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Transport Capacity Improvement in and around Ports: A Perspective on the Empty-container-truck Trips Problem

By
Samsul Islam

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Operations and Supply Chain Management

The University of Auckland
2014
Abstract

The problem of capacity shortage is an important issue for the major ports of the world. In particular, there is an increased necessity for additional transport capacity for containerised goods travelling to and from the hinterland (the region served by the port). For such travel, transportation using roads is often more popular than other methods (e.g., rail). A potential mechanism to increase road-side transport capacity is to lessen the number of empty truck trips by transferring increased numbers of containers using the same number of trucks. This forms the key Research Question (RQ) for this thesis. Namely, **how can the number of empty container truck trips to and from a port be reduced to increase the road transport capacity?**

To date, much of the existing literature on the empty trips issue has been largely of an analytical nature (e.g., the backhaul problem) and thus has generally disregarded the potential benefits of the idea of involving all of the parties concerned in the container transport chain. To bridge that research gap, this thesis extends the shared-transportation concept, which is already proving popular in other areas (car-sharing and bike-sharing systems, for example), to the maritime logistics domain, in the form of truck-sharing. For this reason, the overall thesis work involves a combination of different research methodologies, which may be either qualitative (e.g., exploratory) or quantitative (e.g., simulation).

However, before diving into the specifics of empty truck trips, the thesis looks broadly at capacity shortages at ports and particularly at **how can a port’s capacity be improved?** Therefore, a system-dynamics framework is produced based on a review of the factors influencing port capacity, to guide and improve overall port capacity (including, but not limited to, transport capacity). The thesis also shows the potential usefulness of the suggested framework as an operational tool for capacity-expansion decisions (e.g., transport capacity improvement).

In support of the question of reducing empty container truck trips, the thesis has four supporting research questions. First, RQ1 is: **What are the different mechanisms available in different disciplines and domains for reducing empty truck trips?** One of the key findings for this question is the prospect of using the truck-sharing concept for container transportation. RQ2 is: **Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips?** This research question further applies and extends the truck-sharing concept. Therefore, the model developed to answer this question is referred to as a Truck-Sharing Service (TSS). However, the successful implementation of the suggested truck-sharing model depends on truck-sharing constraints that have not been fully explored. Therefore, RQ3 is: **What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges?** Research findings show that port-related attributes, such as a lack of flexibility in the truck appointment system, form constraints against truck-sharing. Finally, to quantify the effect of the truck-sharing model on the potential for the improvement of transport capacity and its related carbon emission saving possibilities, RQ4 is: **How will the case study port’s transport capacity be affected by different scenarios?** Simulation results show improvement in performance using the truck-sharing idea. In particular, the truck-sharing concept boosts port gate- and transport-capacity, handles the increasing future truck volume effectively, and decreases carbon emissions generated from container trucks.

The findings of this thesis work have important implications for the study of both freight transportation and maritime logistics in the reduction of the number of empty trips made by container trucks; this thesis provides theoretical grounds for practical ways of understanding and reforming the containerised cargo transportation process for road carriers. The aim is to increasing freight transport capacity and achieving sustainable transportation benefits at the port.
Acknowledgements
The writing of my thesis was a thoroughly memorable and enjoyable experience. I would like to thank the following people for all their effort, motivation and support during this research study:

- Professor Tava Olsen, whose experience and expert advice, valuable guidance and professional assistance helped me in choosing the research topic to work on
- the personnel of the Ports of Auckland, including, but not limited to, Yvonne Theuerkauf (Logistics Manager), Antony de Pont (Gate Operations and Documentation Manager) and Matthew Kidman (Commercial Relationships Manager)
- the talented entrepreneur Andrew Bishop (director of a load matching company), who met me and shared his valuable experience in truck-sharing service in Australasia region
- Executive Officer Nicola Tapper of National Road Carriers (New Zealand’s leading transport association) for her contribution and efforts over the past year
- the many road carriers for allowing me to use their data, and providing their comments
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Table of Contents

Abstract.................................................................................................................................ii

Acknowledgement..................................................................................................................iii

Table of contents..................................................................................................................iv

List of tables...................................................................................................................................vii

List of figures.....................................................................................................................................viii

List of original articles..............................................................................................................xii

Chapter 1: Introduction

1.0 Introduction......................................................................................................................... 01

1.1 Problem background: Capacity shortage at ports......................................................02

1.2 Causes of empty truck trips.........................................................................................07

1.3 Increasing container transport capacity by reducing empty truck trips..............10

1.4 Benefits of reducing empty truck trips........................................................................10

1.5 Literature related to the empty trucks problem........................................................14

1.6 Problem summary and key research questions.......................................................16

1.7 Research methodology.................................................................................................19

1.8 Major contribution of the thesis..................................................................................20

1.9 Organisation of the thesis relative to published articles.......................................21

Chapter 2: From a review to a framework to handle capacity problems

2.1 A review of Operations Research (OR) at ports: An update..............................26

2.2 A review of factors affecting port capacity...............................................................32

2.3 Managerial implications of the framework.................................................................38

Chapter 3: Exploring potential solutions to reduce empty truck trips

3.1 Introduction......................................................................................................................43

3.2 Research methodology.................................................................................................45
## 3.3 Review of potential concepts ................................................................. 46
## 3.4 Synthesis of concepts .......................................................................... 60
## 3.5 Conceptual implications ....................................................................... 61
## 3.6 Managerial implications ........................................................................ 62
## 3.7 Conclusion .............................................................................................. 62

### Chapter 4: Developing a truck-sharing mechanism to reduce empty trips

4.1 Introduction............................................................................................... 63
4.2 Literature review ....................................................................................... 64
4.3 Research methodology ............................................................................. 65
4.4 Study of a seaport ................................................................................... 69
4.5 To-be truck hauling process .................................................................... 76
4.6 Conclusion ................................................................................................ 83

### Chapter 5: Exploring truck-sharing constraints to reduce empty truck trips

5.1 Introduction............................................................................................... 84
5.2 Literature review ....................................................................................... 85
5.3 Research methodology ............................................................................. 91
5.4 The container road carrier industry .......................................................... 96
5.5 The challenges of truck-sharing ............................................................... 98
5.6 A collaboration framework ..................................................................... 104
5.7 Managerial implications ........................................................................ 112
5.8 Conclusion ................................................................................................ 113

### Chapter 6: Measuring truck-sharing benefits to reduce empty truck trips

6.1 Introduction............................................................................................... 114
6.2 Literature review ....................................................................................... 115
6.3 Simulation methodology .......................................................................... 119
6.4 Case study: Truck arrival process at a port................................. 125
6.5 Managerial implications................................................................. 135
6.6 Findings and conclusion ................................................................. 136

Chapter 7: Findings and conclusion

7.1 The research answers .................................................................... 139
7.2 Managerial implications of this thesis ......................................... 143
7.3 Conceptual implications of this thesis .......................................... 143
7.4 Future research needs .................................................................. 143
7.5 Limitations of this thesis ............................................................... 144

Appendix A: Mechanism(s) and constraints of reducing empty truck trips .... 145
Appendix B: A review of Operations Research (OR) at ports: An update ........ 162
Appendix C: A review of factors affecting port capacity ....................... 165
Appendix D: Examples of interview questions .................................... 174
Appendix E: Demographic data of the respondents ............................. 175
References ........................................................................................ 176
List of Tables

Table I. Interdisciplinary concepts and their implications for empty trips issue ........60
Table II. Feature comparison of truck hauling processes........................................71
Table III. The Port’s empty-truck trips in January, 2011........................................72
Table IV. 24 hours BTAS export appointment slots..............................................75
Table V. Interview protocols..................................................................................94
Table VI. Boundary determination for truck-sharing constraints.................................105
Table VII. Random nature of truck arrivals at the port..............................................106
Table VIII. Expected performance measures in a truck-sharing PMS.........................108
Table IX. Examples of application of simulation in process modelling.........................116
Table X. Examples of views expressed in the literature..............................................121
Table XI. Difference between three simulation models..............................................121
Table XII. The port’s empty-truck trips for February, 2011.......................................126
Table XIII. Approximate percentage of trucks using the self-service kiosks.................131
Table XIV. Performance of the as-is process..........................................................133
Table XV. Performance of the to-be process..........................................................133
Table XVI. Container origin and destination groups for the Port...............................135
List of Figures

Figure 1. Leading reasons for capacity shortage at container terminals ..................... 04
Figure 2. Most significant consequences of capacity shortage ................................. 04
Figure 3. Key mechanisms available for a port to expand its overall capacity ................ 06
Figure 4. Four legs of an import container movement .............................................. 08
Figure 5. Sources of empty truck trips in an import process .................................... 08
Figure 6. Four legs of an export container movement ............................................. 09
Figure 7. Sources of empty truck trips in an export process ................................... 09
Figure 8. Standard classification of sustainable benefits for empty trips reduction .... 11
Figure 9. Prime literature related to the empty trips problem ................................. 16
Figure 10. The main research question, and sub-questions of the thesis .................... 19
Figure 11. Major contributions of this thesis to the literature .................................. 21
Figure 12. Organisation of the thesis chapters ...................................................... 23
Figure 13. An overview of the interrelationship between the sections ....................... 24
Figure 14. Distribution of publications across years .............................................. 28
Figure 15. Applied research methodologies of the surveyed studies ....................... 29
Figure 16. Optimisation areas of a container terminal ....................................... 30
Figure 17. Stock and Flow view of factors affecting port capacity ...................... 34
Figure 18. Gate lanes required in a sample port .................................................. 35
Figure 19. Research opportunities pyramid on factors affecting port capacity .... 36
Figure 20. A simplified sample CLD for yard capacity ....................................... 39
Figure 21. A sample user interface for yard capacity .......................................... 40
Figure 22. A simplified sample CLD for terminal capacity .................................. 40
Figure 23. Major content categories of the literature review ............................... 44
Figure 24. Trucking hinterland chain ................................................................. 48
Figure 25. Reduction in the number of empty truck trips due to the street-turn........ 51
Figure 26. A connected dry port established to have an impact on empty truck........ 52
Figure 27. Ride-sharing classification scheme ............................................. 54
Figure 28. Information sharing in more traditional supply chain context .............. 56
Figure 29. Information sharing in CPFR-based supply chain context ..................... 56
Figure 30. CTM partners to maximise transport benefits .................................. 57
Figure 31. Route network diagram for a code-sharing agreement.......................... 58
Figure 32. Major contributions of this chapter to the literature ............................... 65
Figure 33. The suggested BPR methodology for maritime terminals .................... 66
Figure 34. Post-BTAS monthly average truck turnaround time (minutes) ............... 70
Figure 35. Conventional truck dispatch process ............................................. 73
Figure 36. ATAS laden container delivery process .......................................... 75
Figure 37. DFD diagram (context level) of TSS functions .................................... 78
Figure 38. ATAS laden container delivery process: Integrated with TSS structure.... 79
Figure 39. Components of the integrated truck appointment system and TSS........... 80
Figure 40. A list of the factors constraining full loading of vehicles in return trips.... 86
Figure 41. Factors constraining the backloading of trucks .................................. 86
Figure 42. Classification of the constraints on vehicle utilisation ............................. 87
Figure 43. Sources of potential empty trips of a container truck ............................ 88
Figure 44. Sources of potential empty trips of a general truck .............................. 88
Figure 45. The contributions of research question (truck-sharing constraints) ......... 89
Figure 46. The contributions of research question (overcoming challenges) ........... 91
Figure 47. A cause and effect diagram to demonstrate truck-sharing challenges ....... 98
Figure 48. Flexible port policies as a driver for truck-sharing .............................. 107
Figure 49. A relationship-building model for road carriers................................. 109

Figure 50. Major contributions of this chapter to the literature............................. 116

Figure 51. Examples of asset utilisation in many types of service industries......... 117

Figure 52. The process simulation framework adopted for use in this chapter ....... 123

Figure 53. Modelling boundary of the current simulation project......................... 127

Figure 54. Outline of data collection methods and key priority areas ................. 129

Figure 55. Graphical representation of the truck arrival process.......................... 130
List of Original Articles

The body of this thesis consists of an introduction, a conclusion and five chapters. Most of these chapters are based on papers that have been either published or submitted to a refereed journal. The papers can be classified into two categories: papers related to the overall port-capacity shortage problem (Category 1: Articles I to II) and papers related to the transport-capacity shortage problem (Category 2: Articles IV to VII). The articles are listed below:

**Category 1: Overall port capacity shortage problem (including transport capacity shortage)**


**Abstract:** Decision makers today face the problem of exploring ways to increase port capacity. The determination to increase port capacity is influenced by continuous growth in the number of containers entering or departing the port, the constant increase in ship size, as well as by many other, previously unforeseen, factors. In order to make contributions to this maritime logistics domain, this study explores the drawbacks in the typical sub-system based literature that is available in regard to the subject of port capacity (i.e., literature focusing on specific components of a port): this study also examines studies that could potentially address, diversify and broaden the research pertaining to port capacity expansion. Therefore, the study presents an extensive review of the Operations Research (OR) literature, including a trend analysis.

**Keywords:** Simulation, Operations Research (OR), container terminal, capacity management

**Major findings:** To increase port capacity, this study identifies the need for further research on the integrated approach (i.e., taking into account the whole port) using simulation procedures.


**Abstract:** One of the most important dynamic problems that decision makers face in today’s maritime ports is where and how to upgrade the existing port capacity for rising port demands due to continuous growth in containerised trade and the tendency for bigger ships to visit ports. The purpose of this study is to offer a conceptual framework to summarise the research in the field concerned with the factors influencing port capacity using a holistic approach after reviewing academic and industry-related studies. This study is significant as there is limited literature on this subject concerning factors affecting capacity and studies carried out so far on capacity improvement mechanisms are constrained by the lack of integrated points of view.

**Keywords:** Simulation, productivity, performance, container terminal, capacity

**Connection to the Article I:** In continuation to the previous article written on the urge to use all components of a port in order to increase capacity, this study reviews earlier literature. The reviewed literature concerned with the factors influencing port capacity from a holistic point of view (i.e., taking into account the whole port), and hence offers a conceptualisation (framework).

**Abstract**: A port is a key part of a supply chain. However the problem of system-wide capacity shortage puts port authorities under pressure to keep up to date with ways in which to solve it. The purpose of this study is to propose a System Dynamics (SD) framework for managerial decision making that is developed based on the factors affecting port capacity. Hence, the proposed capacity management framework inherits the potential for use at ports in capacity-management-related problem solving. The framework would be of importance in assisting managers in identifying possible capacity expansion opportunities. Academics and those with corporate interests in the capacity management of ports have raised many issues in recent years in which there has been growth in the number of containers transported worldwide.

**Keywords**: Simulation, System Dynamics (SD), container terminal, capacity management, port

**Connection to the Article II**: Although the earlier article has reviewed the factors affecting port capacity and offered a framework, it did not suggest a promising solution for assessing the usefulness of the suggested framework. By taking that limitation into account, this study further explores the usefulness of the framework from both a micro- and a macro-perspective.

**Category 2: Transport capacity shortage problem**


**Abstract**: With the aim of increasing container transport capacity, a synthesis of literature from different, but complementary, research areas should result in the identification of a set of concepts that can give useful insights; these, in turn, could lead to the full utilisation of otherwise partially or fully unutilised container trucks. An extensive review of academic and industry-related papers is comprehensively conducted. The aim is to create an overview of recent research that has been conducted on the empty trips issue from different conceptual and disciplinary perspectives, as well as the trends in each field, and the extent and type of research prevailing.

