. Consequently, higher logistics costs including higher prices of flour and noodles are the direct effects of the disruptive events. The various propagation effects characteristics are explained in Table 6-8 below.

Further, poor commercial reputation, which may cause loss of profit for sellers or entities in the supply chain, is the indirect consequences of the case due to the disruptive event. In addition to identifying different characteristics of disruptive events that may include delay, deviation, stoppage of service, and loss of service platform, it may also affect the consequences by different degrees of severity. Four different parameters are used to unambiguously identify the nature of the propagation effect under consideration. By using the enumerative approach in categorising the effects into four types such as scope, consequences, characters, and processes; maritime providers may select effective and acceptable disruption management plans appropriately.
Table 6-8. Classification of propagation effect

<table>
<thead>
<tr>
<th>CLASSIFICATIONS</th>
<th>CHARACTERS</th>
<th>EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
<td>Internal</td>
<td>Shortage of shipping service</td>
</tr>
<tr>
<td></td>
<td>External</td>
<td>Lower shipping transport capacity</td>
</tr>
<tr>
<td>Consequences</td>
<td>Direct</td>
<td>Cargo rerouting + changing shipment operation → higher logistics costs → higher flour + noodles</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>Poor seller reputation → Loss of profit</td>
</tr>
<tr>
<td>Characters</td>
<td>Delay</td>
<td>Insufficient of empty containers</td>
</tr>
<tr>
<td></td>
<td>Deviation</td>
<td>Shortages of storage services at ports</td>
</tr>
<tr>
<td></td>
<td>Stoppage of service</td>
<td>Shortage of shipping service</td>
</tr>
<tr>
<td></td>
<td>Loss of service platform</td>
<td>Dispute of shipping and port operators</td>
</tr>
<tr>
<td>Processes</td>
<td>Serial</td>
<td>Shortage of shipping service → higher shipping freight for international and domestic leg</td>
</tr>
<tr>
<td></td>
<td>Parallel</td>
<td>Lower shipping transport capacity → lower supply chain performance in time and quantity</td>
</tr>
</tbody>
</table>

Source: Adapted from Reiners et al. (2009)

6.7 Summary

The assessment of a disruption management scenario serves a further purpose as it contains decision making variables, which are used to explore the linkages between various disruption management strategies selected with the consequences when maritime disruptions occur. The approach used for the disruption assessments has been developed using Markovian techniques developed by the researcher in optimising three essential factors such as i) the shippers’ preferences; ii) the acceptance standard of consequences, and iii) the correlation of management plans and supply chain performances in the Australian-Indonesian wheat supply chain.

As a result, by using the Markov probabilistic theory, the projection of future probabilities, consequences value, frequencies, and propagation impacts due to multi-mitigation scenarios may be identified from the knowledge of previous outcomes. In the Australian-Indonesian wheat supply chain, the dynamics of maritime disruption in terms of the period of disruption may be estimated by the values of EF as transition probabilities. In addition, at the end of the assessment period, it is of interest to find that farmers and final consumers are entities who receive the highest risk value (R+) in the wheat supply chain. In addition, by applying the Markov process, the approach recommends adaptation strategies for senior managers as a tool to select the best
outcomes in managing maritime disruptions from the three strategies of mitigation, adaptation, and intervention.

The following chapter, Chapter Seven, presents the conclusion, research limitations and recommendation for future research that may be conducted for various reasons and aspects.
CHAPTER SEVEN

SUMMARY AND CONCLUSIONS
7.1 Introduction

This research began in Chapter 1 by explaining that supply chain operators are facing uncertainties in a wheat supply chain network due to various internal and external factors disrupting the process of transporting wheat products from the origin of the wheat source to various destinations. Within this thesis it became evident that the maritime leg in the Australian-Indonesian wheat supply chain is a critical sector due to maritime disruptions that may occur in shipping and port-related entities.

This final chapter, which contains four sections, provides a summary of the maritime disruption research, including the study findings, contributions and how the primary and subsidiary research questions have been addressed. The chapter also explains the study limitations in terms of seven factors including the participants in the sample, behaviour questionnaire, self-reporting issues, sensitivity, internal validity, real cases, and generalisability. The final section provides suggestions and recommendations for future research.

7.2 Summary of results

This research set out to examine the extent to which the operational mechanism of maritime disruption impacts on supply chain processes in general and on the Australian-Indonesian wheat supply chain in particular. The primary research question (PRQ) enquired ‘Does the maritime leg contribute to disruptions in the wheat supply chain between Australia and Indonesia?’. The research found that maritime disruptions in the wheat supply chain exist and can be considered a significant factor in diminishing supply chain performance. Various unwanted internal and external factors creating uncertainty and severe negative consequences in the maritime leg are involved in maritime disruption risks. Maritime disruption was found to consist of four types of disruption states: the delay and deviation stages of previously normal operational plans, which may subsequently create a stoppage of the maritime service, and then possibly culminating in the loss of the service platform or a disaster for the maritime operation. Another finding was that these four stages of maritime disruption are not fully
investigated in the supply chain risk literature. Therefore, this thesis has had to expand on the existing outcomes of others (Blackhurst et al. 2004; Cavinato 2004; Bearing-Point & Hewlett-Packard 2005; Yang et al. 2005; Gaonkar & Viswanadham 2007; Handfield et al. 2008). In addition, the four significant factors of (a) instigating factors, (b) inter-dependent factors, (c) leadership risks, and (d) progressive factors are the framework analysis that may contribute to the occurrence of maritime disruptions in the wheat supply chain. The framework analysis of maritime disruptions presented in this thesis resulted in adding to the existing literature in the area of supply chain disruption by identifying these four factors as a source of a maritime disruptive event and in doing so, assists in addressing PRQ.

Another significant finding of the research is that a dynamic risk management strategy is ideally suited to detecting and monitoring maritime disruptions. In addition, the research found that a network of risk management and response strategies implementing single reactions across entities in the wheat supply chain can be a cost-effective option to assist disruption mitigation. However, due to the use of general risk management approaches, events creating delays and deviations were not accounted for, resulting in insufficient preparedness and response by senior managers in the wheat supply chain. This is of concern particularly in port and shipping operations because the maritime leg is highly disruptive and variable (spatially and temporally).

The operational impact in the wheat supply chain is evidence of maritime disruptions. Senior managers in the wheat supply chain in this study indicated that 31 possible maritime event disruptions are becoming more prevalent particularly in a port area. The 31 events comprised 20 events in the supply chain and another 11 events at a port. In general, respondents indicate that maritime disruptions significantly reduce the level of port services (due to delays and deviations from planned operations), and stop port services (due to port closures and loss of port service platform). Events such as congestion, earthquakes (particularly those in Indonesia), and severe weather generated port closures. Moreover, senior managers (particularly those in Indonesia) experienced the loss of service platform of their ports due to earthquakes. There are 13 events that created delays and 14 events that generated deviations at ports. These findings are consistent with previous discussions where individual maritime disruptions were
correlated with short-term consequences (such as delays and deviation) and extensive unavailability of port services with a long-term orientation (Vanags 2002; Bearing-Point & Hewlett-Packard 2005; Pinto & Wayne 2006; Pettitt 2007; Garcia 2008; Guerrero et al. 2008; Handfield et al. 2008). Further, in terms of a disruption cycle, the research found that maritime disruptions in the wheat supply chain are risk events which have a relatively long-term period of 90 days from the stage of discovery to recovery. Thus, maritime users in the current study recognised the existence of the range of maritime disruptions in the wheat supply chain. The above discussion on operational impacts and the disruption cycle provides answers to the first subsidiary research question (SRQ1): Are shippers and consignees aware of the disruptions that may occur in the maritime leg of the Australian-Indonesian wheat supply chain?

As a result of the data collected via the telephone survey, the study found that the main strategies applied by all entities in the wheat supply chain are mitigation, adaptation, coordination, and intervention strategies. This finding addresses the second subsidiary research question (SRQ2): Are shippers and consignees in the Australian-Indonesian wheat supply chain implementing supply risk assessments or mitigation strategies to minimise the maritime disruption events? In relation to mitigation strategies, entities in the wheat supply chain used two major contingency actions, supply flexibility and insurance management. This was achieved through transferring risk or risk-sharing decision methods such as insurance plans (generally for marine cargo insurance) and outsourcing strategies. Other entities along the chain also utilised reserved maritime routes, providing strategic stock (through agency service) and back-up systems, and optimum ordering policies in their contingency plans for responding to worst case scenarios of maritime disruptions. These mitigations were undertaken problems arose with the shortage of dry bulk ships in the market and port congestion problems, particularly in some Australian grain terminals.

Adaptation strategies implemented by entities were inventory polling at ports, various changing of working practices, and applying the impact monitoring programs. Inventory pooling at ports was selected if problems such as the shortage of ships, the closure of unloading ports for various reasons, and the payment delay of cargoes in the country of
buyers occur. The other essential adaptation strategy implemented in the disruption stage was to employ impact monitoring action.

In terms of intervention strategies, the current study found that the intervention response in the wheat supply chain is usually controlled by dominant agribusiness corporations in the chain rather than individual farmers. In addition, the structure of the bargaining power in the wheat supply, including the transportation process, is controlled by 3 P/Ls or 4 P/Ls, wheat marketing bodies (such as Australian Wheat Board, and BULOG in Indonesia), and government agencies such as port authorities.

To address the third subsidiary research question (SRQ3): *Are current risk mitigation and detection processes in maritime operations effective in the Australian-Indonesian wheat supply chain system?*, the research has noted that, senior managers suggested that the efficient and effective responses or strategies in managing disruptions are obtained mainly through contingency, flexible supply, and business continuity management responses between entities along the chain. Through the commercial and operational consequences when maritime disruptions occurred, it was found that there is uncertainty in the practice of providing actions to manage disruptions. As a result, mitigations and responses of entities along the chain rely upon external factors to their organisation such as from 3P/L or 4P/L, a wheat marketing body, and government agencies. Thus, the resulting actions were relatively passive rather than providing an active certain response within their organisation.

In order to further explore the SRQ 3 in terms of disruption management efficiency, the assessment of disruption management scenarios using the Markov chain method has been suggested, as a value added contribution of the study, to optimise the outcomes of the decision making process during maritime disruption risk events. The use of the Markov chain approach is to provide a comprehensive network scale assessment of disruptive events when compared to traditional maritime risk analysis. Traditional maritime risk analysis processes are mainly aimed at providing detailed problem insights within small scale interactions of entities in the supply chain (Yu & Qi 2004; Blackhurst et al. 2005). In addition, the existing risk mitigation processes are not set up to work early in conceptual design with limited information. Therefore by using the
Markov chain approach, potential responses and preparedness to eliminate possible disruptive events may be quantified and optimised early in the planning process of a supply chain before spending a significant amount of the risk management budget to examine them.

The responses and preparedness, from the primary data collected from the telephone survey, were then applied to the single-entity during the process of transporting wheat, to improve the accuracy of the supply chain performance. This approach offers considerable cost savings for maritime disruption applications. Due to the complexity of the wheat supply chain from Australia to Indonesia, a set of multi-scenarios were established to encompass more than one active response, and therefore provide a networked mitigation for several single-disruption events.

The assessment of multi-disruption management scenarios adds to the existing literature on the stochastic approach of the Markov decision process (Yang et al. 2005; Tomlin 2006; Carpignano et al. 2009; Xiao et al. 2009; Jensen 2010). Therefore, although this thesis mainly focuses on the case of the Australian-Indonesian wheat supply chain, the methodology can be utilised for a variety of applications in other supply chains particularly in grain or agriculture with dry-bulk and containerised based shipments.

The first important feature of this process is that it emphasizes the sources of maritime disruptions. Further, the process allows for the examination of a set of assumptions about the possible internal and external factors generating disruptions in the wheat supply chain. The disruption risks associated with these assumptions are examined. It is easier to demonstrate where the disruption risks originated and how the probabilities and consequences were determined. The other important feature of this process is the collective risk across the supply chain network and its consequence values on each scenario. Using the secondary data of the 2006-2008 dry bulk ship shortage in the Australian-Indonesian wheat supply chain, it can be identified that the unavailability of ships due to higher freight level costs, including the competition with other industries such as mining, during that period created disruptive flows of loading and transporting accessibility for Australian farmers exporting to the Indonesian market. As the impact of the supply disruptions from Australia to Indonesia increased (due to the problem of
ship shortages), final consumers in Indonesia suffered by paying a higher price for flour and other manufactured wheat commodities due to a higher level of shipping freight.

