AN ANALYTICAL FRAMEWORK OF MARITIME DISRUPTION MANAGEMENT WITHIN A SUPPLY CHAIN

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Abstract

This paper develops the concept of maritime disruption management (MDISM) from the context of maritime service users and providers in supply chains. In particular, the focus is on the manifestation of disruptive risk which is expanded from the concept initially proposed by Gaonkar and Viswanadham (2007) to include the delay, deviation, stoppage, or the loss of service platform as a result of a maritime disruption. Characteristics associated with the risk perceptions and instigating factors of maritime disruptions such as security and safety related factors, service and infrastructure, market, organisation and environment related factors are investigated including how MDISM is implemented by entities when managing maritime disruption and the strategies applied to detect, discover, and to recover from maritime disruptions. The data was obtained from the responses to a maritime disruption survey undertaken in 2009-2010 of 34 senior managers as maritime users, maritime providers and entities of a wheat supply chain between Australia and Indonesia. As a result the paper recommends four management strategies: 1) mitigation, 2) adaptation 3) coordination, and 4) intervention, as a means to manage unwanted maritime events that create disruptions in a supply chain. In addition, the research also find that the major restrictions to MDISM are the complexity of the supply chain structure because it discourages entities and maritime operators to change their risk management approach concerning various possible disruptive events.

Keywords

Maritime disruption, supply chain
1. Disruption framework on supply chain risk

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

<table>
<thead>
<tr>
<th>Authors</th>
<th>Definition of disruption</th>
<th>Related to disruption risks</th>
</tr>
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<tbody>
<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>
<td></td>
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<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>
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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>
<td></td>
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<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>
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<tr>
<td>Wagner and Bode (2008, p. 310)</td>
<td>‘The combination of (1) an unintended, anomalous triggering event that materialize somewhere in the supply chain or its environment, and (2) a consequential situations which significantly threatens normal business operations of the firms in the supply chain’.</td>
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<tr>
<td>Handfield et al. (2008, p. 34)</td>
<td>‘A major breakdown in production or distribution nodes that impacts other nodes in the supply chain’.</td>
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</table>

Source: Gurning (2011)

In the context of risk, disruption is an unwanted event occurring in the internal operations of an entity. 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 1 below). Firstly, uncertainties are events in a supply chain difficult to predict (Vorst, 2002, Brown, 2008, Jack...
et al., 2002, Parlar and Perry, 1996) and forecast (Blackhurst et al., 2004, Haigh and Holt, 2000, 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 in the literature. For example, Wilding (1998) presents the complexity triangle of a supply chain to help 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.

![Disruptions and supply chain risks taxonomy](source: Adapted from Gurning and Cahoon (2009))

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 (Handfield et al., 2008, Craighead et al., 2007, Parmar, 2007, Yu and Qi, 2004).

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 occur. 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 from a crisis perspective as it creates critical and chaotic conditions (Aguilera, 1990, Smith, 2000) and a resulting loss of capabilities in providing services in a supply chain (Barnes, 2004). However, the loss of capabilities also presents opportunities for a supply chain entity to develop other improved ways to provide services (Brockner, 2008, Fink, 1986, Pearson and Clair, 1998). 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.

This paper aims to develop an analytical framework of maritime disruption management (MDISM) from a supply chain perspective that incorporates the extensive effects of maritime disruption on supply chains including the delay, deviation, stoppage and the loss of service platform. Characteristics associated with the risk perceptions and instigating factors of maritime disruptions such as security and safety related factors, service and infrastructure, market, organisation and environment related factors are also investigated. The paper then suggests the implications of how MDISM is implemented by entities when managing maritime disruption. The paper concludes by discussing the strategies applied to detect, discover and recover from maritime disruptions.

2. Maritime disruption as crisis in the literature

There appears to be few studies that precisely define a maritime disruption. One example, by Bearing-Point and Hewlett-Packard (2005, p. 2), explains 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 show an inconsistency in terms of the consequences of maritime disruption and their significant 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, Ana, 2005, Farris, 2008). The other internal operational risks investigated in the literatures are low shipping performance (Song et al., 2005), trade security (Kraska and Wilson, 2009, Banomyong, 2005), security threats (Barnes, 2004, Williams and Treadaway, 1992), low port performance (Paul and Maloni, 2010, Robinson, 2007, Pettitt, 2007), higher transportation costs (Pinto and Wayne, 2006, Lewis et al., 2006, Michaelowa and Krause, 2008) and negative economic and social impact (Vanags, 2002, Everett, 2006). In contrast, the research of Wagner and Bode (2008, p. 310) suggests 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 have 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 the disaster 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 Blackhurst et al., 2005, Elkins et al., 2008, Handfield et al., 2008, Sheffi, 2001). However, the consequences of port closure due to maritime services such as shipping operations at port are not discussed in detail. In addition, 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.

3. Data collection process by telephone interview

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.

3.1. Sampling frames

Due to the pragmatic limitations of time and the research budget, 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. The sampling frame is structured and 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. The nature of wheat traders disperses maritime disruption widely across Australian-Indonesian routes. A response rate of...
67 per cent or 34 interviews 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.

3.2. Respondent profiles

Table 2 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. In addition, of all respondents, 35 per cent of the senior managers have less than five years of experience, 44 per cent were “experienced” (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 this research.