**Keywords**: The shared-transportation concept, Transport capacity shortage, Supply chain management, Truck-sharing, Traffic congestion, Carbon emission, Congestion

**Major findings**: This study reviews studies and explores ideas, which can be applied in the making, or formulation of, a port’s strategy to minimise its empty truck trips and hence to increase transport capacity. On the contrary, the earlier category focuses on the port components as a whole in order to increase port capacity, rather than one of its individual components.

**Abstract:** Empty container trucks may cause a deficit in transport capacity and contribute to congestion and emissions in the port territory. Reengineering of the container truck hauling process to introduce truck-sharing arrangements using the truck appointment system has the potential of reducing the number of empty-truck trips. This research evaluates the results from an investigation of the truck appointment system using a case study approach. The data collection phase involved primary and secondary sources along with using publicly available data on port operations. The study explores a dynamic truck-sharing facility for a computer-based matching system to assign probable export containers to available empty slots of a container truck. The proposed model reengineers the truck appointment system with a potential to reduce the number of empty-truck trips to increase container transport capacity around port gates.

**Keywords:** Transport capacity; Empty-truck; Truck appointment system; Process reengineering; Transportation; Transport management

**Connection to the Article IV:** In the earlier article, a review of studies is conducted to create an overview of different potential mechanisms that can be used to reduce empty truck trips at ports, and hence to increase container transport capacity. Based on those findings, this study extends a specific mechanism (i.e., the shared-transportation concept) by adopting a process reengineering approach to the truck arrival process at the port gate, in order to minimise the empty-truck trips.

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**Abstract:** This study aims to explore the challenges of truck-sharing and effective ways of dealing with those in achieving supply chain collaboration and collaboration in transportation management (e.g. transport collaboration) for transport capacity expansion, and reducing carbon emission and traffic congestion for integrating environmental and social sustainability issues. This study also reveals insights into successful shared-transportation and a reduction in empty trips. This exploratory qualitative study was conducted by means of interviewing road carriers from the container transportation industry. To broaden its appeal, truck-sharing initiatives must be able to overcome challenges by combining theoretical insight with an understanding of the practical aspects of such an endeavour. This original research fosters knowledge that is unique and which also has real-life applications in maritime logistics studies and supply chain literature.

**Keywords:** Carbon emission, Empty trips, Environmental sustainability, Social sustainability, Supply chain collaboration, Traffic congestion, Transport capacity shortage, Truck-sharing

**Connection to the Article V:** Although the earlier study adopts a case study approach to suggest a process reengineering approach to minimise the number of empty-truck trips, they ignore to a large degree the truck-sharing constraints arising from practical aspects of the transportation industry. To cover that research gap, this study aims to explore the challenges of truck-sharing.
**Article VII:** Samsul Islam, and Tava Olsen (2014), "Process simulation of truck arrival process at a seaport: Evaluating truck-sharing benefits for empty trips reduction", will be submitted

**Abstract:** With the aim of a reduction in the number of empty-truck trips, this study simulates the truck-sharing idea of the container truck hauling process in a port and also evaluates the positive effects of the changes made. This simulated experiment is important to justify the theory that the truck-sharing initiative has the potential to improve transport capacity in and around a port territory and is likely to reduce carbon emissions and empty truck trips (and related traffic congestion, fuel consumption and pollution). The simulation results confirm that the truck-sharing event boosts port gate capacity and transport capacity, and it can handle the increasing future truck volume effectively. The model can also account for reduced carbon emissions released from trucks in the port surroundings.

**Keywords:** Simulation, Supply chain collaboration, Sustainability, Carbon emission, Congestion

**Connection to the Article VI:** Although a significant amount of “empty running” may always prevail because of truck-sharing constraints, the simulation results of this study will be useful in persuading port authorities to evaluate and implement a truck-sharing model.
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Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

"The empty truck trips problem at container terminals: An interdisciplinary review to explore alternative solutions", Submitted to "Transport Reviews A Transnational Transdisciplinary Journal"

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"Re-engineering the Seaport Container Truck Hauling Process: Reducing Empty Slot Trips for Transport Capacity Improvement", accepted for publication in Business Process Management Journal at volume 19 and issue 5

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"Truck-sharing challenges for hinterland trucking companies: a perspective of the empty container truck trips problem", Accepted for publication in Business Process Management Journal (BPMJ)

Nature of contribution by PhD candidate: PhD candidate wrote the text
Extent of contribution by PhD candidate (%): 95%

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"Operations Research (OR) at ports: An update", published in 20th International Congress on Modelling and Simulation (MODSIM), Adelaide, South Australia, 01–06 December 2013

Nature of contribution by PhD candidate: PhD candidate wrote the text

Extent of contribution by PhD candidate (%): 95%

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"Factors affecting seaport capacity", published in 19th International Congress on Modelling and Simulation (MODESIM), Perth, Australia, 12–16 December 2011

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The undersigned hereby certify that:

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Last updated: 25 March 2013
Chapter 1: Introduction

Ports are key points-of-transaction between and within countries (Haynes et al., 1997). Many studies confirm that a port is an influential component in supply chain management activities through its cargo distribution processes (Heaver, 2002, Bichou and Gray, 2005, Tongzon and Heng, 2005, Wang and Cullinane, 2006, Panayides and Song, 2008, Panayides and Song, 2009). Sufficient facilities (such as inland transportation networks) and services are required to enhance a port’s competitiveness (Carbone and De Martino, 2003). Key to such competitiveness is ensuring that worldwide transportation services are neither delayed nor interrupted.

The container terminal is regarded as a core part of a seaport (Panayides and Song, 2008). Further, the importance of the container terminal has increased in recent years because of increased containerisation (De Souza et al., 2003). Although port containerisation has many worthwhile benefits (e.g., cheap and fast cargo delivery), it nevertheless brings challenges. Container terminals need dedicated infrastructure and integrated technology and are designed to handle a certain maximum capacity. New container terminals have to be designed and built to accommodate sufficient berths and cranes to handle both the existing and future increases in numbers of containers (Rashidi and Tsang, 2013).

A frequent challenge is the limited capacity in many areas of the container terminal operation, which is a key factor influencing the operational capability of a seaport. The magnitude of the capacity shortage problem at ports has been made clear in many studies (e.g., Paixão and Marlow, 2003, Steenken et al., 2004, Pallis and de Langen, 2010, Maurer and Degain, 2012, Dekker et al., 2013), and its different possible consequences can be found in some other studies (e.g., Ircha, 2001, Baird, 2002, Steenken et al., 2004, Dekker, 2005, Imai et al., 2006, Grossmann, 2008). This system-wide capacity shortage problem has profound effects on the effectiveness and efficiency of containerised freight transportation. Further, the effects of overall capacity shortage on containerised freight transportation are likely to be significant because all port components are inter-connected (Cetin and Cerit, 2010).

One component of capacity shortage is truck capacity, particularly in the hinterland (which represents the service region usually covered by a port). Truck transportation occupies the maximum market share in many ports (European Union Road Federation, 2008, Wang et al., 2011). During the 1990s, California updated its port capacity to handle bigger container ships without improving the transport facilities to connect the port to the hinterland; this created major bottlenecks (Auckland Regional Holdings, 2009). Increased demand for truck transport capacity has also been observed at the Port of Rotterdam (European Union Road Federation, 2008) and at the Ports of Auckland (Auckland Regional Holdings, 2009).

An attempt at solving the capacity shortage problem for container transport capacity by simply increasing the number of container trucks is a potentially harmful solution. Such a non-environmental friendly solution may encourage increased carbon emissions, traffic congestion, fuel consumption and pollution. However, a potential mechanism to increase road-side transport capacity, without a lot of risks, investment, and effort, is to lessen the number of empty truck trips and to transfer an increased number of containers using the same number of trucks. This will both reduce congestion and improve efficiency (Theofanis et al., 2007). This forms the key research question for this thesis. Namely, **how can the number of empty container truck trips to and from a port be reduced to increase the road transport capacity?**
The existing literature on empty truck trips crosses the boundaries of many disciplines including supply chain collaboration, coordination problems in hinterland transport networks, and the traditional backhauling problem. Indeed, the empty trips problem is also addressed, to a certain extent, in other research domains (e.g., passenger transportation). However, a new critical perspective on empty truck trips is deemed necessary to fill a research gap in the literature of maritime logistics and to bridge the connection between theory and practice.

This chapter outlines the contextual framework for this thesis. As such, it calls attention to the research elements relevant to answering the research questions posed in the problem statement. In the next section, the researcher gives further background on the issue of capacity shortages at ports. This issue is then taken up again in Chapter 2, which asks the broader question **how can a port's capacity be improved?** It presents a System Dynamics framework to understand port capacity shortage issues better (e.g., including, but not limited to, the transport capacity shortage problem). The recommended framework could be of significance in assisting transport managers in identifying possible transport capacity expansion opportunities.

Section 1.2 explains what causes empty truck trips. Then, Section 1.3 explores the idea of increasing transport capacity by reducing empty truck trips. Section 1.4 explores the benefits of reducing such empty trips. Section 1.5 describes literature related to the empty trucks problem. These lead to Section 1.6, which summarises the key research questions for the thesis. Section 1.7 describes the research methodologies followed in this thesis. Section 1.8 outlines the thesis’ key contributions and Section 1.9 explains the organisation of the thesis.

The rest of this thesis is organised as follows. First, Chapter 2 takes a step back and examines more broadly how a port's capacity can be improved using a systems dynamics framework (the framework proposed has been developed through a review of existing literature). The suggested framework can be used to improve recommendation performance in multiple seaport components (e.g., berth, container yard, and truck gate) by linking them using a "stock and flow" diagram. Then Chapter 3 presents a review of the academic and industry-related papers concerned with the empty trucks problem. The review utilises insights from a holistic point of view (summarising key contributions from different disciplines and domains). All of the research fields outlined suggest partially, or even completely, different types of existing solutions, or mechanisms. Using these alternate mechanisms, the empty trips problem of maritime logistics can be explored, tested and solved. One of the key findings of Chapter 3 is the potential for using the truck-sharing idea (the shared-transportation concept) to the container truck transportation. Therefore, Chapter 4 further applies and extends the truck-sharing concept, and develops a truck-sharing mechanism with the potential to reduce the number of empty-truck trips in order to increase container transport capacity. To focus on the implementation of the truck-sharing model, Chapter 5 explores the truck-sharing challenges and suggests an effective way of dealing with these from a real-life perspective in order to assist practitioners in gaining information and knowledge. Chapter 6 develops a Discrete Event Simulation (DES) model that verifies the results that the truck-sharing idea boosts port gate- and transport-capacity. Finally, Chapter 7 concludes the thesis.

### 1.1 Problem background: Capacity shortages at ports

In this section, we explore the background to the problem considered here, namely capacity shortages at ports. We first explore opportunities and challenges provided by containerisation. Next, we explore reasons for and consequences of capacity shortages at container terminals. We then examine capacity expansion mechanisms for container terminals and the importance of transport capacity expansion. Finally, we highlight the significance of truck transportation.
1.1.1 Containerisation: Opportunities and challenges

Shipping containers are industrially-manufactured standard boxes to be used for transporting cargo in maritime logistics. Currently, many years after their invention by the entrepreneur Malcom McLean in 1956 (Cudahy, 2006), shipping containers have become ubiquitous; they have been widely adopted by the business world as a means of transport and are now a standard method of efficient freight transportation. They allow for a fast turn around and inexpensive cargo handling (Abrashova et al., 2012). However, this containerisation has its limitations, most of which come in the form of “challenges” that are predominantly applicable to container terminals (Bandeira et al., 2009). For example, in leading ports, new terminals need to be built, just to keep up with increasing demand, and in order to conform with expectations of offering better services to shippers, who often consider diverting freight from one country to another depending on port services. The demand for making new container terminals brings the need for more berths and cranes to be provided to handle containers (Rashidi and Tsang, 2013).

Building more berths and cranes is not the only requirement that ports need to meet in order to be able to offer the minimum amount of service to importers and exporters. In order to be recognised as a leading port in the region in which they are situated, ports are also required to invest in straddle carriers, terminal operators, and internal trucks. Such infrastructural facilities and services are just a few examples that need to be addressed and considered by a port authority when trying to develop operational capacity and capability. However, in the context of a container terminal, the development of increased capacity is a formidable task; the lack of such development may have negative consequences in terms of service quality and cost. Therefore, in identifying the consequences, the study by Wang and Cullinane (2006:84) suggested, “...ports should ensure that existing infrastructure and equipment is utilised to maximum economic and technical efficiency in order to optimise the container production process”. In support of this cautionary statement, on the other hand, ports often lack the necessary capacity to execute their internal terminal operations competently. Capacity shortages are one of the limiting problems currently facing many container terminals of the world (Paul and Maloni, 2010). However, the importance of container terminals as the means of providing containerised cargo transportation services by sea, rail and road has increased, particularly in the last few years (Zhang et al., 2009).

1.1.2 Reasons for capacity shortages at container terminals

Many container terminals of the world are currently facing the problem of a shortage of capacity (Paul and Maloni, 2010); this is due to several factors that influence the demand for container port capacity (Figure 1). For example, in the 1980s, manufacturers replaced their production facilities and moved them to countries where production costs were comparatively lower. In addition, in the 1990s, and 2000s, Chinese manufacturers started exporting their products worldwide causing a major trade boom throughout the world (Pallis and de Langen, 2010). Secondly, the predictions for GDP (Gross Domestic Product) growth rates indicate a positive trend that will have an impact on worldwide trade volume in the future (Chin et al., 2009). A positive economic relationship is expected between GDP growth rate and port demand development (Ocean Shipping Consultants Limited, 2009). Thirdly, the number of Twenty-foot Equivalent Unit (TEU) containers transported annually increased from 39 million to 356 million between the years of 1980 and 2004 with an annual growth rate of 10 percent; this increase is expected to continue until 2020 (if other factors remain constant) (David and Sichman, 2009). The growth rate is positive because of the TEU’s unique advantages (cheaper and easier cargo handling facilities). Fourthly, shipping liner companies are increasing their ship size (Stopford, 2009); this is due to the fact that when ship sizes increase, unit transportation costs decrease.
Figure 1. Leading reasons for capacity shortage at container terminals

Figure 2. Most significant consequences of capacity shortages at container terminals
1.1.3 Consequences of capacity shortages at container terminals

The capacity shortage problem has compelled port authorities to build new facilities and infrastructure for their container terminals. For example, between the years 2007 to 2015, around 700 new terminals were projected to be required to be built in order to accommodate the growing number of containers in East Asian ports (UN and Korea Maritime Institute, 2007). Maritime transport demand is growing at a more rapid rate than the rate at which ports are able to build sufficient facilities to smooth the flow of freight transportation (Pallis and de Langen, 2010); this is due to the fact that it takes many years (ranging from 2 to over 10) from decision making to the completion of changes to port infrastructure to increase capacity (Henesey, 2006). As many ports are exceeding capacity limits, ports need to deal with the problems discussed in Figure 2.

Firstly, capacity shortages create congestion problems in container terminals and congestion has consequences for port users. Some typical examples of such delays are: missed feeders for shipping lines, yard congestion and re-handling for terminal operators, longer waiting times for trucking companies, and longer lead times for shippers (Park and Noh, 1987, David and Sichman, 2009). Thus, the parties involved in the supply chain face losses. Secondly, because of capacity problems and for economic reasons, the larger ships tend to visit a specific number of ports (Henesey et al., 2009). For example, a mega ship that has a capacity of 18,154 TEU can cause a capacity shortage in many ports (Grossmann, 2008), because of lack of an appropriate number of berths, cranes, and storage facilities available to handle bigger container ships. Hence, recently built deep-water ports are able to gain market share from the shallow-water ports (Baird, 2002). If an exporting country sends its containers to an importing country via a hub port, problems such as the following, will occur: (1) the “transit time” will increase; and (2) “cargo handling costs” and “risk of damaging the cargo” will increase due to multiple freight handling in each port during the course of transhipment. Thus, capacity shortages cause supply chains to be ineffective in many ways. Finally, capacity shortages cause a port to increase the price of its service, because of the interaction between demand and supply-side problems. This, in turn, increases the transport cost for the use of some ports and, thus, other less congested ports look more attractive to shippers (Dekker, 2005).