The second group that may attract a medium level of disruption consequences are handlers and processors in Australia and Indonesian shipping companies in Indonesia. These three entities with their value added services such as pooling and processing semi-finished products, international and domestic shipping will have the disruption risk consequences of approximately ten per cent in the wheat supply chain. This probability level is calculated by the Markov chain process based on the service output of these three entities creating parallel services, including the transportation process which includes the transfer of maritime disruption risks. Entities such as Australian shipping companies, forwarders, ports and shippers, and Indonesian forwarders, ports, consignees and wholesalers are estimated to have the same probability level of 0.5 to five per cent. As a group, the future maritime disruption risks may fall to a low level as a consequence of the maritime disruption risks being passed on to farmers and final consumers in the wheat supply chain.

Another unanticipated significant finding of this study in relation to the data collection method is that a telephone survey is an effective means of gathering data from senior managers. In particular, the telephone survey enabled the impact of maritime disruptions, the significant factors in managing the disruptions, and the cycle process of maritime disruptions to be investigated in depth. The success of using telephone interviews is evidenced by a response rate of 68 per cent with the average interview being 32 minutes with a range of 15 to 90 minutes. The response rate compares favourable to previous studies on senior managers that have used telephone interviews (Conklin 1999; Cahoon 2004; Naoya & Wen 2005; Dracther 2007; Bonsall & Shirez 2009). The advantage of conducting a telephone survey in this research is related to three factors as informed by respondents such as (1) the flexibility of time and place, (2) the preference of answering open-ended questions, and (3) the free expression during the interview discussion.
7.3 Study limitations

All research activities have limitations, and all results need to be interpreted according to these limitations. The limitations of this study are presented in relation to participants in the sample, and generalisability. Suggestions for modifications are discussed in the following sub-sections.

7.3.1 Participants: selection bias and manager desirability

The participants were self-selected, highly educated, mostly having a supply chain background, and reported high levels of intentions toward wheat transport as well as the impact of maritime disruptions and its consequences in the wheat trade. It is likely that managers who volunteered to participate in this study are not representative of the general population. Managers in this study are more likely to be concerned about detailed disruption management strategies that are more likely to be executed in relation to various maritime disruptive events. In this research, this process has not been carried out. In any future research, participation of executives in the real case modelling may contribute to the detailed implementation procedures of maritime disruption risk mitigations.

7.3.2 Generalisability

The study results may be generalised to other applications of the wheat supply chain such as similar shipping and port operations both in Australia and Indonesia, but the complexity of maritime services may not be generalised to one particular area. In addition, most respondents were assumed to have sufficient information and perceptions of maritime operations and wheat supply chain process in both countries. However, the variety of education level and knowledge of respondents in the supply chain have created different levels of perception of the maritime operations. In addition, different roles of similarly titled of positions such as operation manager in both countries across the wheat supply chain may have different authorities in implementing policy and direct reactions to minimise maritime disruptions.

Decision making processes for collaboration and coordination and the information recovery
cost were not recorded, which may have influenced interpretation of the status of maritime disruptions. Future research may include other measures of network or community scale behaviours where maritime disruptions occur. Experimental studies of intentions behaviours relationships for crisis situations or stages are issues that can also be covered in future research. Studies of Carpignano et al. (2009), James (2008) and Anderson-Berry (2003) suggest that implementation intentions (specifying how, when, and where someone will participate in certain behaviours) may be more effective in evaluating intentions than general statements of intentions that were used in this study.

### 7.4 Suggestions and recommendations for future research

In this study the disruptions management scenarios were generated in post-processing mode and applied to the single frequency network in order to investigate the performance of the proposed data processing methodology. In the case of a long-term deployment of such a mitigation-based maritime monitoring system however, a near real-time solution is expected by practitioners in the wheat business. Maritime disruption management results can then be consequently analysed in order to detect various indicators and to present the results in an easy to understand manner, such as using the propagation and risk assessment. It is important to ensure that the operation planner can understand and use this information for assessment of the disruptions presented by a potential maritime service with minimum delays, deviations, and stoppages. The real cases of the other 17 maritime disruptive events as found in the survey need to be investigated in the future in order to explore various disruption management strategies on different instigating factors respectively. In addition, the network of the wheat supply chain in domestic markets in both Australia and Indonesia to include other grain commodities could be undertaken in future research such as soya bean and rice as these two commodities have a high volume of international trade between Australia and Indonesia.

In order to move towards a ‘true’ real-time disruption monitoring system, the internal risk management system used to transfer the risk data from the operations stations to the board of manager or directors can be improved. If the internal plans are set as an
asynchronous decision and a unique address is assigned to each disruptive event, data from all states in the wheat supply chain can be sent continuously and sorted by other stages in the same supply chain. This allows a larger number of wheat chain entities in the network to respond consistently because the response pooling methodology currently in use restricts the number of reactions by the wheat controlling body. The disruption management corrections should be transferred to the operation section in the transportation stage to enable service processing without delay. Eventually this can result in an intelligent maritime disruptions monitoring system that is able to change between the processing of hourly static events in operations periods and processing in contingency mode if increased maritime disruption activity is observed.

Further, decision makers have the authority to eliminate risky mitigation, adaptation, and intervention options but also should have the ability to demonstrate why these options were eliminated. Since disruption strategy options are likely to be more risky, potential preparedness strategies can be chosen with the express purpose of being robust enough to change. Being able to choose a disruption management approach that is robust over a variety of potential future scenarios can increase the probability of the company avoiding losses due to various maritime disruptions. As minimum losses are the primary driver for most companies, this is a reference point that can be used for future research in assessing optimum disruption management scenarios. In addition, the mitigation assessment process in the future is expected to allow decision makers to have a better understanding of how management decision making does not only concern the performance requirements within their organisation, but also both life cycles of management cost and maritime disruption events.

It is suggested that future studies should investigate topics such as:

- Maritime disruptions in liquid bulk cargo such as oil tanker and LNG shipping operations both in domestic and international waters.
- Preparing an optimised budget to be allocated for applying adaptation strategies in managing maritime disruptions.
- Broadening the scope of maritime disruption management in the context of crisis management.
- Developing the assessment technique of disruption management with a robust optimisation method.

Finally, the results of this current study indicate that maritime disruptions are important to academic researchers as a theoretical discipline, and as a practical ground for examining such risk events in a complex supply chain network. Also, the balance of mitigation, adaptation, and intervention are important for any managers of a wheat supply chain network to understand. Hence, it is hoped that the new insights resulted by this study will augment the existing body of distinguished literature, and also assist senior managers as they attempt to manage dynamic and complex inter-organisational supply chain relationships. In addition, the results suggest that maritime disruptions in a supply chain are worthy of continued research with a view towards a commercial assessment and implementation.
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APPENDIX A : SURVEY INSTRUMENT
CONFIDENTIAL

2009 STUDY OF MARITIME DISRUPTIONS IN THE AUSTRALIA-INDONESIA WHEAT SUPPLY CHAIN

Document Number : ______________________
Date of Interview : ______/__________/2009
Time Started : ______________________
Time Completed : ______________________
Length of Interview : ______________________
INTRODUCTION

Good morning/afternoon Mr/Mrs/Ms ______________I am Saut Gurning calling you from the Australian Maritime College, about the study on maritime disruptions in the Australia-Indonesia wheat supply chain. At an earlier time, you indicated that you would be willing to participate in an interview at this time.

Is this still a convenient time for you?

Better time

The interview will last about 30 minutes, and can be arranged for a time convenient to your schedule. Which day and time would be suitable for you?

Start the interview

Involvement in this interview is entirely voluntary. You may decline to answer any of the interview questions you do not wish to answer and may terminate the interview at any time. All information you provide will be treated as confidential.

As I indicated on the letter, the purpose of the study is to evaluate the contribution of maritime operations in the wheat supply chain process and then determine the effectiveness of the responses and mitigation activities when maritime disruptions occur. You will not be identified by name in the research report.

Are you ready to continue?

Recording of interview

Would you be agreeable to me recording this interview to ensure your responses are recorded accurately?

Response Card

We will be using several response cards during the interview. They were included with the letter I sent. Do you have them with you?

Begin survey

Good, then we will begin the survey now.
SECTION A. Demographic questions

A.1 Could you please explain your responsibilities in your organisation?

..............................................................................................................................................................

A.2 Do you have a supply chain role in your organisation?

Yes .................................................................................................................................................. 01 → Go to next question

No .................................................................................................................................................. 02 → Go to question A.4

Unsure ................................................................................................................................................ 03 → Go to question A.4

A.3 For how many years have you had a supply chain role in your organisation?

< 1 ______ 01 2–5 ______ 02 6–10 ______ 03

11–15 ______ 04 16+ ______ 05

A.4 Does your organisation have a formal department or division dealing with risk matters in your supply chain?

Yes .................................................................................................................................................. 01 → Go to next question

No .................................................................................................................................................. 02 → Go to section A.6

Unsure ................................................................................................................................................ 03 → Go to section A.6

A.5 What is the name of the risk department in your organisation?

..............................................................................................................................................................

A.6 In which division in your organisation are risk related factors dealt with?

Marketing ........................................................................................................................................ 01

Operations ......................................................................................................................................... 02

Logistics / Supply chain .................................................................................................................. 03

Sales .................................................................................................................................................. 04

Corporate services .......................................................................................................................... 05

Others ............................................................................................................................................... 06
SECTION B. Disruption process (including delays and deviations)

B.1 Now, I would like to ask you questions about the type of disruptions that may occur in your organisation. In general, a disruption may relate to a service in your supply chain being unavailable. What terminology does your organisation use to refer to this type of risk?

- Interruptions
- Disturbances
- Stoppages
- Delays
- Deviations
- Disruptions
- Others,

B.2 In the last two years, has any part of your organisation experienced any disruptions in your wheat supply chain?

- Yes
- No
- Unsure

(If No or unsure, For B.3 ask: Have any of the following risks occurred in your international supply chain...)

B.3 Which of the following risks best describe any severe disruptions in the international supply chain of your wheat trade in the last two years?

- Market risks (demand, supply, and fluctuation of prices)
- Legal risks (mainly due to a legality of contracts and regulations)
- Technical risks (due to obsolete or not functioning as planned)
- Environmental risks (natural disasters, climate/weather or pollution)
- Operational risks (mainly due to transportation and shipment risks)
- Financial risks (mainly due to shortage of financial resources)
- Security risks (such as terrorism and piracy)
- Are there any types of risks that were not included?

B.4 Please view the wheat supply chain diagram sent with the response cards. The diagram shows the
Australia-Indonesia wheat supply chain starting from Australian farmers to handlers and processors then followed by various maritime distributors in the Australian part of the wheat chain. The diagram then shows the Indonesian section of the wheat chain from the maritime distributors to wholesalers, retailers, and finally to consumers. Could you please indicate any stages of that diagram marked A to M where disruptions have occurred in your wheat supply chain?

A. Farmers to handlers .............................................. 01
B. Handlers to processors ........................................... 02
C. Processors to shippers in Australia ............................ 03
D. Shippers to forwarders in Australia .............................. 04
E. Port operations in Australia ........................................ 05
F. Shipping arrangements in Australia .............................. 06
G. Shipping arrangements in Indonesia ............................ 07
H. Port operations in Indonesia ....................................... 08
J. Forwarders to Consignees in Indonesia .......................... 09
K. Consignees to wholesalers in Indonesia ......................... 10
L. Wholesalers to retailers in Indonesia ........................... 11
M. Retailers to consumers in Indonesia ............................ 12

B.5 In relation to this, please indicate where your organisation’s activities are located at this time in the diagram from A to M?

B.6 Now, please view Response Card A. Consider the six modes of transport. Please rank each one of them based on their importance to your wheat supply chain where 1 is the lowest level of importance and 6 is to the most important.
Which of the following wheat routes describe your international wheat supply chain over the last two years?

