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

RAJA OLOAN SAUT GURNING
ST (Sarjana Teknik/ Bachelor Engineering), M.Sc (Master of Science)

Submitted in fulfilment of the
Requirements for the degree of
Doctor of Philosophy

AUSTRALIAN MARITIME COLLEGE
AS AN INSTITUTE OF UNIVERSITY OF TASMANIA

JULY, 21st, 2011
DECLARATION OF ORIGINALITY

The thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duty acknowledged in the thesis, and to be the best of the candidate's knowledge and belief no material previously published or written by another person except where due to acknowledgement is made in the text of the text.

........................................Saut Gurning, 21st of July 2011
STATEMENT OF AUTHORITY OF ACCESS

This thesis may be made available for loan and limited copying in accordance with the Copyright Act 1968.

...........................................
Saut Gurning, 21st of July 2011
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.
ACKNOWLEDGEMENTS

Conducting this research study is not possible without the help and support of a range of individuals and institutions. Firstly, I want to thank my main supervisor, Dr. Stephen Cahoon. The knowledge, passion and guidance of my esteemed supervisor are gratefully acknowledged here at AMC. The time we have spent together has resulted in a wonderful learning experience for me, – thanks a million Stephen. I would like also to thank Dr. Hong-Oanh (Owen) Nguyen, as my second supervisor. Dr Nguyen has kept me on track for the duration of my studies and has always shown an interest and understanding in my chosen subject. My sincere gratitude goes also to Dr. Devinder Grewal my former supervisor for his key role in facilitating my entry into AMC and stimulated my initial interest in studying the wheat transport for this PhD study.

The faculty and staff in the Department of Maritime and Logistics Management at AMC Dr. Peggy Chen, Dr. Jiangang Fei , Hilary Haugstetter, Peter Cain, Prashant Bhaskar, Colin Kittel, Claire Gregory, Lee-Anne Britcliffe, Heather Hepburn, Jackie Evans, Dr. Elizabeth Vagg, Dianne Hazelwood, Capt. John Lloyd, and John Francis have all been extremely supportive over my three and half years and literally teaching me so many things I need to know about conducting research and productive academia atmosphere. Your kindness and grateful assistance will always be remembered.

To my research colleagues Indika Sigera, Hai Thanh Tran, Imanuel Dindin and Quazi Sakalayen in the Department of Maritime and Logistics Management, and from the Engineering group of Sinshuke Matsubara, Dr. Vikram Garaniya, Dr. Cing Bong, and around the postgraduate corridor of Australian Maritime College. Special thanks also goes to Dr. Ben Brooks for his advice, understanding, and most importantly his calming influence when things were the most challenging.

Without the support of Asosiasi Pengusaha Tepung Terigu Indonesia (APTINDO) and Australian Wheat Board providing information, contacts, and learning opportunity, this study would get a good progress. Special thanks Mr. Ian Faquar who has introduced me to such a valuable network in Australia as well as Ibu Ratna Sari Loppies who shared her ideas and experiences in the Indonesian wheat industry. I wish to thank to Brian
Cole, Peter Horsh, Barry Robinson, Diana Hollins, Andrea Cass, Ferry Kissi, Eka Kissi, Brian and Maree Cole and Joy Marmion who have contributed in my writing stage and warm friendship in Launceston. Many thanks should I give also to Prof Djauhar Manfaat, Pak Alam Baheramsyah, Pak Dwi Priyanta and Dr. Tri Achmadi who have fully supported me during my last session in finishing the study at ITS. Your attention and concern have encouraged me.

My wife and sons deserved special mention. The journey of my study would not have been possible without the loving and faithfully support of my wife, Fransiska Hutahaean. May God always bless you in your life especially for the next dreaming you want to after. My love and thanks also for my sons: David and Abednego who have motivated me.