1.1.4 Capacity expansion mechanisms for container terminals

All of the foregoing issues discussed that relate to capacity influencing factors and their effects have resulted in capacity shortages in many container terminals of the world (Paul and Maloni, 2010). In addition, there are other related problems, such as, increases in cargo handling costs. Understanding and taking these consequences into account, and considering the need to minimise the capacity shortage problem, the majority of existing studies have suggested that the capacity problem in ports can be solved by either the implementation of “structural mechanisms” leading to facility expansion (McCalla, 1999), or, the creation of “non-structural mechanisms”. Non-structural mechanisms assist in the improvement of the utilisation of existing facilities (Dekker, 2005) through the adoption of more advanced technology (Ballis et al., 1997), improvements in the organisation of work (Paixão and Marlow, 2003), Business Process Re-engineering (BPR) or, Business Process Improvement (BPI) (Islam and Ahmed, 2012). Each solution has its advantages and disadvantages (Figure 3), and each has its own cost profile. For example, structural mechanisms to improve port capacity may be expensive and lengthy to implement, but which, in practice, may have wide applicability. On the other hand, non-structural mechanisms to expand port capacity may be much cheaper and quicker to implement.
1.1.5 Importance of transport capacity expansion
A container distribution system is shaped by a series of capacity influencing components that are functionally interconnected with each other. This means that changes in any one part can affect other parts. Thus, the performance of each component determines the overall performance of the port (Cetin and Cerit, 2010). However, these components are influenced by many stakeholders, usually, such as: shipping lines, road carriers, and others. One common problem with such a distribution system is that each of these stakeholders may react to its welfare and may not be concerned about the overall performance of the port (Dowd and Leschine, 1990). Hence, the real value of increased efficiency is finally the contribution it makes to the port’s overall capacity expansion potential (Dowd and Leschine, 1990). Hence, in order to improve the capacity shortage problem, it is important to consider the improvement of transport capacity.

1.1.6 Significance of truck transportation
As stated before, a port is required to offer sufficient facilities to connect itself with the customer base in order to satisfy its market's needs and plan its growth strategy; additionally, in establishing such a connection, hinterland connections are vital along with the other services offered (Carbone and De Martino, 2003). To ensure optimum capacity in the current transportation system, a port has alternatives (road, rail and barge services). However, the transportation of cargo by roads is more popular than other alternatives in many ports. Further, the demand for truck transportation has increased in many terminals and is projected to continue in the future. As evidence, it has been found that the truck has the maximum market share, which represents the highest percentage of share, of 60% in the case of Port of Rotterdam’s current modal split; the remaining percentage is divided between barge and rail transportation, with
barge transportation having more than twice the share of rail. In a similar example, according to the European Union Road Federation (2008), during the period 1996-2006, the European hinterland market share for road transportation increased by around 5% (representing the highest market share of 76%) and the demand for rail decreased by about 4%. All these facts have one thing in common: the truck dominates the market because it has convenient features. Most importantly, trucks are able to offer faster delivery for short distances around the port regions and provides door-to-door service on demand (Wang and Yun, 2013). Slower rail and barge transportation is more cost-effective, but it does not provide fast door-to-door transportation.

1.1.7 Empty trips in the truck transportation industry
The empty trips problem is noticeable in the domain of truck transportation. For example, in the Netherlands in 2005, empty mileage accounted for 33% of container freight transportation and the proportion was 25% for 2009 and 2010 (Odijk, 2009). In another instance, around 43% truck trips were empty (arriving or leaving empty) from, or to, the Port of Rotterdam in the year 2003 (Bakker and Bruin, 2007). The utilisation of capacity was only 2.3 TEU (Twenty-foot Equivalent Unit) out of a capacity of 4 TEU. The lower utilisation also meant that 42% of the truck trips could have carried an additional load of 2 TEU to and from the port (Heide, 2010).

1.2 Causes of empty truck trips
A typical container truck may perform many road trips each day in order to complete export or import jobs for shippers. In each of these trips, the objective is to complete a part of an export or import process. As detailed next, a single import or export job may generate multiple trips and each of these trips may be partially or greatly underutilised; this can be the source of empty truck trips. The reader is referred to Chapter 5 for a more detailed understanding of the sources of the empty trips problem. Literature that explores the causes of empty trips, includes Steenken et al. (2004), Notteboom (2004), Theofanis et al. (2007), Guan and Liu (2008), and Mittal (2008).

1.2.1 Empty truck trips (import)
From an importer’s perspective, the procedure for every import container that comes into the country has four legs, as shown in Figure 4. The truck driver will transport each imported container from the port and then swing it onto the ground of the importer's warehouse as a full import container. When the importer requires the empty container to be taken away, the trucker will swing the emptied container back onto the truck and cart it to the empty depot of the port.

In this import process, many empty truck trips may occur each day to complete the cycle (Figure 5). (1) Initially, an empty truck trip may be caused by the driving of a completely unutilised container truck from the carrier to the port to pick up a laden container, which has just been dropped off from a ship. Here, neither of the two slots (it is assumed that a truck has a two-slot capacity for transportation purposes) of the container truck is occupied. (2) In the next step of the process, an underutilised truck trip may arise if the container truck picks up only one 20-foot laden container at the port and delivers it to the importer's warehouse. (3) Since the empty container needs to be returned to the port, the carrier collects the container from the warehouse and drives it to the port. This is likely to cause another underutilised truck movement if both the transporting container is 20-foot long and the rest of the truck space is empty or if the truck picking up the empty container had to drive from elsewhere. (4) Finally, the truck may leave the port territory without carrying any cargo, which represents an underutilised trip from the port.
Figure 4. Four legs of an import container movement

Figure 5. Sources of empty truck trips in an import process

1.2.2 Empty truck trips (export)
Similar to the import process, consideration of container truck trips is also vital from an exporter’s perspective. For instance, every container that leaves the country also has four trip legs to complete, as shown in Figure 6. The truck driver will take an empty container off port (or possibly from another storage facility for empty containers) and will swing it onto the ground of the exporter’s warehouse. After the container has been loaded at the export company, the trucker will swing the loaded container back onto the truck and cart it to the port to load onto a ship.

As in the previous importing case, in this export process, multiple empty truck movements also occur in a cyclical manner, as shown in Figure 7. It is also assumed here that a container truck can carry two 20-foot containers on each freight trip, from or to the port. (1) Initially, the
truck driver drives an empty truck from the carrier to the port to pick up an empty container for the exporter, who needs a container to load export products. (2) In the second stage of freight transportation, the truck picks up an empty container from the empty depot and delivers it to the exporter’s warehouse. The container may be 20-foot long, thus the capacity to carry another container is lost. (3) To pick up the container from the exporter’s warehouse and deliver it back to the port for the ocean move, the carrier assigns a truck that carries the loaded container to the port. This may create another empty truck movement if only one 20-foot container has been loaded onto a 40-foot container truck, and the other slot remains unused, or if an empty truck is driven to the warehouse. (4) To complete the last stage of the export process, the truck leaves the port, often as an empty or partially-empty truck.

![Figure 6. Four legs of an export container movement](image)

![Figure 7. Sources of empty truck trips in an export process](image)
1.3 Increasing container transport capacity by reducing empty truck trips
Financially unproductive, and thus wasted, empty trips represent an opportunity for meeting the capacity needs of all shippers, and, therefore, improving supply chain outcomes. As a component of such outcomes, it is important to develop a deeper understanding of the interaction between the reduction of empty trips and transport capacity expansion at ports. This prevailing situation, to a certain extent, represents an opportunity to solve the transport capacity shortage problem at container terminals. This concept is feasible for the reason that if the currently underutilised, space on travelling trucks can be made available for use to carry additional number of containers, those trucks would then be able to carry more containers per trip. This would increase the transport capacity of each truck on every trip. Therefore, such an arrangement would affect the transport capacity of the existing road carriers and the overall port region. The fact that, for strict security reasons, only a certain number of port-registered trucks are allowed to participate in port operations (picking up or dropping off containers), potentially impacts on the truck transport capacity (number of containers that can be transported) of a port. Similar findings on the way in which proper utilisation of the space available on trucks can contribute to increasing transport capacity have also been reported in a number of studies. Therefore, other studies have reported similar observations, for example, see Odijk (2009). To develop a further deeper understanding of the interaction between the reduction of empty truck trips and transport capacity expansion at ports, see Section 1.4.3.2, “Expansion in transport capacity for the port”.

1.4 Benefits of reducing empty truck trips
Many benefits are obvious if road carriers work together to develop cooperation strategies with shippers and other stakeholders in the supply chain. Innovative strategies, backed by cooperation and good management, may assist carriers in the exchange of best practices to reduce the number of empty trips. Hence, collaboration between road carriers and shippers brings about the best outcomes for their businesses (for a list of collaboration benefits between road carriers and shippers, see Esper and Williams, 2003) and helps the supply chain, in the broader sense, to thrive in multiple ways that are also sustainable—economically, environmentally and socially (for more information on such sustainable benefits, see Goodwin, 1993, McKinnon, 1996). In one of its sustainability-related reports, DHL (2010:94) highlights the benefits of reducing empty trips: “...it not only improves the carbon footprint, but is also very appealing from an economic perspective.” The sustainable benefits from empty trip reduction are further elaborated here and classified into three major categories (i.e., the triple bottom line) (Figure 8).
1.4.1 Economic sustainability

In terms of economic sustainability and its impact on financial performance, sustainable supply chain practices can have many cost benefits for companies (as exemplified by the study of Carter and Rogers, 2008), including savings from packaging waste prevention (Mollenkopf et al., 2005) and reduced health, safety, labour turnover and recruitment costs resulting from improved warehousing, transportation and working conditions (Brown, 1996, Carter and Stevens, 2007). Similar to these cost benefits, from the perspective of freight transportation, there are several other advantages of empty trip reduction to achieve economic sustainability. For example, a shared truck allows the distribution of operating costs (fuel, truck driver and miscellaneous items) among more than one shipper to the same destination, and thus reduces the financial burden on each shipper and makes it easier for them to save more on transport billing. It is precisely because of such cost benefits that Seyedabrisami et al. (2012:324) emphasise the role that shared-transportation can play: “Saving money on fuel, parking, repairs and other vehicle-
related costs are also noticeable benefits for that.” Similarly, to be specific about benefits, Jacobson and King (2009) demonstrate the benefits of fuel saving from shared-transportation; although the study confirms that the expected benefit depends on route-related traffic conditions. Similar impacts on fuel saving have also been suggested in a study by Agatz et al. (2011).

A saving (in the form of driver cost, less fuel usage) on overall transport bills, in turn, may have an impact on the final price of the product being sold. An illustration of this was given by Audy et al. (2007) in an example in which a reduction by 15% in backhaul trips contributed to a 6 to 7 percent saving in transportation costs for the Norwegian wood industry. In another comparable example, in order to reduce the number of empty miles, two transportation companies started working together and enjoyed significant savings in freight transportation (Ergun et al., 2007a, Ergun et al., 2007b). More information on cost-saving solutions and benefits derived from transport collaboration can be found in some other studies (Lynch, 2001b, Strozniak, 2001, Golicic and Davis, 2003).

A potential cost-saving strategy is important since cost reduction in transportation activities is a top priority for many carriers and shippers involved in freight movements (Asawasakulson, 2009). The cost-saving priority for carriers has been established by low-profit margins, high driver turnover, and rising fuel and insurance costs; for shippers, the cost-saving priority has been driven by the necessity to send smaller quantities of product in order to reduce inventory volume while fulfilling the customer's needs in a shorter time frame (Ergun et al., 2007b).

1.4.2 Environmental sustainability
Environmental sustainability focuses on the “management of natural resources” as highlighted by Ashby et al. (2012) and Hagelaar and van der Vorst (2001). This dimension (frequently referred to as the “green supply chain”) of sustainability has been mentioned in many supply chain studies. For example, to list a few, see Zhu et al. (2007), Darnall et al. (2008), and Hahn et al. (2010). The environmental benefits of reducing the number of empty trips are as follows.

1.4.2.1 Reduction in Vehicle Miles Travelled (VMT). Feasible solutions for the production of greenhouse gas emissions can be made by paying attention to effective transport management arrangements. For example, the emission of greenhouse gases depends on the VMT of a vehicle, among many other factors (Garren et al., 2011). This can be reduced by sharing space in container trucks with a neighbour or shipper. Apart from controlling greenhouse gas emissions at minimum cost or effort, there is also an underlying factor which is simply that, as suggested and confirmed by Duane and Malaczynski (2009), VMTs were predicted to rise 160% between the years 2005 and 2030. This is an alarming prediction for the freight and logistics industry. However, to minimise the risk to the logistics industry, adopting shared-transportation to reduce VMT is perceived in many studies to be an advantage (see Morency, 2007, Jacobson and King, 2009, Agatz et al., 2011, Seyedabrishami et al., 2012).

1.4.2.2 Reduction in emissions. Because of the VMT reduction with cautious management of the empty space in container trucks, there is another effect that goes deeper, which is that trucks emit carbon dioxide, carbon monoxide, nitrogen oxide, and sulphur oxide (De Souza, 1999). All of these substances have adverse consequences on people; for example, nitrogen oxide is harmful to human health, and sulphur oxide can cause respiratory disease and premature death. It is also interesting to note that the transportation sector emits the highest amount of greenhouse gases (GHG) (ASSS, 2006). A reduction in emissions is, therefore, required.
1.4.2.3 Less traffic and congestion. Along with reducing the emission levels from heavy-duty container trucks because of container truck-sharing, other significant benefits can be attributable to a reduction in traffic movements, both in peak and off-peak hours, due to fewer trucks being on the road. A decrease in the number of trucks on the road also means less traffic congestion. The idea, that shared-transportation can lead to reduced traffic congestion, has been advocated by several studies (for some selected examples, see Baldacci et al., 2004, Millard-Ball et al., 2005, Dewan and Ahmad, 2006, Noland et al., 2006, Morency, 2007, Agatz et al., 2011, Manzini and Pareschi, 2012, Bento et al., 2013). A prominent example of the application of the shared-transportation concept (e.g., carpooling) and its reduction of congestion can be found in the USA, where over 2,500 lane-miles of High Occupancy Vehicle (HOV) lanes have been built to reduce congestion and automobile emissions (Shewmake, 2012).

1.4.3 Social sustainability
Social sustainability is often a neglected dimension of the sustainability discussion (Kleindorfer et al., 2005, Esty and Winston, 2006, Bansal and McKnight, 2009). However, the social component of sustainability refers to the management of social resources, including, for example, as defined by Ashby et al. (2012:506), “…people’s skills and abilities, institutions, relationships and social values”. From a business perspective, this dimension may include practices that may ultimately affect employment stability in a company and more specifically, from a supply chain perspective, it may also refer to providing good employee welfare worldwide, which has been suggested by Gladwin et al. (1995). It can also be proposed that a truck-sharing initiative would produce a range of social benefits enabling sustainable development, such as earning additional income for drivers. All of these benefits are discussed briefly as follows.