- Australia - Indonesia only
- Australia - Indonesia and other international routes
- Australia - East Asian countries
- Are there any other wheat routes your organisation is dealing with?

SECTION C. Maritime disruptive events (Shipping, Port, and Freight Forwarders)

C.1 Now I would like you to consider how often, on average, the following maritime disruptions have occurred for your organisation in the last two years. Please use Response Card B to answer this question. I will be asking you about each disruption firstly in the Australian wheat chain and then in the Indonesian wheat chain.

<table>
<thead>
<tr>
<th>Australian Chain</th>
<th>Indonesia Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1Y</td>
</tr>
<tr>
<td>C.1A Security threats (acts of terrorism or piracy)</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1B Political events such as riots or wars</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1C Lack of rail facilities at port</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1D Port strikes</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1E Long customs and administration</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1F The checking cleanliness of wheat products</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1G Severe weather conditions at sea or ports</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1H Earthquakes</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1J Tsunami</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1K Electrical outages</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1L Equipment breakdown</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1M Insufficient empty containers</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1N Port congestion</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1P Shipping-port disputes</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1R Ship accidents in port areas</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1S Shortage of dry bulk ship fleets</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1T Uncertain bunkering (fuel) costs</td>
<td>1 2 3 4 5 0</td>
</tr>
<tr>
<td>C.1U Lack of inland accessibility</td>
<td>1 2 3 4 5 0</td>
</tr>
</tbody>
</table>
C.1V Communication failure
C.1W Shortage of shipping services

C.2 Are there any other disruptions that occurred in the last two years that were not included?

......................................................................................................................................................

......................................................................................................................................................

(If the respondent has only the Australia-Indonesia route then do not ask the C.3 question)

C.3 What are the maritime disruptions your organisation has experienced in the last two years for routes other than between Australia and Indonesia?

......................................................................................................................................................

......................................................................................................................................................

SECTION D. Approach to identifying potential disruptions

In this section, questions focus on how potential disruptions are identified by your organisation.

D.1 How were the maritime disruptions in your wheat supply chain discovered?

News from findings within the organisation ................................................................. 01
Informed by partners or agents ...................................................................................... 02
From industry associations or farmers’ associations ...................................................... 03
Identified through operation problems along the chain ............................................... 04
From past experience ........................................................................................................ 05
Others ........................................................................................................................................ 06

D.2 At what stage were the maritime disruptive events detected?

When significant delays of operational targets occurred ........................................ 01
When a significant deviation from existing operational plans was detected .......... 02
When service platforms were partially corrupted or inactive ................................ 03
When the disruptions produced significant consequences in other stages (after or before your organisation) in the wheat supply chain .......... 04
Others ........................................................................................................................................ 05
D.3 Please view Response Card C to answer this question. How likely is it that the following maritime disruptions may occur in your wheat supply chain in the future?

<table>
<thead>
<tr>
<th></th>
<th>Lowest</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.3A Security threats (acts of terrorism or piracy)</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3B Political events such as riots or wars</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3C Lack of rail facilities at port</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3D Port strikes</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3E Long customs and administration</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3F The checking cleanliness of wheat products</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3G Severe weather conditions at sea or ports</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3H Earthquakes</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3I Tsunami</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3K Electrical outages</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3L Equipment breakdown</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3M Insufficient empty containers</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3N Port congestion</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3P Shipping-port disputes</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3R Ship accidents in port areas</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3S Shortage of dry bulk ship fleets</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3T Uncertain bunkering (fuel) costs</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3U Lack of inland accessibility</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3V Communication failure</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
<tr>
<td>D.3W Shortage of shipping services</td>
<td>&lt; 10%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100% Don’t know</td>
</tr>
</tbody>
</table>

SECTION E. Consequences (costs and lead-time)

E.1 Now we move to questions that focus on the consequences of maritime disruptions in terms of cost, time and other commercial effects in the wheat supply chain. Please view Response Card D. In relation to the following categories of maritime disruptions your organisation has experienced in the last two years, what is the approximate financial impact (in Australian Dollars) of them in your wheat supply chain?

<table>
<thead>
<tr>
<th></th>
<th>Less than 100,000</th>
<th>101,000 to 500,000</th>
<th>501,000 to 1 million</th>
<th>1.1 million to 5 million</th>
<th>More than 5 million</th>
<th>No Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.1A Security/terrorist attacks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1B Political events such as riots</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1C Lack of rail facilities at the port</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1D Port strikes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1E Lengthy customs and administration</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1F The checking cleanliness of wheat products</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1G Severe weather conditions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1H Earthquakes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1I Tsunami</td>
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<tr>
<td>E.1K Electrical outages</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1L Equipment breakdown</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1M Insufficient empty containers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1N Shipping-port disputes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1P Ship accidents in port areas</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>E.1R Port congestion</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
E.1S Shortage of dry bulk ship fleets
E.1T Fuel and bunkering costs
E.1U Inland accessibility problems
E.1V Telecommunication failure
E.1W Shortage of shipping services

E.2 Please view Response Card E to answer this question. To what level do you agree that the following commercial consequences have been experienced by your organisation due to various maritime disruptive events in the last two years?

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.2A Discrepancies in maritime transport costs</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E.2B Loss of profit due to the decreasing of traffic demand</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E.2C Poor business reputation due to unreliable services</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E.2D Customers deciding to go to other competitors</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E.2E Higher emergency costs due to responses taken</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E.2F Permanent stoppages of cargo delivery processes</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>E.2G To attract the customer back from competitors, the tariff or freight rate should be decreased significantly</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

E.3. Are there any other issues regarding commercial consequences that were not included?

*(If yes ask for an explanation)*

E.4 For approximately how many days did maritime disruptions affect the delivery of your organisation’s service in the market in the last two years?

- 0-7
- 8-14
- 15-30
- 31-90
- 91-180
- 181-360
- 360+

E.5 In the past two years approximately how many days notice did your organisation receive that a maritime disruption occurred?

- 0-7
- 8-14
- 15-30
- 31-90
- 91-180
- 181-360
- 360+

E.6 What is the usual period of time in days that it takes for your organisation to return to normal operational levels after a maritime disruption has occurred?
SECTION F. Re-routing in the Australia-Indonesia’s wheat supply chain

We are now half way through the interview process. In the next questions, I would like to ask about re-routing decisions in the Australia to Indonesia wheat supply chain.

F1. Did any disruptions at the ports result in having to re-route the cargo to different ports?

Yes ........................................................................................................ 01 → Go to next question
No ........................................................................................................ 02 → Go to question G.1
Unsure .................................................................................................. 03 → Go to question G.1

F2. Please view Response Card C. Based on the disruptions that have occurred in the past two years resulting in wheat having to be re-routed to another port, how likely is it that a disruption may occur at the following Australian ports?

<table>
<thead>
<tr>
<th>Australian Ports</th>
<th>Lowest</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. 2A Any ports in Queensland (such as Mackay, Gladstone, and Brisbane)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2B Any ports in New South Wales (Newcastle, and Kembla)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2C Any ports in Victoria (Geelong, Melbourne and Portland)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2D Any ports in South Australia (Thevenard, Lincoln, Giles, Adelaide, Pirie, Wallaroo, and Adrossan)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2E Any ports in West Australia (Albany, Kwinana, and Esperance)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
</tbody>
</table>

F3. Please view Response Card C. Based on the disruptions that have occurred in the past two years resulting in wheat having to be re-routed to another port, how likely is it that a disruption may occur at the following Indonesian ports?

<table>
<thead>
<tr>
<th>Indonesian Ports</th>
<th>Lowest</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. 2A Any ports in Java (such as Priok, Perak, and Tanjung Emas)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2B Any ports in Kalimantan (Banjarmasin)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2C Any ports in Sulawesi (Makassar)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
<tr>
<td>F. 2D Any ports in Sumatera (Belawan)</td>
<td>&lt;10%</td>
<td>10% 25%</td>
</tr>
</tbody>
</table>
SECTION G. Single wheat marketing board

Now more specifically I would like to ask about the role of a single wheat marketing board in the Australia to Indonesia wheat supply chain.

G.1 The question requires Response Card E. To what level do you agree that a single wheat marketing board has the right to:

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>G.1A Decide the wheat selling prices</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G.1B Consider and assess the export agency</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G.1C Select the shipping companies</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G.1D Arrange the inland transport arrangements</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G.1E Arrange the selection of loading/unloading terminals</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G.1F Decide the freight level of shipping arrangements</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>G.1G Arrange the shipping contract including its risks</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

G.2 Are there any other issues regarding the single wheat marketing bodies that have not been included? (If yes, ask them to explain, otherwise go to H.1)

...........................................................................................................................................................................................................

SECTION H. Maritime disruptive events at port

H.1 In previous questions we discussed maritime disruptive events in general terms. Now I would like to ask questions that are more specific about disruptive events at ports. Based on your organisation’s experience in the Australian-Indonesian wheat supply chain, please categorise the following maritime disruptive events into consequences that either created port stoppages, or reduced port operations or indicate that the disruption did not occur.

<table>
<thead>
<tr>
<th>Disruptions before the port channel</th>
<th>Port Stoppages</th>
<th>Reduced Port Operations</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems in a nearby ship anchoring area of a port</td>
<td>01a</td>
<td>01b</td>
<td>01c</td>
</tr>
<tr>
<td>Coastguard delaying boarding and clearance</td>
<td>02a</td>
<td>02b</td>
<td>02c</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disruptions in waterways</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship collisions</td>
<td>03a</td>
<td>03b</td>
<td>03c</td>
</tr>
<tr>
<td>Hazardous spill</td>
<td>04a</td>
<td>04b</td>
<td>04c</td>
</tr>
<tr>
<td>Low tide period</td>
<td>05a</td>
<td>05b</td>
<td>05c</td>
</tr>
</tbody>
</table>
Severe waves ........................................... 06a 06b 06c
Queuing ................................................... 07a 07b 07c

**Disruptions at port berths**

Strong winds ........................................... 08a 08b 08c
Lack of pilotage and tug-boat services .......... 09a 09b 09c
Port strikes ............................................ 10a 10b 10c
Cranes and/or grain elevators disabled ....... 11a 11b 11c
Breakdown of straddle carriers in shop ......... 12a 12b 12c
Shortage of chassis and/or choppers .......... 13a 13b 13c
Fire accident on a ship while at port ............ 14a 14b 14c
Insufficient handling equipment ............... 15a 15b 15c
Earthquake ............................................. 16a 16b 16c
Tsunami .................................................. 17a 17b 17c

**Disruptions at port platform**

Port facility failure such as water distribution systems 18a 19b 19c
Heavy rain .............................................. 19a 19b 19c
Terminal information system failure ............. 20a 20b 20c
Shortage of storage or silo area ................. 21a 21b 21c
Insufficient container storage area .............. 22a 22b 22c

**Disruptions at port inland access**

Clearance of medical and quarantine checks .... 23a 23b 23c
Delay of immigration process .................... 24a 24b 24c
Customs clearance delays ......................... 25a 25b 25c

**Disruptions to port supply chain network**

Insufficient road transport infrastructure......................... □ 26a □ 26b □ 26c

Downstream intermodal problems such as inland congestion ...... □ 27a □ 27b □ 27c

H.2 Are there any other issues regarding disruptive events at port that were not included?

(If yes, ask them to explain, otherwise go to section J)

SECTION J. Operational factors of maritime disruptions

Now, I would like to ask to what level do you agree with the following operational-related matters in your maritime services. Please view Response Card E to answer the following questions.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>J.1</td>
<td>ISPS code reduces maritime security threats</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.2</td>
<td>Your organisation always uses a contingency plan for a specific situation when things could go wrong</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.3</td>
<td>Rail service supports your service appropriately</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.4</td>
<td>Labour strikes have occurred in your organisation</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.5</td>
<td>Customs and quarantine agencies are inactive in reducing longer and costly processes</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.6</td>
<td>Your organisation is adopting a reliable maintenance and repair system for any facilities and utilities used for service operations</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.7</td>
<td>Improving port capacity is the best way to deal with port congestion your organisation has faced</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.8</td>
<td>Your organisation is implementing a risk sharing plan with your business partners when disruptive events occur</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.9</td>
<td>A flexible transport arrangement is better for your organisation rather than applying fixed route network when shipping services are unavailable in your wheat supply chain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.10</td>
<td>Your organisation is employing a back up system for bunkering supplies</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.11</td>
<td>Applying a good repositioning plan is used in your organisation in dealing with empty containers</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>J.12</td>
<td>Your organisation prepared a pre-disaster plan for natural disasters that may impact on your facilities</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
SECTION K. Mitigation Process

We now move from questions focusing on risks to some general questions about your organisation’s mitigation strategy.