Table 2: Profile of survey respondents

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job titles</strong></td>
<td></td>
<td></td>
</tr>
<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>
<tr>
<td><strong>Years of experience</strong></td>
<td></td>
<td></td>
</tr>
<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>Experienced (over 10 years)</td>
<td>15</td>
<td>44</td>
</tr>
<tr>
<td><strong>Business or logistics related qualifications</strong></td>
<td></td>
<td></td>
</tr>
<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: Gurning (2011)
4. The results

Various unwanted internal and external factors creating uncertainty and severe negative consequences in the maritime leg can be defined as maritime disruption risks (as seen in Figure 2). The four significant aspects of (a) instigating factors, (b) inter-dependent factors, (c) leadership, 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.

4.1. Instigating factors

Instigating factors or disruptors are the driving forces of maritime disruption risks. Twenty instigating factors are identified in the literature and categorised into five basic causes of maritime disruptions, namely security and safety, service and infrastructure, market, organisation, and environment. However, in the survey, only 17 instigating factors were mentioned by respondents (as shown in Figure 2). Factors such as the failure of communication facilities, uncertain bunkering costs and tsunami were not recognised as disruptive events in the wheat supply chain.

![instigating factors in the literature](Image)

**Figure 2:** The comparison of instigating factors in the literature and the survey

Source: Gurning (2011)

4.2. 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 other words, these two factors are risks that emerge due to the interactions of entities in the supply chain. 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 shown in Figure 3).
<table>
<thead>
<tr>
<th>Access to loaders</th>
<th>Collective risk</th>
<th>Interaction</th>
<th>Risk perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Competition</td>
<td>- Propagating risk</td>
<td>- Lack of information on supply chain flows</td>
<td>- Risk cultures and practices</td>
</tr>
<tr>
<td>- Terminal selection</td>
<td>- Supply chain performance</td>
<td>- Lack of collaborations with community</td>
<td>-</td>
</tr>
<tr>
<td>- Service preference</td>
<td>- Limited coordination with supply chain entities</td>
<td></td>
<td>- Experiences</td>
</tr>
</tbody>
</table>

**Figure 3: Interdependent and leadership factors as the result of the survey**

Source: Gurning (2011)

Competition is a commercial risk factor that has emerged within the wheat supply chain particularly with regards 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)*

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 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 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). Consequently, as commented by one respondent “the bigger the company the more surety it has in its grain supply chain” (Port Manager). In addition, it was stated that the competition between the grain and mining industries in controlling dry bulk fleets 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. 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)

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)

### 4.3. Leadership

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 per cent of respondents 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)

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 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). 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 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.

4.4. 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 (67 per cent of total sample), 88 per cent 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 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)

I think maritime disruptions are really a major issue for Indonesian logistics nowadays (Ship Owner)

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

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. The remaining 45.2 per cent of the total respondents stated that deviations, stoppages, and services had been unavailable in their wheat 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).

...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 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)

Maritime disturbances created low impact to supply chains (Port Manager)

Therefore, in principle, maritime disruption can occur due to many factors; the instigating, inter-dependent, and leadership. In relation to its consequences, the impact of maritime disruption can be identified into four progressive events such as delay, deviation, stoppage, and loss of service platform (Figure 4).

![Figure 4: The analytical framework of maritime disruptions](source: Gurning (2011))
To explain the wide scope of maritime disruptions, a comprehensive framework of disruption management is discussed in the next section.

5. Maritime disruption management (MDISM) framework

Based on the information collected from the telephone survey, a MDISM framework is developed to explain the process of maritime disruption risk management implemented by entities in the Australian-Indonesian wheat supply chain. The main strategy applied by all entities is mitigation strategy. The other three important strategies implemented are adaptation, coordination and intervention strategies (see Figure 5). 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 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. 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. 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. It was found there are seven commercial impacts that entities

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Figure 5: The structure of maritime disruption risk management

Source: Adapted from Gurning, Cahoon, and Sambodho (2010)
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. 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. The major adaptation strategies implemented in the disruption stage by entities are inventory pooling at ports, various changes in working practices, and applying impact monitoring programs. Inventory pooling at ports is implemented 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.

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 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 3 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 3 : Coordination strategies implemented by respondents

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<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>
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<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>
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<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>
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</table>

Source: Gurning (2011)

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).

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 addition, other environmental implications such as lower levels of pollution at a port were 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)*

This study also 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. Figure 6 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.

![Figure 6: Existing supply chain entities controlling transport services](image)

*Source: Guming and Cahoon (2010)*

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 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)*

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. The information obtained from the telephone survey suggests that responses by respondents such as rescheduling the shipment process, using effective and strong coordination, and flexible rerouting to other ports, were only limited to minimising maritime disruptions internally for each entity along the wheat supply chain between Australia and Indonesia but were not effective at the network scale of the chain. The coefficients of the correlation (CR) between those three strategies were lower than 0.5 which is insufficient to provide evidence of the effectiveness of these three strategies in managing maritime disruptions. The discussions above confirm 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, the respondents 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/Ls or 4P/Ls, a wheat marketing body, and government agencies. Thus, the resulting actions were relatively passive rather than providing an active certain response within their organisation.

6. Conclusions

The paper 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. In addition, it was 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 results of this 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. 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.

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