1.4.3.1 Reduction in driver turnover. Applying a collaborative coordination mechanism (for more information on similar concepts, for an example, see Mavrommati and Migdalas, 2002) to share the remaining capacity of a truck between more than one shipper, reducing the number of empty trips, ensures repeatable continuous move routes for a freight truck (Ergun et al., 2007a, Ergun et al., 2007b). Among many benefits, the most significant benefit is its ability to lower driver turnover because of a regular driving schedule for the truck driver (Lynch, 2001b).

1.4.3.2 Expansion in transport capacity for the port. A study by McKinnon (1996) recommends expanding capacity for freight transportation by carriers reducing the number of empty truck trips. A similar idea was expressed by Giuliano et al. (1990:161), who, when they described the benefits of shared-transportation, stated that such systems “…consequently increase the overall capacity of the highway system.” Such assistance ultimately benefits all carriers involved in the transportation process due to the rise in capacity of the container distribution network. The maximum transport capacity of all carriers can be defined as the ability to carry the largest capacity of freight in the region using all the container trucks belonging to all registered carriers (only registered carriers are allowed to pick up or drop off containers in the port area). Other studies have reported similar observations, for example, see Odijk (2009).

Improving transport capacity is an issue in many terminals of the world for many reasons, which have been explored and described in this chapter. All these elements are connected to overall port capacity since capacity shortages in one dimension influence capacity shortages in other dimensions at the same port. This is an important issue to consider. The consequences of capacity shortages may be greater than the expectations of the port community.
1.4.3.3 Additional earnings for truck drivers. Most of the costs associated with operating a truck are usually fixed in nature. It is primarily because of this that in a truck-sharing event, a driver can earn more than usual from their truck driving because more than one shipper shares the same truck and this works towards full capacity utilisation whilst also dividing the costs of transportation between the parties concerned. The extra income opportunities depend on the type of driver employed by the carrier. For example, the container transportation industry tends to use company drivers, owner-drivers, or a mixture of both. Company drivers are paid by the hour while owner-drivers are paid per trip. So, the concept of shared-transportation will benefit the owner-drivers more, who try to make as many trips as possible in a day. In other words, owner-drivers earn increasingly more money, the more frequently they utilise and share the same truck for transportation with other clients. Of course, with the same demand, if some drivers are earning more then others will be earning less, but they will not be incurring costs either.

1.5 Literature related to the empty trucks problem
Although there is no major literature review on this topic, the literature related to the empty trips problem has three key streams of focus (Figure 9), from the perspective of a solution-focused approach. So, the researcher reviews the streams from other research domains as a conceptual basis because the empty trucks problem is found in other areas (both in freight and passenger transport studies) as well. The research gap identified from the different streams of the literature on empty truck trips is illustrated in Figure 11. All streams have crossed into the mainstream that covers challenging collaboration issues. Thus, each research stream contributes to the broader Supply Chain Collaboration (SCC) field. SCC has been discussed in the later part of the thesis; see Chapter 5 (Section 5.2.2 in particular).

1.5.1 Supply chain collaboration
The supply chain collaboration literature puts greater emphasis on the significance of upstream and downstream parties (these include, but are not limited to, suppliers, manufacturers, wholesalers, and retailers) for their mutual collaboration and benefits (Chan and Zhang, 2011). However, there are essential features and real-world aspects that the existing dominant literature on supply chain collaboration ignores (Sutherland, 2003). In particular, the literature disregards the fact that logistics and transport providers are important parts of the supply chain and are involved in the moving of cargo from one location to another. This concern has been expressed, for example, by the studies of Fugate et al. (2009), Quinn (2000), and Chan and Zhang (2011). In addition, the study of Chen et al. (2010:2) further confirms, “Carriers or 3PLs are not often considered by the seller–buyer collaboration and strategic alliance. However, carriers play the role of order execution as physically delivering the goods to the locations appointed by receivers.” Consequently, for these compelling reasons (although the literature focuses more on the upstream and downstream parties), the traditional assumptions of supply chain management should be expanded in order to consider the role of transport providers in addressing the challenges that are common in freight transport management. The focus of attention should be to overcome challenges that hinder both broad and specific supply chain goals; for example, reducing empty miles for carriers to reduce asset repositioning cost (Sutherland, 2003).
1.5.2 Maritime logistics
Another stream of related literature is research on coordination problems in hinterland transport networks; this is an important part of the overall scholarly research as leading shipping lines tend to choose container terminals with good hinterland connections and networks (Wiegmans et al., 2008). The ideas and concepts contributing to these coordination problems in hinterland transport networks have been studied before, but few studies have examined the difficulties or contributed to the investigations of the problems (Panayides, 2002). For the small number of references, as well as for valuable insights on a variety of issues discussed in these studies on coordination problems, see Panayides (2002), Langen and Chouly (2004) and Van Der Horst and De Langen (2008). However, as yet, and as far the researcher is aware, it appears that none of these studies has specifically considered the solution of the empty trips problem from a practical perspective in order to fill this research gap. For more information on the above issues, see Section 3.3.1, “Collaboration in hinterland transport chains”.

1.5.3 Backhauling problem
Another influential research stream relevant to the current discussion is one based on a perspective that usually takes into account only one carrier and its container trucks, in order to decide on efficient routes for each vehicle. This research stream is known as the Vehicle Routing Problem with Backhauls (VRPB), and its aim is to reduce empty miles travelled (Tütüncü, 2010). Thus, a related field similar to the objective of this research is frequently referred to as the backhaul problem, and Pickup and Delivery Problem (PDP). For a comprehensive survey on pickup and delivery problems, especially on the VRPB, see Parragh et al. (2008). In the backhaul problem, carriers face difficulty in finding backhauls because of a lower demand for transport on the return journey (Wang, 2009, Gajpal and Abad, 2009, Demirel et al., 2010, Xing et al., 2011, Zachariadis and Kiranoudis, 2012). The problem is typically viewed as an administrative and scheduling problem in a centralised setting (Brewer and Plott, 2002). Researchers consider these VRPB or PDF problems from the standpoint of a single carrier, which has a fleet of vehicles. Therefore, while useful, the VRPB has drawbacks, in particular the need to work with only one carrier that matches specific criteria from a company's perspective. Taking such limitations into account and based on the perspectives from a collaborative setting concerned with transportation management, the study by Agarwal et al. (2009:374) confirms and warrants that: “Many of the traditional optimisation algorithms that work well when there is only one decision maker become ineffective in a collaboration setting.” Many other studies also confirm and critique the particular characteristics and limitations of the typical one-company-based optimisation approaches (for a list of studies see, Greis and J.D., 1997, Brunell, 1999, Busi and Bititci, 2006). Therefore, it is important to consider all carriers from a supply chain perspective to encourage mutual collaboration in order to assess cooperation opportunities and to improve truck space utilisation. For more information on the backhaul problem, see Section 3.3.2, “The backhaul problem”.

15
1.6 Problem summary and key research questions

As stated previously, capacity shortages are an important issue for the major ports of the world (Paixão and Marlow, 2003, Steenken et al., 2004, Pallis and de Langen, 2010, Maurer and Degain, 2012, Dekker et al., 2013). This capacity shortage problem has an effect on the efficacy and efficiency of containerised transportation. There is considerable likelihood of the effects of capacity shortage occurring in containerised freight transportation since all port components are connected to each other (Cetin and Cerit, 2010). Hence, in order to improve the overall capacity shortage, it is vital to put emphasis on the improvement of transport capacity. The transport capacity of a port depends on road, rail, and barge services, although transportation using roads has been observed to be more popular than other methods. As discussed in Section 1.1.6, truck transportation has grown substantially and occupies the maximum market share in many ports.

Further, as also discussed in Section 1.1.6, the predominance of trucks in freight transportation is expected to continue in the future, because it yields faster cargo delivery for short distances and provides door-to-door service on demand (Wang and Yun, 2013). Taking all these aspects of truck transportation into account, the extent of the capacity shortage problem has already been observed by container trucks (Kulisch, 2004). The limited transport capacity of trucks and overcrowded roads are limitations that fail to support the increased demand for road transportation (Daduna, 2011). Therefore, the management problem (the business problem to be solved) that the thesis looks into how the road-side transport capacity can be increased.

An attempt at solving the container transport capacity problem by simply increasing the number of container trucks is a costly solution, which may encourage an increase in carbon emission, traffic congestion, and pollution. As discussed in Section 1.4.2, trucks emit carbon dioxide, carbon monoxide, nitrogen oxide and sulfur oxide (De Souza, 1999). Further, truck operation, which is the dominant mode of transportation in many ports, as stated before, is not only a key source of emissions but also leads to problems of capacity shortage for leading container terminals (Huynh and Zumerchik, 2010).
Considering all the negative side effects of truck transportation, a potential mechanism to increase road-side transport capacity is to lessen the number of empty truck trips. The objective is to transfer an increased number of containers using the same amount of trucks. Therefore, the addition of extra transport capacity provided by an increase in the utilisation of the container trucks has the potential to improve the connection between the hinterland and its markets by reducing the number of empty truck trips. This is, of course, conditional on road transportation being the principal mode of transport in the world’s leading ports (Visser et al., 2007).

As also discussed in Section 1.3, the maximum transport capacity is the collective result of utilising all of the trucks of all road carriers from a region for all cargo requiring transportation within that region. To a certain extent, in order to maximise transport capacity, the reduction of empty trips should enable an increased number of containerised cargoes to be transported using the same number of trucks in the region without the addition of more new trucks. Such benefits to the improvement of the existing transport capacity are particularly applicable to ports because only registered carriers are permitted to participate in the operations for the picking up or dropping off of containers from, or to, container terminals. Therefore, the main research question of this thesis is formulated as follows: RQ: How can the number of empty container truck trips to and from a port be reduced to increase the road transport capacity? To develop an understanding of the interaction between the reduction of empty truck trips and transport capacity expansion at ports, see Section 1.3, “Increasing container transport capacity by reducing empty truck trips”.

Before delving into this specific research question, we first describe the importance of developing a broader perspective in managing overall port capacity. The optimisation of the port as a whole is important, especially for capacity management, which is a major focus of interest for practitioners as well as for academics. To achieve this important objective from a different perspective (i.e., other than by reducing empty truck trips to increase transport capacity), the second chapter (Figure 10) aims to develop a system-dynamics framework. The suggested framework is developed based on a literature review of the factors influencing port capacity, in order to guide and improve overall port capacity (including, but not limited to, transport capacity) shortage problem. In this particular chapter, the aim of the research is also to show the potential usefulness of the suggested framework as a tool for capacity-expansion decisions (e.g., transport capacity improvement). Therefore, the objective of the chapter is: How can a port's capacity be improved? The framework could be of importance in assisting transport managers in identifying possible transport capacity expansion opportunities.

Later (from the third chapter to the sixth chapter), we drill down into the detail for the empty trips issue. Therefore, to reduce the number of empty trips made by travelling container trucks, additionally, four supporting research questions (Figure 10) are formulated, as are the research methods utilised for their investigation. The first research question aims to summarise the major concepts of many research fields that can potentially contribute to new concepts and practices for the management of empty truck trips. In other words, many research fields suggest slightly differing types of existing solutions by which the problem can be explored, tested and solved, or at least, so that the underlying causes of this empty vehicle performance may be reduced, and hence transport capacity can be improved. Therefore, RQ1 is: What are the different mechanisms available in different disciplines and domains for reducing empty truck trips?
One of the key findings of this first research question is the potential for container truck transportation using the truck-sharing concept (the shared-transportation idea). Therefore, in order to focus on the development of a truck-sharing model, the second research question aims to extend the truck-sharing concept and to suggest a truck-sharing mechanism with the potential to reduce the number of empty-truck trips (with the object of increasing container transport capacity). Accordingly, the RQ2 is: Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips? The model developed in the chapter is referred to as Truck-sharing Service (TSS).

The successful implementation of the suggested truck-sharing model depends on truck-sharing constraints that were not taken into account in the second research question. To fill that research gap, the third research question aims to explore the challenges for truck-sharing and effective ways of dealing with those challenges. In other words, although the second research question explores a dynamic truck-sharing facility for a computer-based matching system to assign probable export containers to available empty slots of a container truck, further contributions to the existing literature describing collaboration challenges or impediment issues are necessary. For that reason, the RQ3 is: What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges? Therefore, the goals of the third research question are to identify and describe the challenges (e.g., flexibility in the truck appointment system, or export cut-off times) that carriers face when dealing with truck-sharing initiatives and to take a look at ways of coping with these challenges to improve container transport capacity.

It is important to note that although the second research question aims to examine the empty trips problem from a co-operative perspective in order to suggest a truck-sharing mechanism, and the third research question aims to explore truck-sharing constraints, both of the research questions do not quantify of the benefits of truck-sharing initiatives. Therefore, an important question, which, thus far, has remained unanswered, is: What are the benefits to be gained by the adoption, by road carriers and shippers, of the truck-sharing concept? Hence, the fourth research question will assist port managers with replies to questions, such as “What impact will truck-sharing have on transport capacity expansion?” In particular, the RQ4 is: How will the case study port's transport capacity be affected by different scenarios? This question is addressed using discrete event simulation and the results of the simulation should be useful in persuading port authorities to evaluate and implement potential truck-sharing initiatives leading to increased transport capacity and supporting future growth.

Together, the supporting research questions will explore the roles that truck-sharing initiatives need to play to ensure the reduction of empty truck trips, and hence the improvement of transport capacity around the port gates. As a result, all of these research questions focus on increasing the capacity of one specific part (i.e., container-transport capacity only) of an entire port. The conclusion chapter further describes the relationship between the key research question and each of the chapters. See the sections on “Relationship to the main research question”.


Figure 10. The main research question, and sub-questions of the thesis

1.7 Research methodology
The thesis consists of seven articles (Chapters 2 to 6), each of which has its own methodology section. Thus, the thesis uses different approaches (quantitative and qualitative) to explore from different perspectives the practices of truck-sharing to increase container transport capacity for road carriers in the transportation industry. In order to achieve these objectives, the thesis employed several research methodologies, which are briefly described below.

1.7.1 Chapter 2: Article I-III
This chapter consists of three different, but interrelated sections that consider the question how can a port’s capacity be improved? This question aims to propose a system dynamics framework to improve the overall port capacity management problem. System dynamics assumes that a real system is a collection of individual parts that work together as a whole. Therefore, system dynamics models try to understand the structural causes (or, performance of the individual components) that bring about the differences in the behaviour of the whole system.

1.7.2 Chapter 3: Article IV
In order to explore alternative solutions to the empty trips problem, the research question examined in this chapter is: What are the different mechanisms available in different
disciplines and domains for reducing empty truck trips? In order to address this, a synthesis of the literature from different research areas is performed, which results in the identification of a set of concepts that can provide useful insight into the full utilisation of under-utilised trucks.

1.7.3 Chapter 4: Article V
The key research question addressed by this chapter is: **Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips?** In order to answer this research question, a qualitative case study approach has been adopted, because a case study approach focuses on understanding the operations of an organisation’s internal situation. So, it enables the in-depth investigation that is required to understand the underlying issue better. A case study method is suitable to investigate a complex phenomenon.

1.7.4 Chapter 5: Article VI
The key research question to be answered in this chapter is: **What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges?** A qualitative approach allows a better understanding of the truck transportation strategy utilised by each road carrier's transport manager and the larger social context of today in which truck-sharing initiatives can occur. Therefore, by adopting a qualitative research approach, this chapter gains rich real-life insights into truck-sharing constraints and ways of dealing with those challenges.

1.7.5 Chapter 6: Article VII
The research question for this chapter is: **How will the case study port's transport capacity be affected by different scenarios?** In order to answer this research question, a simulation methodology has been adopted; this is because computer-based simulations are graphical visualisations of processes that can be dynamically observed, statistically analysed, and reconfigured into many different process scenarios. A successful simulation can be used to conduct experiments for comparing and contrasting alternative scenarios. Here, in this chapter, a Discrete-event Simulation (DES) methodology has been used to establish a quantitative relationship between empty trips reduction and transport capacity expansion.