K.1. Please view Response Card F to answer this question. When maritime disruption occurs, does your organisation respond with any of the following actions to control the large impacts of maritime disruptive events?

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.1A Rescheduling the shipment process</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1B Increase some inventories at loading/unloading ports</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1C Utilise supply alliance networks in order to have a flexible supply-base</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1D Employing economic supply incentives</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1E Apply flexible rerouting to other ports</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1F Real-time decision support</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1G A redundancy system which includes risk detection and correction methods</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1H Controlling product exposure to customers</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1J An effective and strong coordination with other players in the wheat supply chain</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1K Business continuity plan in operation/services</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K.1L Bottom up approach to set up the mitigation plan</td>
<td>5 4 3 2 1 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

K.2 If there are various alternative responses when maritime disruptions occurs, please describe in general how decision making processes are determined.

............................................................................................................................
............................................................................................................................
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............................................................................................................................
............................................................................................................................
SECTION L. Propagation effect on supply chain performance

L.1. Please view Response Card E to answer this question. To what level do you agree that the following statements may explain the impact of maritime disruptions through the whole wheat supply chain.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.1A</td>
<td>The maritime disruptions affect the wheat retailers’ prices</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L.1B</td>
<td>Stages prior to maritime service (such as handlers) may initiate the maritime disruptions</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L.1C</td>
<td>Inability of your company to fulfil the wheat supply chain performance may create maritime disruptions for companies further down the supply chain</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L.1D</td>
<td>All stages along the chain have an equal risk probability to create maritime disruptions</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L.1E</td>
<td>All stages along the chain have an equal risk probability to suffer from maritime disruptions</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

L.2 Are there any other issues regarding the maritime disruption impact that were not included?

SECTION M. Education qualification

We are almost finished the interview. I have a few questions about the potential benefits of education for working in your industry.

M.1 Do you have any logistics or business-related qualifications?

- Yes................................................................. ☐ 01
- No.................................................................. ☐ 02
- Unsure......................................................... ☐ 03

M.2 Have you found that they were useful for helping you to perform your job in your current and previous position?

- Yes.................................................................. ☐ 01 → Go to next question
- No.................................................................. ☐ 02 → Go to question M.4
- Unsure........................................................... ☐ 03 → Go to question M.4

M.3 How does your logistics or business-related qualification help you in your current and previous position?

..........................................................................................................................
M.4 Would you like to receive a copy of summary results of the study when they become available?

Yes .......................................................... 01 → Then ask the detail contact address
No .......................................................... 02 → Go to closing statement

Name : .......................................................... 03
Position title : ........................................... 04
Email address : ........................................... 05
OR
Postal address : ........................................... 06

CLOSING STATEMENT AND QUESTION

This completes our interview, thank you for your time and assistance with this research. Do you have any further questions?

.........................................................................................................................................................
APPENDIX B : PRETESTING LETTER
Dear ……

Thank you for agreeing to pre-test the telephone survey that will be used in my 2009 Maritime Disruptions Study to fulfil the requirements of a PhD thesis.

I am a PhD candidate at the Department of Maritime and Logistics Management, the Australian Maritime College, University of Tasmania (UTAS).

Please pre-test the following documents:

- Two advance letters
  - One for industry association
  - One for managers
- Confirmatory document for appointments with respondents
- Telephone survey labelled as “confidential” with its response cards
- Participant information sheet (as required by the Ethics Committee)

**The objective of the research**

The main aims of the research are to recognise the contribution of maritime operations in the supply chain process and then determine the effectiveness of the responses and mitigation activities when maritime disruptions occur. To achieve this, samples in Australia and Indonesia of wheat supply chain operators will be surveyed. A potential outcome of this research is the identification of maritime risk-related factors that are critical not only for Australian and Indonesian wheat supply chain operators but also for other international wheat supply chains.

Further, the essential goal of the study is to explore the following research questions which determine the focus of the research.

The primary research question of this study is as follows:

*Are shippers and consignees aware of the disruptions that may occur in the maritime leg of the Australian-Indonesian wheat supply chain?*

The two secondary research questions are as follows:

*Are shippers and consignees in the Australian-Indonesian wheat supply chain implementing supply risk assessments or mitigation strategies to minimise the maritime disruption events?*

*Are current risk mitigation and detection processes in maritime operations effective in the Australian-Indonesian wheat supply chain systems?*
The telephone survey process

The process for conducting the survey is:

1. An attached document presents the list of questions to be considered when pretesting the questionnaire.
2. All potential respondents will be contacted by advance letter in order to invite them in participating in this study.
3. Each of the potential respondents will be called to arrange a time to conduct the telephone survey. In some cases, the survey may be conducted at the time or a later agreed time. The confirmatory document will be used during this stage.
4. Prior to beginning the telephone interview, respondents will be asked for permission to record the interview. Recording will enable an accurate account of issues discussed and assist with the error control process.
5. In general, there are fourteen sections of questions that will be discussed in the telephone surveys. Please be aware that there are no sections labelled “I” and “O” in order to prevent confusion with “1” and “0” when data analysis is undertaken.
6. In the question section C.1A - C.19U, the code 1Y means (once a year), followed with 1T (once a three months), 1M (once a month), 1F (once a fortnightly), 1W (once a week), N (never).
7. Any sentences in italics are either prompts for the interviewer or question routing.
8. The word “others” with the empty spaces underlined such as questions A6 and B1 is provided for any other inputs from respondents that may be added in the interview process.
9. The respondent will not receive a copy of the telephone research questionnaire.
10. The researcher will make all the phone calls and conduct the telephone interviews.
11. Please feel free to make any comments and corrections directly on the questionnaire.

If you have any questions about the telephone survey questionnaire, please either call me on (03) 6335 4696 or email at rgurning@utas.edu.au.

Regards
APPENDIX C: RESPONSE CARDS
WHEAT SUPPLY CHAIN DIAGRAM
Please answer the question with response that is most close to your view.

There are no right or wrong answers. Only your personal opinion matters.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transport by ship</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Rail service for wheat commodities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Trucking operations</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Ferry transport</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. River transport</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. Multimodal transports</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Where 1 is the lowest level and the least importance. While 6 is the most important.

2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain
Please answer the question with a response that is most close to your view.

There are no right or wrong answers. Only your personal opinion matters.

- Once a year
- Once a three months
- Once a month
- Once a fortnightly
- Once a week
- Never

2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain
Please answer the question with a response that is most close to your view.

There are no right or wrong answers. Only your personal opinion matters.

2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain
Please choose the amount that reflects the approximate financial impact for each category raised by the interviewer.

There are no right or wrong answers. Only your personal opinion matters.

Less than 100,000
101,000 to 500,000
501,000 to 1 million
1.1 Million to 5 Million
More than 5 Million
No Costs

2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain
Please answer the question with a response that is most close to your view.

There are no right or wrong answers. Only your personal opinion matters.

2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain
Please answer the question with a response that is most close to your view.

There are no right or wrong answers. Only your personal opinion matters.

- Always
- Often
- Sometimes
- Never
- Unsure
- Not Applicable

2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain
APPENDIX D : ADVANCE LETTER
Re: Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain

We are writing to request the support of <<the>> for an important study being conducted by the Department of Maritime and Logistics Management at the Australian Maritime College.

This study aims to identify the effect of maritime disruptive events in the wheat supply chain between Australia and Indonesia. The study is being conducted in partial fulfilment of a Doctor of Philosophy degree for Mr. Saut Gurning under the supervision of Dr. Stephen Cahoon.

The study is conducted by a personal interview over the telephone. To help your members answer the questions, six response cards will be provided. Further details on how the study is conducted, the possible benefits to you and an explanation that your members’ participation is voluntary, is included in the enclosed Participation Information Sheet and Consent Form. The input from your members and other participants will make a significant contribution to identifying effective mitigation strategies in response to disruptive events in the maritime transport networks of wheat supply chain entities.

All information collected by this study will be treated confidentially. A general summary of the survey result will be provided to all your members upon request. The report will be a constructive reference for planning future mitigation strategies in your members’ wheat supply chains.

Within one week, Saut Gurning will be contacting you by telephone or email to confirm your Association’s participation in this major study. And if so, to discuss an appropriate means of contacting your members and providing them with the response cards. If you have any questions, please do not hesitate to contact Saut Gurning by email at rgurning@utas.edu.au or by telephone on (03) 6335 4696.

Yours sincerely

Mr. Saut Gurning
Researcher

Dr. Stephen Cahoon
Head, Department of Maritime and Logistics Management
Dear <<Title>> <<LastName>>

Re: Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain

We are writing to request your support for an important study being conducted by the Department of Maritime and Logistics Management at the Australian Maritime College. This study aims to identify the effect of maritime disruptive events in the wheat supply chain between Australia and Indonesia. The study is being conducted in partial fulfilment of a Doctor of Philosophy degree for Mr. Saut Gurning under the supervision of Dr. Stephen Cahoon.

As part of a randomly selected sample of professionals and practitioners in the wheat supply chain, you have been identified as being someone who would have an in-depth interest in this study. The study is conducted by a personal interview over the telephone. To help you answer the questions, six response cards are enclosed. It would be appreciated if the response cards could be kept handy for our interview. All information collected by this study will be treated confidentially. Further details on how the study is conducted, the possible benefits to you and an explanation that your participation is voluntary, is included in the enclosed Participation Information Sheet and Consent Form. The input from you and other participants will make a significant contribution to identifying effective mitigation strategies in response to disruptive events in the maritime transport networks of wheat supply chain entities.

Within one week, Saut Gurning will be contacting you by telephone or email to confirm your participation in this major study. A summary of the survey result will be provided to all respondents upon request. The results will firstly, explain the range of maritime disruptions that occur in the wheat supply chain and secondly, identify effective mitigation strategies in response to disruptive events in the maritime transport networks of wheat supply chain entities.

If you have any questions, please do not hesitate to contact Saut Gurning by email at rgurning@utas.edu.au or by telephone on (03) 63354696.

Thank you for your cooperation.

Yours sincerely

Mr. Saut Gurning
Researcher

Dr. Stephen Cahoon
Head, Department of Maritime and Logistics Management
APPENDIX E:
PARTICIPANT INFORMATION SHEET
PARTICIPANT INFORMATION SHEET
SOCIAL SCIENCE/HUMANITIES RESEARCH

Title of Project: **2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain**

**Invitation**

You are invited to participate in a research study into the maritime disruptions in the Australia-Indonesia wheat trade. Before you decide to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. The study is being conducted in partial fulfilment of a Doctor of Philosophy degree for Mr. Saut Gurning under the supervision of Dr. Stephen Cahoon in the Department of Maritime and Logistics Management, the Australian Maritime College at the University of Tasmania, Australia.

1. **What is the purpose of this study?**

The purpose is to investigate i). The characteristics and extent of the consequences of disruptive maritime events in the Australia-Indonesia wheat supply chain when transported through maritime operations and services; ii). The effectiveness of the responses and mitigation activities when maritime disruptions occur by shippers, consignees and wheat supply chain entities.

2. **Why have I been invited to participate in this study?**

You have been invited to participate as a professional in the wheat supply chain which may include maritime operations or shipping business. Professionals from associations, government, non-government and other institutions are also being invited to participate due to their specialist knowledge of the Australian or Indonesian or the broader global wheat business. We expect that 61 people will join the study.