Lastly but the most important one, I would like to praise my Lord, who let me passing this journey till the ending stage. I am so weak, but His so strong, and provides everything I need.
# GLOSSARY

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

DECLARATION OF ORIGINALITY ................................................................. ii

STATEMENT OF AUTHORITY OF ACCESS ..................................................... iii

ABSTRACT ........................................................................................................ iv

ACKNOWLEDGEMENTS .................................................................................... vii

GLOSSARY ........................................................................................................ ix

TABLE OF CONTENTS ..................................................................................... x

LIST OF TABLES ............................................................................................... xvii

CHAPTER ONE: INTRODUCTION ..................................................................... 1

1.1 Background .................................................................................................. 2

1.2 The wheat supply chain as a multifaceted chain structure ....................... 5

1.3 Australian-Indonesian wheat supply chain .............................................. 6

1.4 Research questions and research objectives ............................................ 7

1.4.1 Research questions ............................................................................... 7

1.4.2 Research objectives ............................................................................. 8

1.5 Organisation of the thesis ......................................................................... 9

CHAPTER TWO: THE AUSTRALIAN INDONESIAN WHEAT SUPPLY CHAIN ....... 11

2.1 Introduction ................................................................................................ 12

2.2 A generic wheat supply chain .................................................................. 12

2.3 The trade structure between Australia and Indonesia ............................. 14

2.3.1 Categories of wheat ............................................................................ 17

2.3.2 The major wheat handlers in Australia and Indonesia ....................... 19

2.3.3 Functionality and behaviour of wheat marketing bodies ................... 22

2.4 Maritime service providers and wheat trading terms ............................ 24

2.5 The impact of maritime disruptions on the wheat price ......................... 28

2.6 Summary ................................................................................................... 33
CHAPTER THREE: MARITIME DISRUPTIONS IN A WHEAT SUPPLY CHAIN ......................................................................................................................34

3.1 Introduction .......................................................................................................................... 35

3.2 Disruption framework of supply chain risk ........................................................................ 35
   3.2.1 Disruption stages ........................................................................................................ 40
   3.2.2 The cycle process of a disruption ............................................................................... 41
   3.2.3 Maritime disruptions ................................................................................................. 45

3.3 The drivers of supply chain risks in the maritime leg ............................................................ 47
   3.3.1 Severe weather conditions ...................................................................................... 52
   3.3.2 Security issues .......................................................................................................... 54
   3.3.3 Port strikes .............................................................................................................. 55
   3.3.4 Port congestion ........................................................................................................ 57
   3.3.5 Earthquakes ............................................................................................................. 59
   3.3.6 Political events ......................................................................................................... 60
   3.3.7 Port related equipment ............................................................................................ 60
   3.3.8 Customs clearance ................................................................................................. 61

3.4 Disruption management process ........................................................................................ 62
   3.4.1 Definition of mitigation approach ........................................................................... 62
   3.4.2 Mitigation approach in disruption management ....................................................... 65
      3.4.2.1 Inventory and sourcing .................................................................................... 68
      3.4.2.2 Contingency rerouting .................................................................................... 69
      3.4.2.3 Business continuity ......................................................................................... 70
      3.4.2.4 Recovery planning .......................................................................................... 70
   3.4.3 Disruption management approach in the transportation processes .......................... 71

3.5 Supply chain risk management in the wheat chain processes .............................................. 73

3.6 Maritime disruption analysis using the Markov process .................................................. 77
   3.6.1 The application of the Markov chain ...................................................................... 78
   3.6.2 Maritime risk approach by Markov chain ............................................................... 81

3.7 Propagation scenario ........................................................................................................ 85
   3.7.1 The concept of propagation effect on the supply chain network ............................. 86
   3.7.2 Propagation effect based on Markov process .......................................................... 88

3.8 Summary .......................................................................................................................... 90

CHAPTER FOUR : RESEARCH METHODOLOGY ..................................................................92

4.1 Introduction ....................................................................................................................... 92
CHAPTER FIVE: RESULTS OF THE RESEARCH SURVEY ............................125