1.8 Major contribution of the thesis
The empty trips problem requires immediate attention and intervention in order to meet, for example, the implied transport capacity target in leading container terminals, or even exceed it. The reason is to ensure that freight transportation facilities can meet the requirements needed to transfer containerised cargo from, or to, the port; or to solve environmental issues that demonstrate evidence of responsible behaviour at container terminals. However, as far as the researcher is concerned, the literature related to this topic is limited, especially from a solution-based perspective. For more information on bridging the research gap, see Chapter 4. However, as stated before, the literature (Figure 11) is interdisciplinary in perspective, because the similar study problem crosses many research domains. For example, the related literature ranges from supply chain collaboration to hinterland coordination problems in maritime logistics, and also includes the literature relating to the backhauling problem. The backhauling problem, to a certain extent is more analytical in nature than other studies (e.g., supply chain collaboration), and specifically focuses on empty running of arrival trips (backhauling) of container trucks. For a summary of related literature, see Section 1.5, “Literature related to the empty trucks problem”. A brief review of the related literature can also be found in Chapter 4 and 6.
The boundaries between these research streams are not blurred. However, none of the research streams offers a comprehensive review of the empty trip problem, including causes, benefits, constraints, and solution mechanisms on how to minimise it. This is particularly correct from a maritime logistics perspective where an understanding of container trucks and their operational and physical characteristics, and freight-hauling activities (e.g., imports and exports) is of importance. The thesis contributes to that specific research gap. An example is given below.

Although some truck-sharing constraints have been previously reported and classified in the limited amount of literature that is available on the topic. Those few studies that have directly examined truck-sharing constraints as an explanation for scarce backloading opportunities have mainly focused on the type of freight trucks that are for general, rather than specific, use. General-purpose trucks are frequently used in the retail industry (more specifically, in the department store environment). Conversely, the thesis identified different types of truck-sharing constraints that are explicitly applicable to maritime container trucks (see Chapter 5). A more detailed description of the thesis’ contributions is provided in Chapter 7.

![Major contributions of this thesis](image)

**Figure 11.** Major contributions of this thesis to the literature

### 1.9 Organisation of the thesis relative to published articles

The thesis has seven chapters (Figure 12) including the Introduction and Conclusion. All chapters are presented below accompanied by a short description of the chapter content. The relationship to published articles by the author is also outlined.

#### 1.9.1 Chapter 1: Introduction

This chapter provides a summary of the thesis and its contextual framework. It includes an outline of the key research questions, the related literature, and the major contributions of the thesis. The chapter also gives a brief introduction to the empty-trips problem, and its importance and relationship to the transport-capacity improvement potential at ports. The chapter reviews some preliminary concepts—for example, how causes of capacity shortage motivate port authorities to seek alternative strategies to extract capacity from the port. It motivates the core research question for the thesis, namely, **how can the number of empty container truck trips to and from a port be reduced to increase the road transport capacity?**
1.9.2 Chapter 2: Article I-III
This chapter consists of three different, but interrelated sections that consider the question **how can a port's capacity be improved?** All of these sections explain different aspects of overall port capacity shortage problem, and are described briefly below:

- **Section 2.1 (Article I).** This section addresses the drawbacks in the typical sub-system based literature that is available in regard to the subject of port capacity (i.e., literature focusing on specific components of a port); this section also examines studies that could potentially address, and broaden the research pertaining to port capacity expansion. So, this section presents a review of the Operations Research (OR) literature, including a trend analysis.

- **Section 2.2 (Article II).** The purpose of this section is to offer a conceptual framework to summarise the research in the field concerned with the factors influencing port capacity using a holistic approach after reviewing related papers.

- **Section 2.3 (Article III).** The purpose of this section is to propose a System Dynamics framework for managerial decision making that is developed based on the factors affecting port capacity. Hence, the proposed capacity management framework inherits the potential for use at ports in capacity-management-related problem solving. The framework would be of importance in assisting managers in identifying possible capacity expansion opportunities.

1.9.3 Chapter 3: Article IV
To examine RQ1: **What are the different mechanisms available in different disciplines and domains for reducing empty truck trips?**, an extensive review of existing studies is comprehensively conducted in this chapter. The aim is to create an overview of recent research that has been conducted on the empty trips issue from different conceptual and disciplinary perspectives, as well as the trends in each field, and the extent and type of research activity currently prevailing. Therefore, this chapter reviews potential tools and techniques for better utilising the existing capacity of container trucks.

1.9.4 Chapter 4: Article V
Reengineering of the container truck hauling process to introduce truck-sharing arrangements using the truck appointment system has the potential of reducing the number of empty-truck trips. Therefore, this chapter evaluates the results from an investigation of the truck appointment system using a case study approach. In brief, this research aims to introduce a truck-sharing system to improve port transport capacity and to reduce truck traffic-related congestion and answers RQ2: **Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips?**

1.9.5 Chapter 5: Article VI
This chapter explores RQ3: **What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges?** It studies the challenges of truck-sharing and effective ways of dealing with those in achieving supply chain collaboration for transport capacity expansion, and reducing carbon emission and traffic congestion. This chapter also reveals insights into successful shared-transportation and a reduction in empty trips.
1.9.6 Chapter 6: Article VII
With the aim of a reduction in the number of empty-truck trips, this chapter simulates a truck-sharing idea of the truck hauling process in a port and also evaluates the positive effects of the changes made. This simulated experiment is important to justify the idea that the truck-sharing event has the potential to improve transport capacity in and around a port territory and is likely to reduce empty truck trips (and related traffic congestion). The research question, RQ4, is: **How will the case study port’s transport capacity be affected by different scenarios?**

1.9.7 Chapter 7: Findings and conclusion
This chapter summarises the main aspects of this thesis. Hence, this chapter also presents the findings. The findings lead to the answers to the research questions presented in the beginning. Further, the relationships between the research sub-questions of each chapter and the core research question for the thesis are explicitly explored. The findings and contributions are discussed followed by the conclusion.

**Figure 12.** Organisation of the thesis chapters
Chapter 2: From a review to a framework to handle capacity problems

As stated previously, a road carrier is likely to be successful in increasing capacity for freight transportation if its number of empty trips can be decreased. Such a savings in the occurrence of empty trips for a carrier will have a significant effect on growing freight capacity and should also result in the maximisation of the total transport capacity of trucks for all participating road carriers. Therefore, the next chapters (Chapters 3 to 6) focus on different aspects of the empty trips problem using the truck-sharing concept to increase container transport capacity. Together, these chapters explore the roles that truck-sharing initiatives need to play to ensure the reduction of empty truck trips and hence, the improvement of transport capacity for container trucks.

However, before delving into the specific research questions addressed in this thesis, taking a broader perspective (i.e., apart from the reduction of empty truck trips), this chapter asks the question: How can a port's capacity be improved? It begins with a literature review (Section 2.1), which urges, among other findings, the improvement of the existing port capacity by taking into account all of its components, particularly by using simulation, rather than studying each individual dimension separately. This review leads into a study of the factors influencing port capacity, to guide and improve overall port capacity (including, but not limited to, transport capacity) and presents a system-dynamics framework (Section 2.2). Managerial implications of the framework are studied in Section 2.3. The framework could be of importance in assisting managers in identifying possible transport capacity expansion opportunities. Figure 13 provides an overview and explains the inter-relationship between the sections.

As stated before in this Introduction and Chapter 1, this chapter aims to propose a system dynamics framework to improve the overall port capacity management problem. Hence the framework inherits the potential for use at ports in capacity-management-related problem solving. The framework could be of significance in assisting managers in the identification of possible transport capacity expansion opportunities as well. Since the framework integrates system dynamics, a brief literature review on the application of system dynamics is given here. Academic research that addresses terminal operations from a system dynamics perspective is still
scarce in contrast to the typical discrete event-driven simulation approaches (Cheng et al., 2010). For examples of discrete event-driven simulations, see Steenken et al. (2004) and Stahlbock and Voß (2008). Conversely, studies aiming to provide a system dynamics perspective of port problems have not been extensively published (for examples of system dynamics problem, see Yeo et al., 2013, and Carlucci and Cirà, 2009). After a brief synopsis on the literature review described here, the research methodology (in order to show the potential usefulness of the suggested capacity improvement framework) proposed in this chapter is explained in the following text. It is also important to note that the next two sections in this chapter each have their own methodologies (content analysis as a method), which will be described within them.

The research question for this chapter is: How can a port's capacity be improved? In order to answer this research question, a system dynamics framework has been suggested in this chapter. Practical implementation of the suggested framework, however, is outside of the scope of this chapter. As a result, in order to guide how to operationalize the framework, a systems dynamics simulation methodology has been proposed, that may allow future researchers to extend application of the suggested framework to the case of determining a port's capacity.

System dynamics (SD) methodology is appropriate for the management of processes with feedback structures (Maani and Cavana, 2000). Therefore, system dynamics models try to understand the structural causes (or, performance of the individual components) that bring about the differences in the behaviour of the whole system (Sterman, 2000). System dynamics assumes that a real system is a collection of individual parts that work together as a complex whole. All of these characteristics well represent those of a seaport system. Therefore, the study by Oztanriseven et al. (2014:1) confirmed the application of the SD to seaports, “We anticipate that this system structure exists in the maritime logistics system.” Following a similar concern, the study by Mahfouz and Arisha (2009:19) further clarified the application and the suitability of the SD to seaports, “Due to port system complexities and dynamic nature, more advanced techniques are required. SD modelling is one of the most appropriate approaches for modelling such complex systems…” The other benefits of system dynamics are listed in the study of Homer and Hirsch (2006): tends to include more variables (based on the opinion of the experts) than other types of simulation approaches, and accounts for causal relationships among multiple variables, which represent complex problems with feedback loops. These types of non-linear systems are difficult to solve analytically (Freeman et al., 2009). A comprehensive list of the benefits of the system dynamics approach can be found in the study of Winz et al. (2009).

SD simulations adopt a high level of aggregation and focus on the overall system behaviour (Ng and Lam, 2010), in contrast to the typical discrete event-driven simulation approaches (Sumari et al., 2013). This benefit of adopting a system dynamics model has been confirmed by many studies. For examples, see Zuckerman and Resnick (2003), Wei et al. (2012), Hsu (2012), Lee and Chung (2012), and Geum et al. (2014). This is a necessity that has already been confirmed by the literature, integrated approaches (i.e., taking into account all components of a seaport) receive less attention and consideration in port performance simulation and assessment (Stahlbock and Voß, 2008). Thus, it is logical to investigate the effects of different capacity-influencing mechanisms for port capacity improvement from an aggregate level using SD modelling, without tracking all details of specific container terminal elements. For more information on the comparison between SD and DES, see Section 6.3, “Research methodology”.
2.1 A review of Operations Research (OR) at ports: An update

2.1.1 Introduction
It can be noted that the increase in the number of Operations Research (OR) publications, than was previously the case, contributing to the field of maritime logistics is vital in ensuring that optimisation plays a major role in every aspect of port management (Steenken et al., 2004). One of the manifestations of the trends that can be seen from the increasing number of publications is, for example, that the same studies further confirm that much of the existing literature focuses on the optimisation of separate parts of an entire port. However, a port is a major player in the transport chain to ensure product delivery from warehouses to final customers. Therefore, the optimisation of the port as a whole is important, especially for capacity management, which is a major focus of interest for practitioners, as well as for academics. Keeping these issues under consideration, this section discusses and investigates the problems arising when addressing the subject of port operations management from a perspective that covers recent trends and information relating to the past few years from the year 2000 to 2010.

2.1.2 Research objective
The surveyed peer-reviewed papers employ traditional Operations Research (OR) methods to optimise single, multiple (more than one), or all, sections of container terminal operations in order to increase port efficiencies or to advance operations planning to gain improvement in contemporary port performance. Therefore, this comprehensive literature review of port studies aims to organise, categorise and to hierarchically present the existing and evolving body of knowledge of the operation research methods of the port operations that are applied in the making, or formulation of, a port’s crucial, strategic, operational and tactical decisions. Using the literature to accomplish the two major research objectives, firstly: (1) This section’s systematic survey provides an approach for both academics and practitioners to grasp and deliver many valuable insights and details at a glance; these facts are useful in optimising and amplifying the capacity of a typical container terminal using operations research methods, which is one of the prime objectives of this literature survey. Secondly: (2) along with this specific research objective, another objective to be explored in further depth is to pinpoint the focus on the findings of the current research study. For example, this section explores a number of facts and expresses the need for further system-wide capacity expansion studies (upcoming) involving terminal operations. Hence the research recommends further research on an integrated view (i.e., including all sections and subsections) of container terminal operations.

To facilitate the achievement of the objectives of this section, the distribution of the publications studied includes the time period of the years 2000-2010. Conference proceedings are excluded; peer reviewed journal papers, only, are included in the analysis. With the intention of making the classification of papers transparent to readers, each paper that has been included in accordance with the categorisation of areas of optimisation, is presented in Appendix B. The collection of literature in this section consists of 243 journal papers.
2.1.3 Literature review
Few studies have been published to date that review the literature on the application of operations research methods to port operations. Only two papers were found that attempted to review the literature comprehensively, namely those of Steenken et al. (2004) and Stahlbock and Voß (2008). Steenken et al. (2004) reviewed a collection of references up to the year 2004 and their classification is well-accepted in the literature. Stahlbock and Voß’s (2008) work is an extension of the study of Steenken et al. (2004), and provides a survey of the state of the art operations at a terminal and classifies their optimisation methods. In addition, other studies review part of the literature briefly, such as Vis and de Koster (2003). This section concisely extends the literature by updating and reviewing the present papers up to 2010. Therefore, the insights expressed in developing and updating this section reflect an adaptation, integration and extension of the basic ideas of earlier literature reviews on container terminal operations and planning, including, but not limited to, Steenken et al. (2004) and Stahlbock and Voß (2008).

2.1.4 Rigour of the research process
Every research methodology has its own unique features along with its limitations. The approach adopted in this section is a content analysis to ensure the objectivity of the research process. However, to overcome its limitations, one of the tests adopted (e.g., content validity) confirms the rigorous research process followed in this section in order to maximise objectivity. Content validity states the representativeness of the intended contents explored from journals and other sources (Patrick et al., 2011). However, the content validity method applied in this section is mainly of a qualitative nature and is dependent on the judgement of the researcher (for more information on the content validity method, see A. Wynd et al., 2003). Given the categories for analysis (e.g., berth and crane allocation issues), content validity is considered high in this section; the section’s findings and recommendations have been taken from journal articles relevant to the specific dimensions of a port. Moreover, since every journal has its own cited references, the references cited were checked and used as a secondary source in this section to be certain that any relevant reference had not been omitted. However, the cited references were not added to the additional references initially found. In order to preserve the rigour of the research process in this review using content analysis, the procedure followed by the researcher was taken as a sign of content validity. A similar approach was adopted by Seuring and Müller (2008) to ensure rigour of the qualitative research process in their literature review.