3. **What does this study involve?**

It is important that you understand that your involvement in this study is voluntary. While we are pleased to have your participation, we respect your right to decline. There will be no consequences to you if you decide not to participate. If you decide to discontinue participation at any time, you may do so without providing an explanation. All information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research. In the final report, you will be referred to by a numeric pseudonym. We will remove any references to personal information that might allow someone to guess your identity. To do this, the researcher will de-identify the data before it is analysed. This means that your name and contact details will be kept in a separate, password-protected computer file.

Locked Bag 1397
Launceston Tasmania 7250 Australia
Phone: +61 3 6335 4696; Fax: +61 3 6335 4720
Email: rgurning@utas.edu.au
from any data that you supply. This will only be able to be linked to your responses by the researcher. The data will be kept securely at Australian Maritime College for five years and will then be destroyed.

The research involves collecting and analysing comments you make during the telephone interview in the context of maritime disruptions and the wheat supply chain. The main data collection process will be semi-structured interviews. We would like you to participate in one telephone interview. With your permission, the interviews will be audio-recorded so we can ensure we make an accurate record of what is said. These recordings will not be used for any other purpose than for transcribing comments.

4. Are there any possible benefits from participation in this study?

If we are able to use the findings of this important study and link them with wider secondary evidence, the result will help us to understand how better to manage disruptions in maritime operations that affect the continuity of wheat business between Australia and Indonesia. Understanding the uncertainties specific to various disruptive events in the maritime domain will benefit stakeholders of wheat businesses, at a time when the availability of such resources is expected to increase in coming decades.

5. Are there any possible risks from participation in this study?

There should be no risks to you with participation in this study, other than other typical risks involved in everyday life. We estimate that the total time commitment required of you, if you were to participate in this research would not exceed 45 minutes.

6. What will happen to the results of the study?

This study constitutes the main source of primary data for the researcher’s doctoral thesis. The findings may later be presented or published at conferences and in other academic arenas, including journals. Copies of such publications can be supplied upon request to any participants in the study.

7. What if I have questions about this research?

If you would like to discuss any aspect of this study please contact the researcher or the chief investigator:

**Researcher:**
Saut Gurning  
Department of Maritime and Logistics Management, Ph: +613 6335 4696  
Email: rgurning@utas.edu.au

**Chief Investigator:**
Dr. Stephen Cahoon, Head of the Department of Maritime and Logistics Management,  
Ph: +613 6335 4769  
Email: s.cahoon@amc.edu.au
We are happy to discuss any aspect of the research with you. When the study is complete upon your request a summary of our findings can be emailed to you. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants.

If you wish to take part in it, please sign the attached consent form and send it back to researcher either by fax or email address mentioned above.

Thank you for taking the time to consider this study
This information sheet is for you to keep.
CONSENT FORM

Title of Project: 2009 Study of Maritime Disruptions in the Australia-Indonesia Wheat Supply Chain

By signing this form, I agree that:

1. I have and understood the information presented in the 'Information Sheet' about a study being conducted by Saut Gurning, Australian Maritime College.

2. I understand that the study involves 45 minutes telephone interview to discuss issues concerning the maritime disruptions in the Australia-Indonesia wheat supply chain.

3. The nature and possible effects of the study have been explained to me. I understand that my participation is low-risk and that discussion will address non-sensitive issues.

4. Any questions that I have asked have been answered to my satisfaction. I am free now, and in the future, to ask questions about the study.

5. The interviewer will ask for permission to audio record the interview to ensure an accurate recording for transcription and coding purposes. If I do not grant permission, the interview will not be audio recorded.

6. I understand that all research data will be securely stored on the Australian Maritime College premises for five years and will then be destroyed.

7. I understand that the researcher will maintain my identity confidential and that any information I supply to the researcher(s) will be used only for the purposes of the research.

8. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.

9. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish may request that any data I have supplied to date be withdrawn from the research.
Name of Participant : .................................................. 
Signature : .............................................. Date: ..............................................

10. Statement by Researcher

☐ I have explained the telephone interview and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

If the Researcher has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project.

Name of Researcher : .................................................. 
Signature : ..................................................
APPENDIX F : CONFIRMATORY LETTER
CONFIRMATORY LETTER

TELEPHONE LOG

Respondent’s Name : _________________________  Date 1: _______/______/ 09
Position : _________________________  Time1:___________ am /pm
Company : _________________________  Date 2: _______/______/ 09
Telephone : _________________________  Time2:___________ am /pm
Email : _________________________  Date 3: _______/______/ 09
Country : Australia / Indonesia  Time3:___________ am /pm

Good morning/afternoon Mr/Mrs ____________, I am Saut Gurning from the Australian Maritime College. Recently, I sent you a letter in relation to research being conducted on maritime disruptions in the Australia-Indonesia wheat supply chain.

I am calling you to ask whether you may be willing to participate in this important study. Other professionals are also being invited including those from wheat farmers’ associations, government, non-government and other institutions involved in the wheat supply chain. Your contribution is valuable to this major study as it will provide important insights on your stage of the wheat supply chain.

In appreciation of your participation in this study, a summary report of the study will be provided to you that discusses the range of disruptions in the maritime transport network in the wheat supply chain and recommends mitigation strategies that may be useful for your company’s risk mitigation plan and management as well as for benchmarking purposes. The study will be conducted by an interview over the telephone. The interview consists of a number of questions relating to maritime disruptions and your organisation’s experience in responding the disruptions when they occurred. If you are interested in participating in this study we can start the interview now or we can plan another convenient time for me to call you back.

Would you be interested in participating in this important study?
[pause and wait for response]

If respondent says YES Then go to Questionnaire material

If respondent asks to arrange other time

1. When would be a better time for you?
   Date : ________________
   Resp’s time : ________________
   I/res time : ________________

If respondent says NO

1. Is there anyone else in your organisation that may be interested in participating in this study?
   YES - Name : ____________
   Telephone : ________________
<table>
<thead>
<tr>
<th>Email</th>
<th>:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>_____</td>
<td></td>
</tr>
<tr>
<td><strong>NO</strong></td>
<td><em>Go to Declaration B</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DECLARATION A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thank you for your valuable time in assisting me to this study. I will contact you again on [mentioned agreed date and time above no.1]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DECLARATION B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thank you for your time</td>
</tr>
</tbody>
</table>
APPENDIX G: DATA ANALYSIS
### Section A. The descriptive of respondent profile by 25/2/2010

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Jobs</th>
<th>Research Code</th>
<th>Duration (minutes)</th>
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<tbody>
<tr>
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<td>14/11/2009</td>
<td>Port Managers</td>
<td>0901</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>14/11/2009</td>
<td>Port Managers</td>
<td>0902</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>15/11/2009</td>
<td>Stevedores/3PL</td>
<td>0903</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>15/11/2009</td>
<td>Shipping/ Shipowner</td>
<td>0904</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>23/11/2009</td>
<td>Distributors/SCM Manager</td>
<td>0905</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>23/01/2009</td>
<td>Distributors/SCM Manager</td>
<td>0906</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>24/01/2009</td>
<td>Ind-Wheat Association</td>
<td>0907</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>25/01/2009</td>
<td>Ind-Flour-Distributor</td>
<td>0908</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>26/01/2009</td>
<td>Shipping Operation Manager</td>
<td>0909</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>27/01/1900</td>
<td>Shipping / Dry-Bulk</td>
<td>0910</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>27/11/2009</td>
<td>Wheat Mills</td>
<td>0911</td>
<td>55</td>
</tr>
<tr>
<td>12</td>
<td>29/11/2009</td>
<td>B-Shipping/ Operation Manager</td>
<td>0912</td>
<td>55</td>
</tr>
<tr>
<td>13</td>
<td>30/11/2009</td>
<td>Wheat Mills</td>
<td>0913</td>
<td>30</td>
</tr>
<tr>
<td>14</td>
<td>30/11/2009</td>
<td>Wheat trade/3PL</td>
<td>0914</td>
<td>30</td>
</tr>
<tr>
<td>15</td>
<td>1/12/2009</td>
<td>Millers/Distributors</td>
<td>0915</td>
<td>30</td>
</tr>
<tr>
<td>16</td>
<td>2/12/2009</td>
<td>Millers/Distributors</td>
<td>0916</td>
<td>20</td>
</tr>
<tr>
<td>17</td>
<td>2/12/2009</td>
<td>Port Managers</td>
<td>0917</td>
<td>50</td>
</tr>
<tr>
<td>18</td>
<td>3/12/2009</td>
<td>Land Transporter</td>
<td>0918</td>
<td>22</td>
</tr>
<tr>
<td>19</td>
<td>8/12/2009</td>
<td>Shipping/Bulk Shipping</td>
<td>0919</td>
<td>15</td>
</tr>
<tr>
<td>20</td>
<td>9/12/2009</td>
<td>Logistics Association</td>
<td>0920</td>
<td>14</td>
</tr>
<tr>
<td>21</td>
<td>11/12/2009</td>
<td>Terminal Operator</td>
<td>0921</td>
<td>20</td>
</tr>
<tr>
<td>22</td>
<td>15/12/2009</td>
<td>Wheat Distributor</td>
<td>0922</td>
<td>30</td>
</tr>
<tr>
<td>23</td>
<td>16/12/2009</td>
<td>Freight Council</td>
<td>0923</td>
<td>35</td>
</tr>
<tr>
<td>24</td>
<td>28/12/2009</td>
<td>Port Managers</td>
<td>0924</td>
<td>60</td>
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<tr>
<td>25</td>
<td>4/01/2010</td>
<td>Port Managers</td>
<td>0925</td>
<td>30</td>
</tr>
<tr>
<td>26</td>
<td>2/02/2010</td>
<td>Director Transport Department</td>
<td>0926</td>
<td>29</td>
</tr>
<tr>
<td>27</td>
<td>13/02/2010</td>
<td>Port-Managers</td>
<td>0927</td>
<td>50</td>
</tr>
<tr>
<td>28</td>
<td>16/02/2010</td>
<td>Safety and Risk Manager</td>
<td>0928</td>
<td>22</td>
</tr>
<tr>
<td>29</td>
<td>16/01/2010</td>
<td>Port General Managers</td>
<td>0929</td>
<td>11</td>
</tr>
<tr>
<td>30</td>
<td>24/01/2010</td>
<td>Distributor/SCM Manager</td>
<td>0930</td>
<td>25</td>
</tr>
<tr>
<td>31</td>
<td>25/01/2010</td>
<td>Wheat Mills</td>
<td>0931</td>
<td>23</td>
</tr>
<tr>
<td>32</td>
<td>25/02/2010</td>
<td>Port Director</td>
<td>0932</td>
<td>24</td>
</tr>
<tr>
<td>33</td>
<td>25/02/2010</td>
<td>Flour Mills</td>
<td>0933</td>
<td>25</td>
</tr>
<tr>
<td>34</td>
<td>25/02/2010</td>
<td>Port Manager</td>
<td>0934</td>
<td>15</td>
</tr>
</tbody>
</table>

Average (minutes) 32.79
Section B. Supply chain role of respondents

Do you have a supply chain role in your organisation?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>100.0%</td>
<td>33</td>
</tr>
<tr>
<td>No (Go to question A.4)</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Unsure (Go to question A.4)</td>
<td>3.0%</td>
<td>1</td>
</tr>
</tbody>
</table>

answered question 33
skipped question 1

Section C. The experience duration of respondents

For how many years have you had a supply chain role in your organisation?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>2-5</td>
<td>35.3%</td>
<td>12</td>
</tr>
<tr>
<td>6-10</td>
<td>20.6%</td>
<td>7</td>
</tr>
<tr>
<td>11-15</td>
<td>38.2%</td>
<td>13</td>
</tr>
<tr>
<td>16+</td>
<td>5.9%</td>
<td>2</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0

Section D. The formal department dealing with risk issues

Does your organisation have a formal department or division dealing with risk matters in your supply chain?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>50.0%</td>
<td>17</td>
</tr>
<tr>
<td>No (Go to section A.6)</td>
<td>47.1%</td>
<td>16</td>
</tr>
<tr>
<td>Uns sure (Go to section A.6)</td>
<td>2.9%</td>
<td>1</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0
Section E. The specific divisions dealing with risk issues