5.1 Introduction ..................................................................................126

5.2 The characteristics of survey respondents ......................................127
  5.2.1 The response rate of the telephone interviews .................................127
  5.2.2 Respondent profiles ..................................................................130
  5.2.3 Question routing .................................................................131

5.3 Risk perception of maritime disruption risk ....................................132
  5.3.1 Risk categories and stages in the wheat supply chain ....................132
  5.3.2 Instigating factors ..................................................................135
    5.3.2.1 Security and safety related factors ........................................135
    5.3.2.2 Service and infrastructure related factors ...............................136
    5.3.2.3 Market related factors ......................................................139
    5.3.2.4 Organisation related factors ................................................141

5.3.2 Risk perception of maritime disruption risk ....................................132
  5.3.1 Risk categories and stages in the wheat supply chain ....................132
  5.3.2 Instigating factors ..................................................................135
    5.3.2.1 Security and safety related factors ........................................135
    5.3.2.2 Service and infrastructure related factors ...............................136
    5.3.2.3 Market related factors ......................................................139
    5.3.2.4 Organisation related factors ................................................141

5.4 Summary ....................................................................................123

4.2 Research design ..........................................................................93

4.3 Research approach ......................................................................96
  4.3.1 Survey approach ..................................................................99
  4.3.2 Telephone interviews ..........................................................100

4.4 Data collection ...........................................................................100
  4.4.1 Secondary data ..................................................................102
  4.4.1 Primary data ......................................................................104
  4.4.2 Data assessment .................................................................104

4.5 Population and sample generation ...............................................106
  4.5.1 Population frame ..................................................................106
  4.5.2 Area frames ......................................................................107
  4.5.3 Sampling frames ..................................................................109

4.6 Survey development and administering ........................................111
  4.6.1 The objectives of the maritime disruption survey .........................112
  4.6.2 Survey questions and measurement scales ..................................112
  4.6.3 Pre-testing ..........................................................................115
  4.6.4 Survey development .............................................................117
  4.6.5 Administering the telephone survey ..........................................119

4.7 The error control process of the telephone interview ......................121
  4.7.1 Measurement error ................................................................122
  4.7.2 Induced bias .......................................................................122
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.3.2.5 Environmental related factors</td>
<td>142</td>
</tr>
<tr>
<td>5.3.3 Interdependent factors</td>
<td>143</td>
</tr>
<tr>
<td>5.3.4 Leadership factors</td>
<td>145</td>
</tr>
<tr>
<td>5.3.5 Progressive factors</td>
<td>147</td>
</tr>
<tr>
<td>5.4 Descriptive data on maritime disruptions</td>
<td>150</td>
</tr>
<tr>
<td>5.4.1 Frequency of maritime disruptive events</td>
<td>150</td>
</tr>
<tr>
<td>5.4.2 The operational impact of maritime disruptive events</td>
<td>151</td>
</tr>
<tr>
<td>5.4.3 The consequence value of maritime disruptive events</td>
<td>156</td>
</tr>
<tr>
<td>5.4.5 Probability level of maritime disruptive events</td>
<td>158</td>
</tr>
<tr>
<td>5.4.6 The cycles of maritime disruptions</td>
<td>161</td>
</tr>
<tr>
<td>5.4.6.1 General disruption process</td>
<td>161</td>
</tr>
<tr>
<td>5.4.6.2 Congestion due to equipment breakdown</td>
<td>162</td>
</tr>
<tr>
<td>5.4.6.3 Port stoppages due to weather factors</td>
<td>164</td>
</tr>
<tr>
<td>5.4.6.4 Disruption due to earthquake</td>
<td>165</td>
</tr>
<tr>
<td>5.4.6.5 Disruptions due the shortage of dry bulk fleet</td>
<td>165</td>
</tr>
<tr>
<td>5.5 General maritime disruption management process</td>
<td>167</td>
</tr>
<tr>
<td>5.5.1 The detection period of maritime disruptive events</td>
<td>167</td>
</tr>
<tr>
<td>5.5.2 Approach to discovering maritime disruptive events</td>
<td>168</td>
</tr>
<tr>
<td>5.5.3 Maritime disruption recovery actions</td>
<td>168</td>
</tr>
<tr>
<td>5.6 Strategies implemented in managing maritime disruptions</td>
<td>172</td>
</tr>
<tr>
<td>5.6.1 Mitigation strategies</td>
<td>173</td>
</tr>
<tr>
<td>5.6.2 Adaptation strategies</td>
<td>177</td>
</tr>
<tr>
<td>5.6.3 Coordination strategies</td>
<td>180</td>
</tr>
<tr>
<td>5.6.4 The intervention response</td>
<td>182</td>
</tr>
<tr>
<td>5.7 The analysis of disruption management strategies</td>
<td>187</td>
</tr>
<tr>
<td>5.7.1 The preference strategies for managing maritime disruption</td>
<td>188</td>
</tr>
<tr>
<td>5.7.2 Correlation factors of managing disruptions on commercial impacts</td>
<td>190</td>
</tr>
<tr>
<td>5.8 Summary</td>
<td>193</td>
</tr>
</tbody>
</table>