2.1.5 Connected components of a container terminal
A container distribution process is fundamentally facilitated and further shaped by a series of functionally distinct, yet highly interdependent, capacity-influencing components, which are conceptually, and in practice, influenced by many stakeholders of the port, such as the port authority itself, railway operators, terminal operators, road carriers, and shipping lines. Since the components that are physically connected in a port are inter-linked and utilise the same space, delay in any one component can affect overall system-wide capacity (Huang et al., 2008). For example, a port is a subsystem of the entire transport system of the supply chain, and the port itself consists of other subsystems (individuals, groups, and departments that interact with one another with non-linear connections) that determine the performance of the entire port (Cetin and Cerit, 2010). A common problem with such an inter-connected distribution system is that individual component owners, groups, or parties, are interested only in their own monetary or non-monetary welfare and have no interest in, or view of, the overall efficiency of the whole distribution system (Dowd and Leschine, 1990). For instance, if container terminal capacity is
increased to process a certain number of containers in a short time, the increased efficiency will also require a boost in the capacity of other parts of the terminal. Hence the key value of this increased efficiency in any one bottleneck resource depends on, for example, the ability of the dedicated straddle carriers and internal trucks to handle the newly added volume. Thus, the real value of an increase in terminal efficiency depends on whether, or not, that increase influences the efficiency of the entire system or creates bottlenecks in other parts (Dowd and Leschine, 1990). Thus, considering all these issues together, the management of the entire port is a complex process (Beškovnik and Twrdy, 2010).

2.1.5.1 Distribution across years and journals. As shown in Figure 14, the number of publications has grown at an increasingly steady rate. An increase in the number of publications can be seen as having occurred during the period of 2006 to 2010. Most were published in the OR Spectrum (29 Papers), European Journal of Operational Research (25 papers), and Transportation Research Part E (20 papers). Thus, the OR Spectrum now plays a more leading role in terms of number of publications per year. Hence, these three journals altogether capture almost 30% of papers published concerned with optimisation methods used in ports.

![Figure 14. Distribution of publications across years](image)

The rest of the papers published are widely spread among the following journal outlets: Transportation Research Part B (10 papers), Engineering Optimisation (9 papers), Computers and Industrial Engineering (8 papers), Computers and Operations Research (8 papers), Journal of Intelligent Manufacturing (8 papers), Maritime Economics and Logistics (7 papers), Naval Research Logistics (7 papers), System Engineering Theory and Practice (6 papers), Transportation Research Record (6 papers), Transportation Science (6 papers), International Journal of Production Economics (5 papers) and Transportation Research Part C (3 papers). Publications are also distributed among other journals in smaller and varying proportions.
2.1.5.2 Applied research methodologies. During the evaluation of the identified studies, it becomes clear that the existing literature can be further subdivided into analytical, simulation, and combined approaches. The combined approach represents both the analytical and simulation approaches that are shown in Figure 15. The majority of the papers (212 out of 243, or 87%) adopted analytical approaches that exclusively apply optimisation algorithms to optimise container terminal operations. However, in order to optimise the entire container terminal operations (Huang et al., 2008), the use of this approach to simultaneously deal with different types of problems, is difficult, although not impossible (especially in regard to stand-alone components). This is a limitation of the widely used analytical approaches in literature. On the other hand, in order to examine and investigate system-wide performance effects (Hamzawi, 1992), approaches using simulation that reproduce and capture the interactions between the connected subsystems of a port system, are also found in the literature in a number of papers (15 out of 243, or almost 6%). In this section, combined approaches represent the models that have been developed in order to study optimisation problems in planning and in the management of port operations for an existing, or new, terminal layout with a fixed set of instruments within an artificially simulated setting; this is in order to test the performance of the optimisation algorithms. Combined approaches also account for a small number of papers (almost 7%).

![Figure 15](image-url)  
*Figure 15. Applied research methodologies of the surveyed studies*

2.1.5.3 Optimisation areas of a container terminal. As stated, the idea of the literature review is the objective of extracting additional capacity (capacity improvement possibilities) from the container terminal using operations research methods (i.e., simulation and optimisation). Seven optimisation areas have been identified and differentiated, these include issues relating to: (1) transport optimisation; (2) berth allocation; (3) crane allocation; (4) storage space allocation; (5) empty container movement or repositioning; (6) integrated approach (simulation); (7) integrated approach (analytical). Figure 16 shows the assignment of papers to the areas of optimisation.
One of the main objectives of the solution for the issues relating to *berth allocation* is to minimise the total amount of ship to yard distance for all containers during the loading and unloading process (Karafa et al., 2013). The proposed solution for the issues relating to *crane allocation* focuses on the distribution of cranes for the bays of a ship and the operating schedule of the bays (Liang et al., 2009); whereas, issues relating to *storage space allocation*, dictate which block and slot is to be selected for a container to be stored in the yard, thus minimising reshuffling (Bazzazi et al., 2009). Transport optimisation involves both quayside and landside optimisation. *Quayside transport optimisation* means the reduction of transportation time and the harmonisation of the crane loading and unloading sequence of the quay with that of transportation (Rashidi and Tsang, 2013). *Landside transport optimisation* pays attention to the selection and distribution, as well as pooling, of vehicles to each part of the operation in accordance with the anticipated workloads; it deals mainly with train and truck operations. The *empty container repositioning problem* is one of the most complex issues relating to global freight distribution, and requires the minimisation of the inefficiencies in container operations, and, in particular, the repositioning of empty equipment to meet cargo demand (Song and Carter, 2009). Each of the acknowledged and described optimisation issues relates to only one of the dimensions of container terminal operations and are the focus of the majority of the published papers (222 out of 243 papers or more than 91%) in the existing literature. A very small number of papers (21 out of 243, or almost 8%) that are concerned with the integrated optimisation of container terminal logistics have been published to date. Those papers are based on the rationale that it is impossible to improve container terminal performance in isolation, requiring the integration of many components that are functionally interconnected with each other; and at least, pair-wise, functionally interconnected. These studies can be further classified into the approaches of integrated-simulation (mainly, simulation) and integrated-analytical (largely, mathematical modelling and optimisation).

![Figure 16. Optimisation areas of a container terminal](image)
The conventional way of solving such optimisation problems is to divide the problem into smaller, but similar, sub-problems, using a, previously described, specified set of parameters; in which each decomposition stands for one specific and completely disconnected portion; this confirms the fact that integrated approaches (as shown in Figure 16) receive less consideration in port performance optimisation and simulation (Stahlbock and Voß, 2008). However, depending on the implementation quality of the components in the process, a condition of the appropriate performance of a port is that each of its many subsystems should fit with the others since they are all functionally unified with the enhancement of performance management; the capacity shortage in one section will affect the service quality in other parts of the system. These system-wide performance effects can be properly investigated through simulation (Hamzawi, 1992). Hence, the next step should be the use of computer-based simulation modelling. Nonetheless, simulation modelling is given lower priority and less focus in the literature (as indicated in Figure 15); however, simulation modelling does need to be investigated in future research.

2.1.6 Conclusion
Within this maritime domain, operations research methods are used in the optimisation processes that are put in place to improve the capacity of the various sections of a typical terminal. The reason is to enable them to adapt sufficiently rapidly to keep pace with environmental change. This section provides an overview of the problems that arise in the management of a terminal and presents a coverage and review of recent papers in the OR literature; the trend analysis being based on year of publication (e.g., from 2000 to 2010), coverage area (e.g., one dimensional versus the integration of dimensions), and approach (e.g., analytical versus simulated).

The section also identifies some important issues that are consistent with the findings of earlier literature (for an example, see Stahlbock and Voß, 2008), concerning the urgent need for further research on the integrated approach using simulation procedures. The reason for this need is that (as shown in Figure 15) the majority of studies have adopted analytical methods for improving the capacity of a specific component of a container terminal; this leaves room for further research on the overall integration of the parts of a port. With respect to the consequences of capacity shortage issues, it is sufficient to draw the conclusion that simulation should be a frequently used method in experiments designed to study the many types of capacity-related issues discussed above. The application of simulations to maritime logistics could involve any port component, or lead to almost any aspect of port planning, operation or management; this could, in turn, to a certain extent, effectively improve existing terminal capacity. Without the active assistance of simulation, the stochastic components that trigger the random process variations in port container operations cause system behaviours that are difficult to imitate, test and experiment with. The use of simulated models avoids risk or disturbance to real-life port processes; this is particularly the case in the high-volume container terminals of leading ports.

In other words, in brief, this section concerns the need for further research on the integrated approach (taking into account all components of a seaport) using simulation procedures for improving seaport capacity. The reason for this is that the majority of studies have adopted analytical methods for improving the capacity of a component of a container terminal; this leaves room for further research on the integration of the parts of a seaport. Therefore, it is important to justify the assertion that the container transport capacity of a seaport has to be improved by taking into account the improved capacity of other components of a seaport. The second section of this chapter is based on the findings of this current section.
2.2 A review of factors affecting port capacity

2.2.1 Introduction
The first section of this chapter concludes with the need for further research on an integrated approach to port improvement (i.e., taking into account all components of a port). Further, as described in Chapter 1, one of the most important problems that decision makers face in today’s maritime ports is where and how the existing port capacity can be upgraded to cater for rising port demands due to continuous growth in containerised trade and the tendency for larger ships to visit ports. The interest in capacity management of both academia and the corporate sector has risen considerably in recent years. To further establish the field of enquiry, the purpose of this section is, after reviewing academic and industry-related papers, to offer a framework to summarise the research in the field concerned with the factors influencing port capacity using a holistic approach. The third section of this chapter then explains the potential managerial implications of this framework in capacity-expansion decision making, in general, and for transport capacity improvement decisions, in particular.

2.2.2 Literature review
To date, as far as the researcher is aware, not many studies are published that review the factors affecting port capacity and the researcher found only two papers that attempt to review part of the literature (Maloni and Jackson, 2005a, Maloni and Jackson, 2005b). Maloni and Jackson (2005a) reviews capacity issues and organises related literature and suggests a taxonomy based on the interrelated operational and strategic stakeholders of container flows. However, the review has one major limitation: it only focuses on the stakeholders (i.e., involved parties) influencing capacity, i.e., it does not aim to select the factors influencing port capacity directly or indirectly. Another study, by Maloni and Jackson (2005b), comes closest to what is attempted in this section. In their contribution, they review capacity factors that are derived from academic and industry literature. However, they exclude some important factors, which affect rail, truck and dry port capacities, and finally system-wide performance of the overall port capacity issues.

2.2.3 Research methodology
The research methodology employed in this section is a content analysis. Each methodology has its own limitations. Although this section follows a logical procedure for searching, this structured process ensures objectivity of the research process in content analysis.

2.2.3.1 Reliability test. To increase the reliability of the conducted research in this section a second coder checks databases and journals as well as the individual industry reports. The content analytic schemes (i.e., the criterion type-coding schemes) are tested for intercoder reliability based on the rule of percent agreement (i.e., conformity or harmony): the number of matches between the two separated coders divided by the number of potential agreements. The minimum standard for acceptability for many studies has been established as 90% and for exploratory studies as 80% (Krippendorff, 2004). For this section, intercoder reliability of 91% is achieved after revising integrated category definitions for couple of times.
2.2.3.2 Content validity test. Content validity is the determination of the content representativeness. A claim for high content validity is made on the basis that categories are extracted directly from the journal articles describing particular contexts, which are different from each other. Here articles and reports generated criterion mentions in texts, served as instant judges of the actuality of the concepts. Moreover, cited references are used as a secondary source to be more certain, but have not received any supplementary paper, which is a sign of validity of the research. Furthermore, in order to cover all capacity dimensions, papers are searched and referred until sufficient redundancy is achieved.

2.2.4 Factors affecting port capacity
A container distribution network forms a series of connected capacity components determined by many stakeholders such as ports, rail lines, drayage operators, terminal operators, stevedoring companies and shipping lines. Delay at any of those points can affect overall capacity severely. Each specific component is very important for the performance of the whole system and for that of the subsequent components. The productivity of each component depends not only on its own performance but also on the performance of other components. For instance, a slow crane performance can occur because of the unavailability of supportive transports, limited skill and lack of experience of the crane operators, weak working capability of the crane itself, poor delivery of containers to the crane or other factors not related to the crane. Some capacity components of a typical port are described in the following:

2.2.4.1 Container yard. The container yard is used for the temporary storage of containers. If there is sufficient land available, it is possible to put every container on a separate chassis, which will allow faster and easier movement of containers among dissimilar terminal locations.

2.2.4.2 Cranes. In a ship, many cranes work simultaneously. The performance of the cranes and the number of cranes in use depends on the size of the ship, the number of containers to be loaded or unloaded, the skill of the crane operators, the availability of the transports (such as straddle carriers and automated vehicles), and the requirements to stop the cranes.

2.2.4.3 Labour. Labour is not a specific component of the terminal system if we view the port as a connected series of processes and sub-processes. It affects the performance of almost all of the processes from gate operations for truckers to berthing activities for shipping lines.

2.2.4.4 Gates. Some ports are using a Vehicle Booking System (VBS) to spread container flows evenly throughout the day and thus use existing capacity more effectively. Ports worldwide are adopting the VBS concept very quickly (Robinson, 2003).

2.2.4.5 Inland waterways. Short Sea Shipping (SSS) provides an alternative and efficient option for transporting containers out of ports to other ports, which increases the existing capacity and reduces many of the capacity burdens.

There are many factors that affect capacity of each component of the terminal system. Factors which affect a particular component are usually different from the factors affecting other components in the system. For example, factors affecting the capacity of highway trucks are design speed, gate congestion, degree of automation at the gate, lane attributes, which are different from the factors affecting container yard capacity. An extensive review of the factors from studies is listed in Figure 17. For a full description of references, see Appendix C.
Figure 17. Stock and Flow view of factors affecting port capacity (all elements of a terminal)
2.2.5 Research opportunities
Port capacity expansion is not an equipment replacement problem, it is about adding more capacity to the current one, which makes the situation complicated. Capacity problems can appear at any of the connected components in the container distribution network for the port, from gates and yard operations to berthing facilities. The traditional way to solve the problem is to divide it into several separate components although all are operationally connected and service quality in one component will disrupt other components, which can be investigated through simulation (Hamzawi, 1992). For example, as mentioned in Chapter 1, during the 1990’s California improved its port’s capability to handle bigger container ships without updating the transport infrastructure connecting the port to the hinterlands, which created bottlenecks (Auckland Regional Holdings, 2009). Therefore, it is important to adopt a ‘whole of port’ approach for capacity management using system modelling, which might be system dynamics, discrete-event simulation, or agent-based simulation, which aim to explain system behaviour and structure. Thus, many research opportunities exist on the factors affecting capacity; these are reviewed briefly below.

2.2.5.1 System Dynamics (SD) simulation. Capacity management is a dynamic management problem, where a dynamic means changing with time. As indicated in Figure 18, the number of required gate entry lane decisions is not made only once; rather it is regularly observed and fine-tuned depending on the prediction and realisation of traffic volumes in every year, which necessitates nonstop managerial activities, adjustment and checking. Moreover, dynamic management problems are created and continue because of the complex relationships among the system variables, which are also applicable for port processes and components (Cetin and Cerit, 2010). The occurrence of these attributes turn ports into perfect candidates for SD simulation. The application of SD includes economics, manufacturing, transportation and many others.

<table>
<thead>
<tr>
<th>Gate Lanes Required For Port of Cleveland</th>
<th>(Number of Trucks Per Month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Monthly Average 2009 (1200)</td>
</tr>
<tr>
<td>Total Trucks Per Week</td>
<td>280</td>
</tr>
<tr>
<td>Total Trucks Per Day</td>
<td>56</td>
</tr>
<tr>
<td>Trucks Per Hour</td>
<td>4</td>
</tr>
<tr>
<td>Gate Entry Lane (Required During Peak Hours)</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 18. Gate lanes required in a sample port
Source: Adapted from Port of Cleveland (2010)
As stated previously, SD models adopt a high level of aggregation and focus on the overall system behaviour (Ng and Lam, 2010). It might be rational to make an accurate distinction and investigate the effects of non-structural mechanisms for capacity improvement from an aggregate level using SD modelling, without tracking all details of a specific terminal element. The reason is to justify the appropriateness of policies. It also permits what-if scenarios for policy makers.