In which division in your organisation are risk related factors dealt with?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing</td>
<td>15.6%</td>
<td>5</td>
</tr>
<tr>
<td>Operations</td>
<td>46.9%</td>
<td>15</td>
</tr>
<tr>
<td>Logistics / Supply Chain</td>
<td>15.6%</td>
<td>5</td>
</tr>
<tr>
<td>Sales</td>
<td>3.1%</td>
<td>1</td>
</tr>
<tr>
<td>Corporate Services</td>
<td>6.3%</td>
<td>2</td>
</tr>
<tr>
<td>Others, please specify</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

answered question 32
skipped question 2

Section F. The terminology of disruptions used

In general, a disruption may relate to a service in your supply chain being unavailable. What terminology does your organisation use to refer to this type of risk?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interruptions</td>
<td>26.2%</td>
<td>16</td>
</tr>
<tr>
<td>Disturbances</td>
<td>21.3%</td>
<td>13</td>
</tr>
<tr>
<td>Stoppages</td>
<td>9.8%</td>
<td>6</td>
</tr>
<tr>
<td>Delays</td>
<td>23.0%</td>
<td>14</td>
</tr>
<tr>
<td>Deviations</td>
<td>13.1%</td>
<td>8</td>
</tr>
<tr>
<td>Disaster</td>
<td>6.6%</td>
<td>4</td>
</tr>
<tr>
<td>Others, please specify</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 61
skipped question 0

Section G. The experience of disruptions

In the last two years, has any part of your organisation experienced any disruptions in your wheat supply chain?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>88.2%</td>
<td>30</td>
</tr>
<tr>
<td>No</td>
<td>9.0%</td>
<td>3</td>
</tr>
<tr>
<td>Unsure</td>
<td>2.8%</td>
<td>1</td>
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</tbody>
</table>

answered question 34
skipped question 0
Section H. The typical of risks in the international supply chain

Which of the following risks best describe any severe disruptions in the international supply chain of your wheat trade in the last two years?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>22.2%</td>
<td>12</td>
</tr>
<tr>
<td>Legal</td>
<td>5.6%</td>
<td>3</td>
</tr>
<tr>
<td>Technical</td>
<td>9.3%</td>
<td>5</td>
</tr>
<tr>
<td>Environmental</td>
<td>11.1%</td>
<td>6</td>
</tr>
<tr>
<td>Operational</td>
<td>35.2%</td>
<td>19</td>
</tr>
<tr>
<td>Financial</td>
<td>14.8%</td>
<td>8</td>
</tr>
<tr>
<td>Security</td>
<td>1.9%</td>
<td>1</td>
</tr>
<tr>
<td>Are there any types of risks that were not included?</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

answered question 56
skipped question 0

Section J. The location of maritime disruptions occurred

Please view the wheat supply chain diagram sent with the response cards. The diagram shows the Australia-Indonesia wheat supply chain starting from Australian farmers to handlers and processors then followed by various maritime distributors in the Australian part of the wheat chain. The diagram then shows the Indonesian section of the wheat chain from the maritime distributors to wholesalers, retailers, and finally to consumers. Could you please indicate any stages of that diagram marked A to M where disruptions have occurred in your wheat supply chain?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers to handlers</td>
<td>4.1%</td>
<td>4</td>
</tr>
<tr>
<td>Handlers to processors</td>
<td>4.1%</td>
<td>4</td>
</tr>
<tr>
<td>Processors to shippers in Australia</td>
<td>6.1%</td>
<td>6</td>
</tr>
<tr>
<td>Shippers to forwarders in Australia</td>
<td>9.2%</td>
<td>9</td>
</tr>
<tr>
<td>Port operations in Australia</td>
<td>11.2%</td>
<td>11</td>
</tr>
<tr>
<td>Shipping arrangements in Australia</td>
<td>14.3%</td>
<td>14</td>
</tr>
<tr>
<td>Shipping arrangements in Indonesia</td>
<td>16.3%</td>
<td>16</td>
</tr>
<tr>
<td>Port operations in Indonesia</td>
<td>15.3%</td>
<td>15</td>
</tr>
<tr>
<td>Forwarders to Consignees in Indonesia</td>
<td>11.2%</td>
<td>11</td>
</tr>
<tr>
<td>Consignees to wholesalers in Indonesia</td>
<td>2.0%</td>
<td>2</td>
</tr>
<tr>
<td>Wholesalers to retailers in Indonesia</td>
<td>3.1%</td>
<td>3</td>
</tr>
<tr>
<td>Retailers to consumers in Indonesia</td>
<td>3.1%</td>
<td>3</td>
</tr>
<tr>
<td>answered question</td>
<td>98</td>
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<tr>
<td>skipped question</td>
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<td></td>
</tr>
</tbody>
</table>
### Section K. The mode of transports in the wheat supply chain

Please rank each one of them based on their importance to your wheat supply chain where 1 is the lowest level of importance and 6 is the most important.

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Rating Average</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ship</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>31</td>
<td>5.68</td>
<td>34</td>
</tr>
<tr>
<td>Rail</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>3.00</td>
<td>34</td>
</tr>
<tr>
<td>Trucking</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>16</td>
<td>3</td>
<td>1</td>
<td>3.35</td>
<td>34</td>
</tr>
<tr>
<td>Ferry</td>
<td>8</td>
<td>18</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2.03</td>
<td>34</td>
</tr>
<tr>
<td>River</td>
<td>19</td>
<td>10</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1.74</td>
<td>34</td>
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<tr>
<td>Multimodal</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>9</td>
<td>3.62</td>
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</tbody>
</table>

### Section L. The mode of transports in the wheat supply chain

Which of the following wheat routes describe your international wheat supply chain over the last two years?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia - Indonesia only</td>
<td>73.5%</td>
<td>25</td>
</tr>
<tr>
<td>Australia - Indonesia and other international routes</td>
<td>29.4%</td>
<td>10</td>
</tr>
<tr>
<td>Australia - East Asian countries</td>
<td>5.9%</td>
<td>2</td>
</tr>
<tr>
<td>Are there any other wheat routes your organisation is dealing with?</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

### Section M. The detection methods in the wheat supply chain

How were the maritime disruptions in your wheat supply chain discovered?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>News from findings within the organisation</td>
<td>23.4%</td>
<td>11</td>
</tr>
<tr>
<td>Informed by partners or agents</td>
<td>44.7%</td>
<td>21</td>
</tr>
<tr>
<td>From industry associations or farmers’ associations</td>
<td>8.5%</td>
<td>4</td>
</tr>
<tr>
<td>Identified through operation problems along the chain</td>
<td>10.6%</td>
<td>5</td>
</tr>
<tr>
<td>From past experience</td>
<td>12.8%</td>
<td>6</td>
</tr>
<tr>
<td>Others, please specify</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0
Section N. The frequency of risk level in the chain

**Now I would like you to consider how often, on average, the following maritime disruptions have occurred for your organisation in the last two years**

### Australian Chain

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Once a year</th>
<th>Once in three months</th>
<th>Once a month</th>
<th>Once fortnightly</th>
<th>Every week</th>
<th>Never</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security threats (acts of terrorism or piracy)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Political events such as riots or wars</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Lack of rail facilities at port</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Port strikes</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Long customs and quarantine processes</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>The checking cleanliness of wheat products</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>30</td>
</tr>
<tr>
<td>Severe weather conditions at sea or ports</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Tsunami</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Electrical outages</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>28</td>
<td>30</td>
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<tr>
<td>Equipment breakdown</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Insufficient empty containers</td>
<td>18</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Port congestion</td>
<td>18</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Shipping-port disputes</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>Ship accidents in port areas</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>Shortage of dry bulk ship fleets</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>30</td>
</tr>
<tr>
<td>Uncertain bunkering (fuel) costs</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Lack of inland accessibility</td>
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<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>Communication failure</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Shortage of shipping services</td>
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<td>0</td>
<td>0</td>
<td>2</td>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>

### Indonesia Chain

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Once a year</th>
<th>Once in three months</th>
<th>Once a month</th>
<th>Once fortnightly</th>
<th>Every week</th>
<th>Never</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security threats (acts of terrorism or piracy)</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>30</td>
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<tr>
<td>Political events such as riots or wars</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Lack of rail facilities at port</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>Port strikes</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Long customs and quarantine processes</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>The checking cleanliness of wheat products</td>
<td>4</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Severe weather conditions at sea or ports</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Earthquakes</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>30</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
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<td>8</td>
<td>4</td>
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<td>0</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Insufficient empty containers</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Port congestion</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Shipping-port disputes</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>30</td>
</tr>
<tr>
<td>Ship accidents in port areas</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>Shortage of dry bulk ship fleets</td>
<td>14</td>
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<td>0</td>
<td>0</td>
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<td>10</td>
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<td>30</td>
<td>30</td>
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<tr>
<td>Lack of inland accessibility</td>
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<td>8</td>
<td>30</td>
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<tr>
<td>Communication failure</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Shortage of shipping services</td>
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<td>30</td>
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<table>
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<th>Question Totals</th>
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<tbody>
<tr>
<td><strong>answered question</strong></td>
</tr>
<tr>
<td><strong>skipped question</strong></td>
</tr>
</tbody>
</table>
Section P. The consequence level of disruption risk level in the chain

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>&lt; 100,000</th>
<th>101,000-500,000 Million</th>
<th>501,000-1 Million</th>
<th>1.1 Million-5 Million</th>
<th>More than 5 Million</th>
<th>No Costs</th>
<th>Response Count</th>
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</thead>
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<tr>
<td>Security/terrorist attacks</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Political events such as riots</td>
<td>25</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Lack of rail facilities at the port</td>
<td>13</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Port strikes</td>
<td>17</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Lengthy customs process</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>The checking cleanliness of wheat products</td>
<td>18</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Severe weather conditions</td>
<td>8</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>4</td>
<td>3</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Tsunami</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electrical outages</td>
<td>18</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Equipment breakdown</td>
<td>14</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Insufficient empty containers</td>
<td>14</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Shipping-port disputes</td>
<td>12</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Ship accidents in port areas</td>
<td>5</td>
<td>17</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Port congestion</td>
<td>0</td>
<td>13</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Shortage of dry bulk ships</td>
<td>13</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Fuel and bunkering costs</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inland accessibility problems</td>
<td>14</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Telecommunication failure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shortage of shipping services</td>
<td>9</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
</tbody>
</table>

Section R. The frequency disruption risk level in chain

At what stage were the maritime disruptive events detected?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>When significant delays of operational targets occurred</td>
<td>54.8%</td>
<td>23</td>
</tr>
<tr>
<td>When a significant deviation from existing operational plans was detected</td>
<td>23.8%</td>
<td>10</td>
</tr>
<tr>
<td>When service platforms were partially corrupted or inactive</td>
<td>11.9%</td>
<td>5</td>
</tr>
<tr>
<td>When the disruptions produced significant consequences in other stages (after or before your organisation) in the wheat supply chain</td>
<td>9.5%</td>
<td>4</td>
</tr>
<tr>
<td>Others, please specify</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

answered question 42
skipped question 0
Section S. The probability level of maritime disruptions

How likely is it that the following maritime disruptions may occur in your wheat supply chain in the future?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>&lt; 10%</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
<th>Don't know</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security threats</td>
<td>21</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Political events</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Rail facilities</td>
<td>0</td>
<td>13</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Port strikes</td>
<td>15</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Long customs and quarantine</td>
<td>0</td>
<td>15</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Cleanliness</td>
<td>0</td>
<td>12</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td>3</td>
<td>10</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Tsunami</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Electrical outages</td>
<td>17</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Equipment breakdown</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Insufficient empty containers</td>
<td>0</td>
<td>10</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Port congestion</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>7</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Shipping-port disputes</td>
<td>0</td>
<td>14</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Ship accidents in port areas</td>
<td>16</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Shortage of dry bulk ship fleets</td>
<td>14</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Uncertain bunkering (fuel) costs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Lack of inland accessibility</td>
<td>0</td>
<td>15</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Communication failure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Shortage of shipping services</td>
<td>16</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
</tbody>
</table>

answered question 30
skipped question 4

Section T. The commercial consequences of maritime disruptions

To what level do you agree that the following commercial consequences have been experienced by your organisation due to various maritime disruptive events in the last two years?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrepancies in maritime transport costs</td>
<td>4</td>
<td>17</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>34</td>
</tr>
<tr>
<td>Loss of profit due to the decreasing of traffic demand</td>
<td>6</td>
<td>16</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>Poor business reputation due to unreliable services</td>
<td>3</td>
<td>17</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>Customers deciding to go to other competitors</td>
<td>4</td>
<td>15</td>
<td>7</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td>Higher emergency costs due to responses taken</td>
<td>4</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>Permanent stoppages of cargo delivery processes</td>
<td>2</td>
<td>9</td>
<td>7</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>To attract the customer back from competitors, the tariff or freight rate should be decreased significantly</td>
<td>8</td>
<td>13</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>34</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0
Section U. The additional lead time when maritime disruptions occur