CHAPTER SIX: DISRUPTION MANAGEMENT SCENARIO .................197

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Introduction</td>
<td>198</td>
</tr>
<tr>
<td>6.2 The general assessment of the Markov chain process</td>
<td>199</td>
</tr>
<tr>
<td>6.3 Data collection for the assessment process</td>
<td>201</td>
</tr>
<tr>
<td>6.4 Markovian approach of disruption management assessment</td>
<td>205</td>
</tr>
<tr>
<td>6.4.1 Basic framework of disruption management assessment</td>
<td>205</td>
</tr>
<tr>
<td>6.4.2 Transition states of wheat supply chain of the case</td>
<td>212</td>
</tr>
</tbody>
</table>
6.4.3 Multi-state scenarios of maritime disruption management ........................................ 213
6.4.4 Formulating the optimised disruption management strategies .................................. 216
6.4.5 Algorithm for optimised mitigation scenario .............................................................. 218
6.4.6 Optimised strategies of the case .................................................................................. 219
6.5 Propagation effect in the wheat supply chain ................................................................. 221
6.5.1 Propagation state definition ....................................................................................... 221
6.5.2 Formulating the propagation matrix ........................................................................... 222
6.5.3 Probabilities prediction of propagation of maritime disruption .................................. 224
6.5.4 Propagation evaluation of the case ............................................................................. 226
6.6 The assessment result .................................................................................................... 227
6.7 Summary ....................................................................................................................... 232

CHAPTER SEVEN : SUMMARY AND CONCLUSION ......................................................... 234
7.1 Introduction .................................................................................................................... 235
7.2 Summary of results ....................................................................................................... 235
7.3 Study limitations .......................................................................................................... 241
7.3.1 Participants: selection bias and manager desirability ................................................. 241
7.3.2 Generalisability ......................................................................................................... 241
7.4 Suggestions and recommendations for future research ................................................ 242

REFERENCES ...................................................................................................................... 245

APPENDIX A : SURVEY INSTRUMENT ............................................................................. 287
APPENDIX B : PRETESTING LETTER ................................................................................. 304
APPENDIX C : RESPONSE CARDS .................................................................................. 307
APPENDIX D : ADVANCE LETTER .................................................................................... 315
APPENDIX E : PARTICIPANT INFORMATION SHEET ....................................................... 320
APPENDIX F : CONFIRMATORY LETTER ......................................................................... 324
APPENDIX G : DATA ANALYSIS ...................................................................................... 327
APPENDIX H : SCENARIO ANALYSIS .............................................................................. 342
APPENDIX I : PRESENTED PAPERS .................................................................................. 345