2.2.5.2 *Discrete Event Simulation (DES).* A container terminal is a decentralised, poorly structured, and complex problem domain (Gambaradella et al., 1998). Modelling complex port operations requires a dynamic discrete event simulation model because internal resource conditions change with time (Nevins et al., 1998). Moreover, DES can quantify port operations to analyse port infrastructure utilisation in detail (Hayuth et al., 1994). Ramani (1996) states the limitations of analytical queuing models for modelling port operations and Huang et al. (2008) affirms the limited applications of mathematical models, which optimise only one specific component rather than the whole container terminal. For example, queuing theory models assume certain situations (e.g., Markovian arrival processes), which are not realistic in practical port operations (Silberholz et al., 1991). But still the use of simulation in capacity management demands more research as stated “Little work has been done in container terminal capacity analysis using simulation.” (Huang et al., 2008:247).

![Research opportunities pyramid on factors affecting port capacity](image)

**Figure 19.** Research opportunities pyramid on factors affecting port capacity

The purpose of Figure 19, which is a pyramid of research opportunities on factors affecting capacity, is to simplify the interpretation and procedure of working with all connected capacity variables. Here, structural variables refer to structural mechanisms for capacity improvement, while non-structural variables refer to non-structural mechanisms for capacity improvement. The analysis starts with numerous structural and non-structural variables (i.e., conforming to “decreasing number of variables” as indicated in Figure 19) because SD (continuous simulation or deterministic approach) is a strategic tool, it is used at a much *higher level for understanding* (i.e., increasing level of abstraction as indicated in Figure 19) overall system behaviour. SEM (Structural Equation Modelling) can facilitate empirically testing the relationship among different latent variables of interest (e.g., degree of automation in gates; motivational level of terminal operators; quality of service, level of safety and comfort in rail transportation; skill level of crane operator, etc.) with several port performance variables (e.g., truck turnaround time, congestion, etc.). DES is used for modelling queuing systems (e.g., ports) where variability is important at a micro level and it is possible to incorporate individual features of a specific variable (i.e., decreasing number of variables as indicated in Figure 19).
2.2.6 Conclusion
This section concerns the need for further research on the integrated approach (taking into account all components of a port) for improving port capacity. In order to fulfil this objective, from a holistic point of view, this section offers a conceptualisation (a conceptual framework - embedded in Figure 17) based on an extensive literature review of the academic and industry-related papers concerned with the factors influencing port capacity. Thus, the section takes a wider look at port capacity management. This chapter is significant as there is limited literature on the subject of the factors affecting capacity; studies carried out to date on capacity improvement mechanisms are constrained principally by the lack of a complete and integrated perspective. The next section explains the potential managerial implications of this framework in capacity-expansion decision making (e.g., transport capacity improvement decisions).
2.3 Managerial implications of the framework

2.3.1 Introduction

The first section of this chapter urges for the improvement of the port capacity by taking into account all of its important components, rather than its individual dimensions. Taking that recommendation into account, by identifying the consequences of capacity shortage at ports and their corresponding supply chains in order to further establish the maritime field, the second section offers a conceptualisation (as embedded in Figure 17). The offered conceptualisation is based on a review of the academic and industry-related papers concerned with the factors influencing port capacity from a holistic point of view. Although, by reviewing the literature to suggest a framework, the second section examines the capacity shortage problem (since there is limited literature on the subject of factors affecting port capacity; studies carried out to date on capacity improvement mechanisms have been partially constrained by the lack of an integrated view), it does not suggest the managerial implications of the framework. Therefore, to show the possible effect of the framework on port capacity improvement potential, this section further explores the usefulness of the suggested framework from both micro and macro perspectives.

2.3.2 Managerial implications

Taking all the important features of SD into account, as we stated in the beginning of this chapter, this section has chosen the methodology to advance and showcase the application of the suggested framework (embedded in Figure 17). Kim (1998) also adopted a similar approach to develop a transportation planning model. Following a comparable approach, this section discusses the managerial implications from two perspectives, namely the micro and the macro. As indicated in the introduction of this chapter, practical implementation of the suggested framework is outside of the scope of this chapter.

2.3.2.1 A micro-level perspective. A micro-level view looks into a capacity management problem at a port from a single dimension, such as, yard operations, which are important in the controlling of container inflows and outflows as terminal space is limited. To focus on yard operations by displaying a list of causes affecting the yard capacity and their interrelationship, a hypothetical Causal Loop Diagram (CLD) is created, as shown in Figure 20. The feedback loops in the CLD represent the complexity of the interconnected variables of the process and the stock element measures the yard capacity. The stock is the difference between the numbers of containers arriving at, or leaving, the yard. Therefore, the arrival of a truck adds to yard capacity and the departure of a truck does the opposite. However, in addition, variations in yard capacity are dependent on many other factors such as; number of truck lanes, degree of automation at the entry gate, and the availability of turn lanes at intersections. These factors also influence one another, for example, the required label of automation at the entry gate depends on the yard capacity that has been projected by the authorities, and the number of trucks in a terminal depends on the provided degree of automation. Limited yard capacity may result in congestion.
Figure 20. A simplified sample CLD for yard capacity (one single dimension) management

The CLD can facilitate in the development of a capacity-management-related scorecard to monitor and manage yard capacity using performance indicators. The objective is to enable interaction between the port authority and the model. For example, the port authority may wish to see the impact of changes on yard capacity of a policy variable of interest (e.g., increasing the availability of turn lanes at intersections or investing in the degree of automation at the entrance gate). Using a slider tool (Figure 21 shows a sample user interface consisting of a diagram and three slider tools), the port authority can select one of the important variables and change the initial value by dragging the slider button during the simulation. The user interface does not require the decision-maker to understand the complexity of the simulation model. This is one of the most important advantages of the suggested simulation model.
Figure 21. A sample user interface for yard capacity (one single dimension) management

Figure 22. A simplified sample CLD for terminal capacity (all dimensions) management
To further explain the application of the concept of the capacity-management-related scorecard to monitor yard capacity, an explanation of the inter-related variables and factors that influence the port’s capacity, is important. For example, as noted in Figure 20, increases in yard capacity due to increases in the number of container trucks are expected to have an impact on the required degree of automation of a facility (e.g., entrance gate of a Port). Moreover, the impact on the degree of automation of the truck arrival process at an arbitrary moment in time, is intended to have further effects on other functionally interconnected subsystems (e.g., the number of container trucks arriving at the Port); this is because the information capturing features of the automation will improve the truck turnaround time in a Port. These all-encompassing changes will have a sequential impact on the ability (yard capacity) of the yard to process an increased number of containers per day. This behaviour of a port system across time can be noted and analysed, after developing a causal loop diagram and filling in the formulas. Thus, the use of a slider tool is necessary in order to make changes in the Port Authority's management and governance to provide benefit from its policies (e.g., the required degree of automation). For example, values with absolute values of less than .10 on the slider tool may indicate that the degree of optimal automation is not achieved, and hence the actual overall impact on the yard capacity will be minimal. The model can be “run” to show how the yard capacity will change given a variety of experimental conditions, such as changes in the number of container trucks licensed to serve the Port and the surrounding industrial areas. These changes in port-related policies over time can easily be captured in the diagram shown in Figure 21.

2.3.2.2 A macro-level perspective. The usual way of solving capacity management problems according to the literature is to divide a port into many dimensions and to focus solely on one dimension at a time, such as; gate operation, yard operation or container storage operation. Such a single-dimension-based solution approach focuses on one specific and disconnected dimension, whilst ignoring the application of the whole port-oriented approach. Thus, the system-wide capacity management method has received little attention in studies on port performance management (Stahlbock and Voß, 2008). However, all components need to work together to ensure the appropriate performance of a port as all elements are functionally and logically interconnected, and a capacity shortage in one dimension affects the service quality of the others. Hence, in order to provide for adjustments in capacity, the macro perspective suggested here considers all dimensions of a port from the operations at its gate to other facilities.

Gate capacity, short sea quay capacity, container yard capacity, deep sea quay capacity, rail terminal capacity and dry port capacity are some of the important stock-related elements of the macro-level CLD developed in Figure 22. Each of these stocks represents the capacity of the port system for each of the dimensions at any given time. One of these stocks is sufficient to be the cause of a bottleneck for the entire port; in addition, a small delay in any of the stocks can introduce significant disruption to the entire system as all of the stocks in the port are connected to each other. For example, the number of container trucks within a terminal depends on the number of container trucks on the highway or at the entry gate. Similarly, the entire container-carrying capacity of the container trucks in the yard is dependent on the loading capacity of the short sea vessels. These stocks are also connected to each other through feedback loops. A feedback loop occurs, for example, when the output of the yard capacity is connected back to the input of the same yard. The factors connected to a stock can also have links with many of the factors related to other stocks. Hence the making of another graphical interface can demonstrate the features of the macro perspective. The interface may include many types of diagrams and the sliders for taking inputs. Other parameters and reporting types may be added to the model.
2.3.3 Conclusion
As stated previously, due to the evolving capacity shortage and the further deterioration of the situation, port authorities seek opportunities that may lead to the resolution of the problem while, at the same time, turning the escalation of the problem into a competitive advantage. As a result of capacity shortage problem, port authorities look for efficient ways of expanding terminal capacity in order to remain competitive in the area of competition. As an approach to facilitate in capacity related issues; it is suggested that solutions may be found by identifying the underlying capacity factors that are lacking in the literature, the second section reviews the literature concerned with the factors affecting port capacity from a holistic point of view, and offers a framework (embedded in Figure 17). Although the second section examines the factors affecting port capacity, it does not offer any solutions for assessing the usefulness of the framework. By taking that limitation into account and identifying potential managerial implications for the framework, the current section further explores the usefulness of the framework from both a micro, and a macro, perspective. The views should be applicable to most ports of the world given the customisation of the framework to accommodate inevitable differences found between ports.
Chapter 3: Exploring potential solutions to reduce empty truck trips

3.1 Introduction

The first chapter describes how the increase in the number of containers (along with other factors) is adding pressure for ports to increase the transport capacity of container trucks. As a result, it is concluded that, one of the most significant problems that decision makers face in today’s maritime ports is how to upgrade the container transport capacity for rising port demands. However, an attempt at solving the transport capacity shortage problem by only increasing the number of container trucks may encourage carbon emissions, traffic congestion, fuel consumption and pollution. Therefore, a key mechanism, to increase transport capacity, is to lessen the number of empty truck trips and to transfer increased number of containers using the same number of trucks. (See Chapter 2 for other methods for increasing port capacity.) Therefore, in order to explore alternative solutions to the empty trips problem, the research question examined in this chapter is: What are the different mechanisms available in different disciplines and domains for reducing empty truck trips?

In order to address this research question, a synthesis of the literature from different research areas is performed, which results in the identification of a set of concepts that can provide useful insight into the full utilisation of under-utilised trucks. These solutions can be explored so that the underlying causes for this empty vehicle performance may be reduced, and hence so that transport capacity may be improved. Such an exploration is the objective of this chapter. In order words, this chapter reviews potential solutions, for the empty trips problem.

A significant research gap remains in regard to synthesising the existing literature relating to the empty truck trips problem. For that reason, this chapter’s integrative literature review aims to explore the possible inter-related research domains that play a key conceptual role in the topic of empty-truck transportation. Stahlbock and Voß (2008:29) state that, “…the number of papers focusing on trucks and trailers at container terminals is very limited.” Among these limited truck-related studies at container terminals, as far as the researcher is aware, as to this date, there have been no major reviews that may help port authorities in their decisions concerning the empty trips issue around port gates. However, a number of extensive literature reviews have been already published that summarises the academic research on container terminals and port operations well. For a comprehensive review of this literature, see Vis and de Koster (2003), Steenken et al. (2004), Günther and Kim (2006), and Stahlbock and Voß (2008).

A number of relatively smaller literature reviews can be found in Murty et al. (2005a), Murty et al. (2005b), Vacca et al. (2007), and Kulak et al. (2013), just to name a few. However, as mentioned earlier, a research gap remains in the area of empty trips transportation to synthesise existing literature (i.e., concepts and principles) from a range of different, but relevant scholarly disciplines. This provides a basis for an adaptation of theories from other disciplines to maritime logistics research using literature reviews and synthesis techniques, as justified by the statement of Woo et al. (2013:461), “…maritime researchers have been required to adopt theories and research models from other disciplines and to apply various research methodologies and data analysis techniques that were not previously used in seaport research.” This is considered normal for newer disciplines as there is a continuous research development pattern that tends to follow borrowing concepts from other more mature disciplines (Stock, 1997). In brief, the findings of this review reported here bring together and summarise the major concepts of many research fields. These ideas can potentially contribute to new concepts and practices for the management of empty truck trips for this emerging maritime logistics domain.
Figure 23. Major content categories of the literature review to explore alternative solutions
3.1.1 Organisation of the chapter
The rest of the chapter is organised as follows. The second section provides more details of the research methodology employed. The third section summarises the important interdisciplinary concepts and their implications. This is followed by a discussion and synthesis of the reviewed literature in the third section. The fifth and sixth sections provide the conceptual and managerial implications of this chapter and the concluding section reviews the overall aspects of the chapter.

3.2 Research methodology
The empty trips problem of container trucks has many important aspects to explore. One of these may concern the difficulties that arise when consideration of collaboration strategies begins to exert an influence on the supply chain parties involved in the distribution process of a maritime container (Franc and Horst, 2008). Therefore, there is a need for discussion on the issue of mutual collaboration among supply chain members, and it is also important to consider the minimising and overcoming of collaboration difficulties (Martijn and Peter, 2008). Apart from these collaborative aspects, the same problem can also be regarded from another perspective. This perspective highlights the fact that efficient resource utilisation is important for a carrier, from a resource-based view. To explore this view further, the broad perspective of the resource-based view suggests that the maximum utilisation of internal resources of an organisation is the key to staying competitive in this changing yet challenging business environment. This can be accomplished by the use of an innovative conceptual idea. This key fact has been highlighted by many studies in the recent past (e.g., Shelby and Morgan, 1995, Strazza et al., 2011). Based on the same key idea, the purpose of this review is to examine the literature available both in the maritime logistics field, as well as outside the maritime logistics field, in order to explore the alternative ideas. These ideas are being attributed to efficient utilisation of transport capacity and to gain an understanding of the state of research in the discipline.

3.2.1 Literature classification
The literature on the topic of increasing efficient utilisation of transport resources and hence, the reduction of empty vehicle trips, can be divided into two categories (Fig. 23). In one category are all studies that fit suitably with maritime transportation (i.e., transportation studies addressed on the subject of port-related research). In another category are all studies that are concerned with the research of non-maritime transportation (i.e., transportation studies, where these are often focused on the retail industry, rather than on the characteristics of the port industry).

The category of maritime transportation studies are further classified into three subcategories: (i) centralised perspective; (ii) decentralised perspective; and (iii) other novel concepts. A contribution of the earlier reported studies to this centralised perspective is to focus on transport optimisation. The focus of the transport optimisation is largely single-company oriented. Conversely, the decentralised perspective promotes the idea that the centralised perspective overlooks the benefits for all involved carriers and shippers in the supply chain through collaboration. This is an important concern for the achievement of supply chain efficiency and effectiveness. Apart from these two categories of study that are specific to collaboration or non-collaboration, some other potential alternative solutions and transport scenarios that have been reported in the literature are also explored here. The focus is on how to improve the utilisation of truck capacity for all road carriers and shippers across the port.
In the non-maritime category, there is a group of studies that maritime researchers could also gain insights in regard to collaboration issues. They suggest mechanisms to improve underutilised vehicle movements; these are also reported in this chapter as a source of the researchers’ understanding of the empty trips issue. The areas of study referred to are: (i) the concept of shared-transportation; (ii) Collaborative Transportation Management (CTM); (iii) Collaborative Logistics Network (CLN); and (iv) code-sharing agreements.