For approximately how many days did maritime disruptions affect the delivery of your organisation’s service in the market in the last two years?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7</td>
<td>52.9%</td>
<td>18</td>
</tr>
<tr>
<td>8-14</td>
<td>26.5%</td>
<td>9</td>
</tr>
<tr>
<td>15-30</td>
<td>11.8%</td>
<td>4</td>
</tr>
<tr>
<td>31-90</td>
<td>2.9%</td>
<td>1</td>
</tr>
<tr>
<td>91-180</td>
<td>2.9%</td>
<td>1</td>
</tr>
<tr>
<td>181-360</td>
<td>2.9%</td>
<td>1</td>
</tr>
<tr>
<td>360+</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0

Section V. The time needed to detect maritime disruptions

In the past two years approximately how many days notice did your organisation receive that a maritime disruption occurred?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7</td>
<td>52.9%</td>
<td>18</td>
</tr>
<tr>
<td>8-14</td>
<td>17.6%</td>
<td>6</td>
</tr>
<tr>
<td>15-30</td>
<td>17.6%</td>
<td>6</td>
</tr>
<tr>
<td>31-90</td>
<td>8.8%</td>
<td>3</td>
</tr>
<tr>
<td>91-180</td>
<td>2.9%</td>
<td>1</td>
</tr>
<tr>
<td>181-360</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>360+</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0

Section X. The time needed to obtain the recovery stage

What is the usual period of time in days that it takes for your organisation to return to normal operational levels after a maritime disruption has occurred?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-7</td>
<td>8.8%</td>
<td>3</td>
</tr>
<tr>
<td>8-14</td>
<td>17.6%</td>
<td>6</td>
</tr>
<tr>
<td>15-30</td>
<td>26.5%</td>
<td>9</td>
</tr>
<tr>
<td>31-90</td>
<td>26.5%</td>
<td>9</td>
</tr>
<tr>
<td>91-180</td>
<td>11.8%</td>
<td>4</td>
</tr>
<tr>
<td>181-360</td>
<td>5.9%</td>
<td>2</td>
</tr>
<tr>
<td>360+</td>
<td>2.9%</td>
<td>1</td>
</tr>
</tbody>
</table>

answered question 34
skipped question 0
Section W. The rerouting strategies

Did any disruptions at the ports result in having to re-route the cargo to different ports?

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>74.2%</td>
<td>23</td>
</tr>
<tr>
<td>No</td>
<td>16.1%</td>
<td>8</td>
</tr>
<tr>
<td>Unsure</td>
<td>3.2%</td>
<td>1</td>
</tr>
</tbody>
</table>

Answered question: 31
Skipped question: 3

Section Z. The rerouting probabilities at Australian ports

Based on the disruptions that have occurred in the past two years resulting in wheat having to be re-routed to another port, how likely is it that a disruption may occur at the following Australian ports?

Answer Options

<table>
<thead>
<tr>
<th>Any ports in Queensland (such as Mackay, Gladstone, Tropic)</th>
<th>&lt; 10%</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
<th>Don't know</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>Any ports in New South Wales (Newcastle, Kembla)</td>
<td>10</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>Any ports in Victoria (Geelong, Melbourne, Portland)</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>Any ports in South Australia (Thevenard, Gilles, Adelaide)</td>
<td>12</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>33</td>
</tr>
<tr>
<td>Any ports in West Australia (Albany, Geraldton)</td>
<td>8</td>
<td>13</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>33</td>
</tr>
<tr>
<td>Kwinana, and Esperance</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>33</td>
</tr>
</tbody>
</table>

Answered question: 31
Skipped question: 3

Section AA. The rerouting probabilities at Indonesian ports

Based on the disruptions that have occurred in the past two years resulting in wheat having to be re-routed to another port, how likely is it that a disruption may occur at the following Indonesian ports?

Answer Options

<table>
<thead>
<tr>
<th>Any ports in Java (such as Priok, Perak, and Tanjung Emas)</th>
<th>&lt; 10%</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
<th>Tidak tahu</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
<td>4</td>
<td>14</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Any ports in Kalimantan (Banjarmasin)</td>
<td>18</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td>Any ports in Sulawesi (Makassar)</td>
<td>19</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>Any ports in Sumatera (Belawan)</td>
<td>9</td>
<td>15</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>31</td>
</tr>
</tbody>
</table>

Answered question: 31
Skipped question: 3
Section AB. The perceptions on wheat marketing bodies

To what level do you agree that a single wheat marketing board has the right to:

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decide the wheat selling prices</td>
<td>4</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td>Consider and assess the export agency</td>
<td>5</td>
<td>16</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Select the shipping companies</td>
<td>3</td>
<td>11</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Arrange the inland transport arrangements</td>
<td>4</td>
<td>13</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Arrange the selection of loading/unloading terminals</td>
<td>4</td>
<td>11</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Decide the freight level of shipping arrangements</td>
<td>2</td>
<td>6</td>
<td>13</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>Arrange the shipping contract including its risks</td>
<td>13</td>
<td>12</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>31</td>
</tr>
</tbody>
</table>

answered question 31
skipped question 3

Section AC. Responses on operational factors of entities

Now, I would like to ask to what level do you agree with the following operational-related matters in your maritime services.

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not applicable</th>
<th>Average rating</th>
<th>Rating Level</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISPS code reduces maritime security threats</td>
<td>3</td>
<td>21</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4.6</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Your organisation always uses a contingency plan for a specific purpose</td>
<td>6</td>
<td>20</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4.9</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Rail service supports your service appropriately</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>10</td>
<td>2.9</td>
<td>Disagree</td>
<td>33</td>
</tr>
<tr>
<td>Labour strikes have occurred in your organisation</td>
<td>0</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>0</td>
<td>2</td>
<td>3.8</td>
<td>Unsure</td>
<td>32</td>
</tr>
<tr>
<td>Customs and quarantine agencies are inactive in</td>
<td>5</td>
<td>12</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>4.4</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>reducing longer and costly processes</td>
<td>4</td>
<td>3</td>
<td>10</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>3.6</td>
<td>Unsure</td>
<td>32</td>
</tr>
<tr>
<td>Your organisation is adopting a reliable maintenance and repair plan</td>
<td>4</td>
<td>18</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>4.6</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Improving port capacity is the best way to deal with port</td>
<td>5</td>
<td>18</td>
<td>0</td>
<td>8</td>
<td>1</td>
<td>0</td>
<td>4.6</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Your organisation is implementing a risk sharing plan</td>
<td>2</td>
<td>16</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>4.3</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>with your business partners when disruptive events occur</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A flexible transport arrangement is better for your organisation</td>
<td>4</td>
<td>19</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4.7</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Your organisation is employing a back up system for bunkering</td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>4.1</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Applying a good repositioning plan is used in your organisation in</td>
<td>4</td>
<td>12</td>
<td>8</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>4.1</td>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Your organisation prepared a pre-disaster plan for natural disasters that may impact on your facilities</td>
<td>7</td>
<td>12</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>4</td>
<td>4.3</td>
<td>Agree</td>
<td>32</td>
</tr>
</tbody>
</table>

answered question 32
skipped question 2
Section AD. Comparison of mitigation, adaptation, intervention and coordination strategies

<table>
<thead>
<tr>
<th>General disruption management responses</th>
<th>Always (%)</th>
<th>Often (%)</th>
<th>Sometimes (%)</th>
<th>Never (%)</th>
<th>Unsure (%)</th>
<th>Not applicable</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rescheduling the shipment process</td>
<td>(45%) 9</td>
<td>(19%) 6</td>
<td>39% (12)</td>
<td>(13%) 4</td>
<td>(0%) 0</td>
<td>(0%) 0</td>
<td>5</td>
</tr>
<tr>
<td>An effective and strong coordination with other players</td>
<td>(10%) 5</td>
<td>(45%) 14</td>
<td>(45%) 9</td>
<td>(10%) 3</td>
<td>(0%) 0</td>
<td>(0%) 0</td>
<td>5</td>
</tr>
<tr>
<td>Increase some inventories at loading/unloading ports</td>
<td>(6%) 2</td>
<td>(26%) 8</td>
<td>(39%) 12</td>
<td>(23%) 7</td>
<td>(6%) 2</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Utilise supply alliance networks in order to have a flexible supply-base</td>
<td>(10%) 5</td>
<td>(19%) 6</td>
<td>(23%) 7</td>
<td>(32%) 10</td>
<td>(10%) 3</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Employing economic supply incentives</td>
<td>(13%) 4</td>
<td>(19%) 6</td>
<td>(39%) 12</td>
<td>(6%) 2</td>
<td>(0%) 0</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Apply flexible rerouting to other ports</td>
<td>(13%) 4</td>
<td>(45%) 9</td>
<td>(32%) 10</td>
<td>(16%) 5</td>
<td>(10%) 3</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Real-time decision support</td>
<td>(13%) 4</td>
<td>(16%) 5</td>
<td>(42%) 13</td>
<td>(16%) 5</td>
<td>(13%) 4</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>A redundancy system which includes risk detection and correction methods</td>
<td>(13%) 4</td>
<td>(10%) 3</td>
<td>(35%) 11</td>
<td>(39%) 12</td>
<td>(3%) 1</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Controlling product exposure to customers</td>
<td>(10%) 3</td>
<td>(16%) 5</td>
<td>(23%) 7</td>
<td>(35%) 11</td>
<td>(13%) 4</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Business continuity plan in operation/services</td>
<td>(13%) 4</td>
<td>(26%) 8</td>
<td>(23%) 7</td>
<td>(32%) 10</td>
<td>(6%) 2</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
<tr>
<td>Bottom up approach to set up the mitigation plan</td>
<td>(10%) 5</td>
<td>(23%) 7</td>
<td>(35%) 11</td>
<td>(13%) 4</td>
<td>(13%) 4</td>
<td>(0%) 0</td>
<td>4</td>
</tr>
</tbody>
</table>

Section AE. The propagation effects of at maritime disruptions

<table>
<thead>
<tr>
<th>To what level do you agree that the following statements may explain the impact of maritime disruptions through the whole wheat supply chain</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Unsure</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Not Applicable</th>
<th>Rating Average</th>
<th>Opinion Average</th>
<th>Answered Question</th>
<th>Skipped Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>The maritime disruptions affect the wheat retailers’ prices</td>
<td>5</td>
<td>14</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>4.4</td>
<td>Agree</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>Stages prior to maritime service (such as handlers) may initiate the maritime disruptions</td>
<td>3</td>
<td>12</td>
<td>5</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>4.1</td>
<td>Agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inability of your company to fulfil the wheat supply chain performance may create maritime disruptions</td>
<td>5</td>
<td>20</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4.9</td>
<td>Agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All stages along the chain have an equal risk probability create maritime disruptions</td>
<td>4</td>
<td>22</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4.9</td>
<td>Agree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All stages along the chain have an equal risk probability to probability suffer from maritime disruptions</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>11</td>
<td>8</td>
<td>0</td>
<td>3.3</td>
<td>Agree</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section AF. The operational impacts of maritime disruptions in the port service performance

Based on your organisation’s experience in the Australian-Indonesian wheat supply chain, please categorise the following maritime disruptive events into consequences that either created port stoppages, or reduced port operations.

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Port Stoppages</th>
<th>Reduced Port Operations</th>
<th>Not Applicable</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems in a nearby ship anchoring area of a port</td>
<td>6</td>
<td>21</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Coastguard delaying boarding and clearance</td>
<td>5</td>
<td>20</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Ship collisions</td>
<td>5</td>
<td>22</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Hazardous spill</td>
<td>3</td>
<td>21</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Low tide period</td>
<td>3</td>
<td>17</td>
<td>11</td>
<td>31</td>
</tr>
<tr>
<td>Severe waves</td>
<td>9</td>
<td>13</td>
<td>9</td>
<td>31</td>
</tr>
<tr>
<td>Queuing or congestion</td>
<td>16</td>
<td>11</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Strong winds</td>
<td>2</td>
<td>19</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Lack of pilotage and tug-boat services</td>
<td>5</td>
<td>22</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Port strikes</td>
<td>8</td>
<td>17</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Cranes and/or grain elevators disabled</td>
<td>3</td>
<td>22</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Breakdown of straddle carriers in shop</td>
<td>4</td>
<td>20</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Shortage of chassis and/or choppers</td>
<td>5</td>
<td>19</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Fire accident on a ship while at port</td>
<td>6</td>
<td>16</td>
<td>9</td>
<td>31</td>
</tr>
<tr>
<td>Insufficient handling equipment</td>
<td>7</td>
<td>19</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>Earthquake</td>
<td>15</td>
<td>10</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Tsunami</td>
<td>16</td>
<td>8</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Port facility failure such as water distribution systems</td>
<td>3</td>
<td>15</td>
<td>13</td>
<td>31</td>
</tr>
<tr>
<td>Heavy rain</td>
<td>5</td>
<td>16</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Terminal information system failure</td>
<td>4</td>
<td>20</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Shortage of storage or silo area</td>
<td>7</td>
<td>18</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td>Insufficient container storage area</td>
<td>4</td>
<td>22</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>Delays in clearance of medical and quarantine checks</td>
<td>2</td>
<td>24</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>Delays in immigration checking</td>
<td>6</td>
<td>22</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>Customs clearance delays</td>
<td>2</td>
<td>22</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td>Insufficient road transport infrastructure</td>
<td>2</td>
<td>24</td>
<td>5</td>
<td>31</td>
</tr>
<tr>
<td>Downstream intermodal problems such as inland congestion</td>
<td>4</td>
<td>23</td>
<td>4</td>
<td>31</td>
</tr>
</tbody>
</table>

Answered question: 31
Skipped question: 3
Section AG. The standard deviation of disruption consequences

<table>
<thead>
<tr>
<th>Maritime Disruptive Events</th>
<th>N Respds</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>153,333</td>
<td>6,133</td>
</tr>
<tr>
<td>Political events</td>
<td>30</td>
<td>50,000</td>
<td>750,000</td>
<td>66,667</td>
<td>3,333</td>
</tr>
<tr>
<td>Rail facilities</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>113,333</td>
<td>6,800</td>
</tr>
<tr>
<td>Port strikes</td>
<td>30</td>
<td>50,000</td>
<td>750,000</td>
<td>153,333</td>
<td>6,133</td>
</tr>
<tr>
<td>Lengthy customs and quarantine process</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>71,667</td>
<td>2,867</td>
</tr>
<tr>
<td>The checking cleanliness of the wheat products</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>63,333</td>
<td>5,067</td>
</tr>
<tr>
<td>Severe weather conditions</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>130,000</td>
<td>11,700</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>30</td>
<td>50,000</td>
<td>2,500,000</td>
<td>1,006,667</td>
<td>10,067</td>
</tr>
<tr>
<td>Electrical outages</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>55,000</td>
<td>2,200</td>
</tr>
<tr>
<td>Equipment breakdown</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>148,333</td>
<td>7,417</td>
</tr>
<tr>
<td>Insufficient empty containers</td>
<td>30</td>
<td>50,000</td>
<td>750,000</td>
<td>165,000</td>
<td>9,900</td>
</tr>
<tr>
<td>Shipping-port disputes</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>103,333</td>
<td>8,267</td>
</tr>
<tr>
<td>Ship accidents in port areas</td>
<td>30</td>
<td>50,000</td>
<td>750,000</td>
<td>225,000</td>
<td>9,000</td>
</tr>
<tr>
<td>Port congestion</td>
<td>30</td>
<td>50,000</td>
<td>2,500,000</td>
<td>700,000</td>
<td>63,000</td>
</tr>
<tr>
<td>Shortage of dry bulk ship fleets</td>
<td>30</td>
<td>50,000</td>
<td>250,000</td>
<td>105,000</td>
<td>7,350</td>
</tr>
<tr>
<td>Inland accessibility problems</td>
<td>30</td>
<td>50,000</td>
<td>2,500,000</td>
<td>273,333</td>
<td>24,600</td>
</tr>
<tr>
<td>Shortage of shipping services</td>
<td>30</td>
<td>50,000</td>
<td>750,000</td>
<td>190,000</td>
<td>11,400</td>
</tr>
</tbody>
</table>
APPENDIX H : SCENARIO ANALYSIS
Section A. The correlation factors of reactions in managing maritime disruptions

<table>
<thead>
<tr>
<th>Reactions</th>
<th>General</th>
<th>Correlation factors</th>
<th>Farmers</th>
<th>Handlers</th>
<th>Processors</th>
<th>MarOpr</th>
<th>Wholesalers</th>
<th>Retailers</th>
<th>Consumers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contribution of stages to maritime disruptions</strong></td>
<td>0.50</td>
<td>0.5</td>
<td>0.05</td>
<td>0.5</td>
<td>0.05</td>
<td>0.4</td>
<td>0.07</td>
<td>0.5</td>
<td>0.04</td>
</tr>
<tr>
<td>All stages along the chain have an equal risk probability to probability suffer from maritime disruptions</td>
<td>0.40</td>
<td>0.4</td>
<td>0.03</td>
<td>0.4</td>
<td>0.03</td>
<td>0.5</td>
<td>0.03</td>
<td>0.4</td>
<td>0.03</td>
</tr>
<tr>
<td>All stages along the chain have an equal risk probability create maritime disruptions</td>
<td>0.40</td>
<td>0.4</td>
<td>0.06</td>
<td>0.5</td>
<td>0.06</td>
<td>0.5</td>
<td>0.06</td>
<td>0.5</td>
<td>0.06</td>
</tr>
</tbody>
</table>

| Factor in managing maritime disruptions | 0.90 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.06 | 0.9 | 0.05 | 0.9 | 0.05 | 0.9 | 0.07 | 0.9 | 0.08 | 0.9 | 0.08 |
| Contingency plan | 0.90 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.05 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.08 | 0.9 | 0.09 | 0.9 | 0.07 |
| A flexible transport arrangement in supply chain | 0.80 | 0.7 | 0.05 | 0.7 | 0.05 | 0.9 | 0.05 | 0.8 | 0.05 | 0.9 | 0.05 | 0.8 | 0.05 | 0.8 | 0.05 | 0.8 | 0.05 |
| Better human resource management | 0.80 | 0.7 | 0.04 | 0.7 | 0.04 | 0.9 | 0.04 | 0.7 | 0.04 | 0.8 | 0.06 | 0.8 | 0.04 | 0.8 | 0.04 | 0.8 | 0.04 |
| Improving port capacity and facility | 0.80 | 0.8 | 0.03 | 0.7 | 0.03 | 0.7 | 0.02 | 0.7 | 0.03 | 0.8 | 0.03 | 0.9 | 0.09 | 0.9 | 0.09 | 0.9 | 0.06 |
| Risk sharing plan | 0.80 | 0.7 | 0.03 | 0.7 | 0.03 | 0.8 | 0.03 | 0.7 | 0.03 | 0.8 | 0.05 | 0.9 | 0.03 | 0.9 | 0.09 | 0.9 | 0.06 |
| Reposition plan for empty containers | 0.60 | N/A | - | 0.6 | - | 0.6 | - | 0.7 | - | 0.6 | - | 0.7 | - | 0.7 | - | 0.7 | - |
| Active response of custom and quarantine agency | 0.50 | 0.6 | 0.05 | 0.5 | 0.05 | 0.5 | 0.05 | 0.7 | 0.05 | 0.5 | 0.05 | 0.5 | 0.05 | 0.5 | 0.05 | 0.5 | 0.05 |
| Back up system for bunkering supplies | 0.30 | 0.4 | 0.05 | 0.3 | 0.05 | 0.3 | 0.04 | 0.5 | 0.05 | 0.3 | 0.02 | 0.3 | 0.04 | 0.3 | 0.04 | 0.3 | 0.04 |
| Maintenance and repair system | 0.20 | 0.3 | 0.06 | 0.2 | 0.06 | 0.2 | 0.06 | 0.3 | 0.06 | 0.2 | 0.06 | 0.2 | 0.06 | 0.2 | 0.06 | 0.2 | 0.06 |
| Rail services | 0.20 | 0.3 | 0.06 | 0.2 | 0.06 | 0.2 | 0.05 | 0.3 | 0.06 | 0.2 | 0.04 | 0.2 | 0.07 | 0.2 | 0.08 |

| Strategies to deal with third or fourth party logistics | 0.90 | 0.9 | 0.06 | 0.8 | 0.06 | 0.9 | 0.06 | 0.8 | 0.06 | 0.9 | 0.05 | 0.9 | 0.06 | 0.9 | 0.08 | 0.9 | 0.08 |
| Negotiate the wheat selling prices | 0.90 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.05 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.07 | 0.9 | 0.07 |
| Arrange the shipping contract including its risks | 0.90 | 0.7 | 0.05 | 0.9 | 0.05 | 0.9 | 0.06 | 0.9 | 0.05 | 0.9 | 0.08 | 0.9 | 0.08 | 0.9 | 0.08 | 0.9 | 0.08 |
| Arrange the inland transport arrangements | 0.80 | 0.8 | 0.04 | 0.8 | 0.04 | 0.9 | 0.04 | 0.9 | 0.04 | 0.8 | 0.04 | 0.8 | 0.04 | 0.8 | 0.04 | 0.8 | 0.04 |
| Select the shipping companies | 0.80 | 0.9 | 0.06 | 0.8 | 0.06 | 0.8 | 0.07 | 0.8 | 0.06 | 0.9 | 0.05 | 0.7 | 0.05 | 0.7 | 0.06 | 0.7 | 0.06 |
| Substitute additional shipping costs | 0.50 | 0.5 | 0.07 | 0.5 | 0.07 | 0.6 | 0.07 | 0.6 | 0.07 | 0.5 | 0.07 | 0.5 | 0.07 | 0.5 | 0.07 | 0.5 | 0.07 |

**Note:**

CF: correlation factors
SD: standard deviation
Section B. The transition probabilities of disruption management scenarios on 341-360 days

Initial
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360

Farmers Handlers Processors Australian Shippers Australian Forwarders Australian shipping
0.21502 0.109663 0.0989329 0.054186236
0.042252363
0.039008714
0.21502 0.109663 0.0989329 0.054186236
0.042252362
0.039008714
0.21502 0.109663 0.0989329 0.054186235
0.042252362
0.039008714
0.21502 0.109663 0.0989329 0.054186235
0.042252362
0.039008714
0.21502 0.109663 0.0989329 0.054186235
0.042252362
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0.042252357
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Australian ports Indonesian shipping
0.010643725
0.104323052
0.010643725
0.104323051
0.010643725
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0.010643724
0.10432304
0.010643724
0.10432304
0.010643724
0.104323039
0.010643724
0.104323038

Indonesian ports Indonesian forwarders
0.048924151
0.031916338
0.048924151
0.031916338
0.04892415
0.031916338
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0.031916338
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0.031916338
0.048924149
0.031916337
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0.048924145
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0.031916335
0.048924145
0.031916334

Consignees Wholesalers Retailers
0.02470028 0.005156089 0.000242
0.02470028 0.005156089 0.000242
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0.02470028 0.005156089 0.000242

Final Consumers
0.215024746
0.215024745
0.215024743
0.215024742
0.215024741
0.215024739
0.215024738
0.215024736
0.215024735
0.215024734
0.215024732
0.215024731
0.21502473
0.215024728
0.215024727
0.215024726
0.215024724
0.215024723
0.215024722
0.21502472
0.215024719

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