3.2.2 Literature search strategy
The objective of the literature review is to identify proven and potential concepts from many other research fields for improving the efficient utilisation of resources among container road carriers to improve their vehicles’ overall transport capacity. Therefore, a comprehensive, three-phased literature search strategy has been adopted to ensure in the process both consistency and integrity to the greatest possible extent. A similar approach was adopted by the extensive literature review in Verdonck et al. (2013) in which they highlighted their focus on the operational planning of horizontal cooperation between road carriers.

In the first stage of the search strategy, based on paper titles and abstracts in particular, the primary assessment tool used in the course of the review process was the searching of electronic databases. This included the searching of business databases (e.g., Science Direct, Emerald, and Business Source Premier). In the second stage of the process, the literature search was extended and included several articles from peer-reviewed journals and conference proceedings, but those were not initially found in the databases searched at that time. In the final stage of the process, bibliographies of cited articles were reviewed to identify additional studies and reviews for inclusion. At times, these cited references helped the researcher to gain a new perspective into a research field. The same process steps were repeated for all concepts reviewed, evaluated, and described in this chapter. The overall searching process was comparatively systematic and comprehensive, and the article selection process was random in a few instances. This reflected the subjectivity of the approach and was used in order to ensure that important information as specified and deemed necessary by the researcher on some occasions was not excluded.

3.2.3 Keyword search strategy
Concept-related keywords used in database searching varied from case-to-case both in number and in clarity. A typical example of this can be understood from the exploration of the shared-transportation concept. This particular idea is represented in the literature in the form of many other related concepts, for example: ride-sharing (Kamar and Horvitz, 2009, Chan and Shaheen, 2012); and carpooling (Dueker and Levin, 1976, Beroldo, 1990), to name but a few of them. A similar and comparable approach was adopted for all concepts and practices explored in the current chapter. The primary aim was to approach a concept from different perspectives to ensure that important aspects were covered and that the main theme was explored and evaluated.

3.3 Review of potential concepts
Following a review of concepts that can help transport managers to compare their current transport policies and to realise the many opportunities available to them to improve their truck-capacity utilisation, this section represents a description of the literature examined.
3.3.1 Collaboration in hinterland transport chains

The logistics and supply chain management literature includes descriptions of a number of studies that are specific to collaboration problems in the hinterland (the region served by the Port) transport services (for examples, see Monios, 2011, Van den Berg and De Langen, 2011, van der Horst and van der Lugt, 2011). Access to quality transport services for the hinterland and the addressing of related issues has become a major concern among maritime researchers and transport decision makers. The reason is comparatively obvious and simple, since providing quality transport services to its hinterland is one of the many basic reasons for the existence of many port companies (Lugt et al., 2013). This also ensures the competitiveness and profitability of the ports in this dynamic and complex environment (Notteboom, 1997). Apart from that, there is another reason that goes deeper and is based on the underlying rationale that deep-sea shipping lines prefer to choose those particular container terminals that are well-connected and close to their hinterlands, among many other important factors (Wiegmans et al., 2008:523). This is what the study is referring to when it mentions, “…hinterland accessibility profile (intermodal interface for trucks, rail, barge and short-sea)…” Each of these inland nodes (e.g., trucks, rail, and barge) may be important in various combinations and degrees in different container terminals as they affect the overall quality of the hinterland accessibility.

To get the maximum potential benefits from operating these inland nodes, collaboration among the port community is important. The quality of hinterland access largely depends on responsible collective behaviour of the many interrelated and diverse actors in the container distribution chain (Franc and Horst, 2008). These interdependent actors include, but are not limited to, shipping lines, terminal operators, forwarders, and port authorities. Therefore, the problem of ensuring hinterland access quality is primarily viewed as involving a number of supply chain actors working together towards closer collaboration with key partners. These key partners get benefits from the improved hinterland access that help them to maintain a smooth flow of the container elements from and to the port. To overcome the collaboration problem in order to improve the quality of hinterland transport services, the study by Langen and Chouly (2004) discussed the concept of “hinterland access regime”, which, they state, will not develop automatically or effortlessly. The study further argues that “the formation of various sorts of coalitions” to facilitate greater communication, which requires continuous collaboration.

Of the major problems that arise because of the absence of collaboration between a large number of port actors, one of them can be largely attributed to the issue of “limited exchange of cargo and trucking capacity”. This refers to the fact that carriers and shippers do not usually share available truck capacity with each other; more specifically, this is especially relevant in the case of coordination problems among container road carriers and freight forwarders (Martijn and Peter, 2008). The same study further argued that the solution to the problem will eventually lead to an efficient utilisation of truck capacity. An example of this efficiency gain can be clearly seen in Figure 24, where the higher extent of collaboration among carriers (the carrier is one of the important actors in the container distribution chain) will result in maximum utilisation of their available resources (e.g., container trucks and their spaces) and related transport capacity. While the many benefits (e.g., increased carrying capacity) of full utilisation of truck capacity for transportation are as applicable to the individual road carrier and its shippers, as they are to the wider transport industry and the port community. Because of this reason, especially for the benefits of all carriers, in this chapter this category or concept is termed as “decentralised perspective- benefits incurred by all relevant stakeholders of the port industry” (Figure 23).
3.3.2 The backhaul problem
To reduce the adverse impact of container truck operations on empty trips issue, there is another particularly relevant major research stream, which is frequently known as the “Vehicle Routing Problem with Backhauls (VRPB)” (Imai et al., 2007). An extended version of the original VRP (Vehicle Routing Problem) is VRPB, where all customers are classified into two broad categories: Linehaul and Backhaul customers (Toth and Vigo, 1999). Here the primary purpose of a linehaul customer (e.g., delivery demands, a supermarket or shop) is to receive goods of a required quantity from the depot. Conversely, a backhaul customer (e.g., pick-up demands, a grocery supplier) expects to deliver goods, based on a given quantity, to the depot. The study by Potvin et al. (1996) further explains that a typical VRPB can be formulated as: (1) each truck serves only a specific set of routes; (2) the total delivery loads for the linehaul customers cannot exceed the carrying capacity of the vehicle; (3) similarly, the total pickup loads for the backhaul customers cannot exceed the transport capacity of the vehicle; (4) all backhaul customers are served only after all of the linehaul customers are served, because linehaul customers are given higher priority, and also because of the physical constraints associated with each vehicle (e.g., the vehicle is rear-loaded); and (5) whilst satisfying all these constraints, the objective is to find a set of routes that minimise the total distance (originating and ending at the same depot) travelled and hence total cost incurred by each vehicle. Because of the limiting of benefits to only one road carrier, in this chapter this concept is termed “centralised perspective” (Figure 23).

The mathematical formulations of the VRPB can be found in Anbuudayasankar et al. (2012) and Tavakkoli-Moghaddam et al. (2006). Many solutions are available in the literature for the variants of the problem, such as the Vehicle Routing Problem with Backhaul and Inventory (VRPBI) (Liu and Chung, 2009), Vehicle Routing Problem with Forced Backhaul (BVFB) (Anbuudayasankar et al., 2012), and Pickup and Delivery problem (PDP) (Dumas et al., 1991). Other variations of the problem can be found where the focus is on container terminal operations and their relevance to drayage operations around ports. An example of this is the study by Lai et
al. (2013), in which containers are delivered to the importers from the port, and picked up from exporters to transport to the port, without the trucks and containers being separated during customer service. Similar studies with variations on drayage operations can be found in Imai et al. (2007) and Caris and Janssens (2009).

Such methods of optimisation sometimes have been criticised in the literature on the grounds that, for example, as stated by Agarwal et al. (2009:374), “Many of the traditional optimisation algorithms that work well when there is only one decision maker become ineffective in a collaborative setting, where there are multiple decision makers. This is because individual decision makers, though often working towards a common objective, are guided by their own self-interests.” The same problem with collaborative practice (and environment), and the effectiveness of the traditional optimisation algorithms developed to serve only one particular decision-maker, is evident in this maritime logistics field as well. This is especially evident in the case of the container distribution chain. Here multiple road carriers and other separate parties are involved in the course of the decision-making process. It is also now evident that it is not only academics, but also practitioners, who are aware of the limitations of the management practices and performance of single-company-based operations (Brunell, 1999). Following the same line of thought that urges the integration of innovative, collaborative, initiatives and appropriate techniques to manage multiple decision-makers, and hence to overcome the limitations of the present operations management methods and its “single company-oriented approach”, the study by Busi and Bititci (2006:11) further confirms that direction of improvement, “Operations management research calls for newer methods, tools and techniques that will support management of collaborative enterprise.” In addition, similar ideas have been supported by the conclusions of other studies (e.g., Holmberg, 2000, Wognum and Faber, 2002). It is also worthy of note, as previously highlighted in the study of Peetijade and Bangviwat (2012), that a single company cannot do enough to solve the issue of vehicle capacity utilisation and the empty running problem. The reason is that a customer does not load cargoes for both journeys (i.e., linehaul and backhaul). So, a collaborative view is one of the goals for stakeholders to achieve.

3.3.3 The Chassis Exchange Terminal (CET) concept

The development of a CET may comprise another mechanism to reduce the number of empty trucks passing a port. A detailed description of the concept is provided in a study of Dekker et al. (2013). The CET has two process components. (1) One consists of the chassis exchange, often initiated in the CET by a container truck delivering a laden container after arriving at the port and picking up an imported container before exiting the port. In this process, every container is placed on a chassis during daylight hours. (2) The second part is the process of shuttle management between the CET and other terminals of the port. This means the transfer of export containers from the CET to the terminal in off-peak hours using a shuttle service, and also bringing back imported containers in order to distribute them to the hinterland.

The first and most important part of the CET concept is further explained in detail here. An automatic gate system processes all incoming trucks at the entry gate. The gate processing system checks whether the truck is attending an appointment and provides information concerning the appropriate location in the container terminal for coupling on the new chassis to the truck (i.e., importing). The provided information also includes data such as the location of the container terminal for uncoupling the current chassis (i.e., exporting). The truck driver executes the orders according to specific instructions. This means that the truck first uncouples its chassis and then couples on the new one. The truck is scanned again at the exit gate with an automatic
system before allowing the truck to leave the port, and this ensures that the chassis, that is coupled on, is the correct one. The truck then leaves the port territory.

The potential benefit of using CET is shortening the turnaround time for container trucks because it does not require dedicated personnel or equipment to facilitate in the container dropping off or picking up procedure. The shortening of truck turnaround time in the chassis exchange terminal results in less waiting time and thus reduces idling engine time that, in turn, has a positive impact on fuel consumption and vehicle emission rates. The reduction in turnaround time also results in many more trips for a truck in a day. There is another benefit for the empty truck management aspect of the operation. Therefore, for example, as every truck needs to drop off a container for export and to pick up a container for import, if the procedure is followed, this will increase the truck utilisation capacity in two way moves. Although it has been studied for its benefits, there is one disadvantage to using this CET concept for reducing the number of empty truck trips, this is: that it takes huge areas of land in order to stack containers on wheels. This issue has been recognised by the study of Henesey (2006).

3.3.4 The street-turn strategy
Another interesting concept to consider is that of the impact of the street-turn strategy that can potentially reduce the number of empty truck trips. The way this strategy works is probably best understood by the description of Deidda et al. (2008:503), “This option consists in the distribution of trucks delivering loaded containers to import customers, the subsequent allocation of empty containers to export customers and the final dispatch of loaded containers to departure ports.” Therefore, in simple terms, the strategy facilitates the movement of empty containers (emptied by local importers) to local exporters instead of sending them back to the empty-depot that is located within the port. Thus, the strategy improves the container transportation process by reducing the number of truck movements (Figure 25) that a road carrier must carry out during an import or export action. Many other benefits of using this strategy have been pointed out in brief by the study of Jula et al. (2006:47), “The potential benefits of street-turns are enormous, including: reducing the number of truck trips and consequently reducing the traffic congestion, noise, and emissions, and saving driving times to and from marine terminals by avoiding the congested areas around the gates.” Apart from those mentioned here, the quantitative benefits (e.g., the amount of carbon emission reduction achieved) that show the effectiveness of this strategy can be found in the study of Tarudin (2013) and The Tioga Group (2002). One of the problems associated with this strategy, however, is that determining truck routes for the transportation of containers can be difficult (Deidda et al., 2008). The Tioga Group (2002) also conducted a review of the requirements for the successful implementation of the street-turn strategy and considered both the institutional (e.g., container and chassis combination) and the informational requirements (e.g., opportunity for empty reuse).
3.3.5 The dry port

Similar to the earlier street-turn strategy, the port authority should also attempt to help stakeholders understand the benefits that a dry port will bring to reduce the number of empty truck trips around a port territory. A dry port is a commercially viable concept which has been defined by the study of Leveque and Roso (2002:4) as, “A Dry Port is an inland intermodal terminal directly connected to a seaport, with high capacity traffic modes, where customers can leave/collect their goods in intermodal loading units, as if directly to the seaport.” Hence, a dry port is an adjacent terminal. This terminal is connected to a port, and acts as a backup facility to move freight volumes from the road to a more efficient mode (e.g., rail) to relieve congestion around the port gates (Roso et al., 2009). This idea is shown briefly in Figure 26, where a port is connected (i.e., joined by high-speed rail connection) with a dry port and their shippers.

A port with a dedicated dry port offers much more to the port authority and the stakeholders than does a typical port, although a dry port is not located within the main port. However many of the benefits of establishing a dry port to perform certain container handling operations are obvious while others are less apparent (i.e., they have been less well covered in the literature on the empty trips issue), yet significant. Without compromising the core activities of the port, and to reduce road congestion and also port capacity problems, some of the important benefits that a dry port offers include: storage, consolidation, depot, maintenance and customs clearance of containers (Roso, 2007). Because of all of these facilities (e.g., the unique but necessary consolidation benefit that is provided), along with the placing of greater emphasis on the role of a dry port in container transportation issues in order to get an accurate insight into the reduction of empty truck trips, it has been clearly stated by the study of UNCTAD (1991:7), “A dry port can reduce empty rail wagon or truck movements by acting as a consolidation centre for return loads of export cargo. The consignment increase in load factor may enable some savings to be made in overall transport costs.” Ultimately this argument is based on the rationale that, if a dry port can be used as a consolidation centre, this will allow the benefit of picking up an import
container every time a truck drops off an export container. The aim is to achieve higher truck utilisation rate as there will be no unnecessary empty trips back to the carrier. An identical idea was put forward by other researchers. Therefore, for example, while focusing on the discussion of regional transport connectivity, UNCRD (2013:18) stated, “Dry port and logistics centres can act as freight consolidation centres also have the potential to reduce empty truck trips. For example, 12-30% of trucks run empty in Pakistan and 43% in the People’s Republic of China”.

Therefore, to fully utilise truck capacity, the establishment of a dry port has been proposed in the literature. One of the key factors that is involved in establishing a dry port, for example, is that; overall container charges may increase because of multiple handling (van Klink and van den Berg, 1998). So, establishing a dry port may be more expensive as it is a container that needs careful handling both in the main port and in the dry port. Furthermore, one of the challenges of establishing a dry port is the complex planning issues that can be encountered throughout the implementation process. The absence of an investment source can be another major challenge. For a complete list of the establishment challenges, see Trainaviciute et al. (2009).

**Figure 26.** A connected dry port established to have an impact on empty truck trips reduction  
Source: Roso et al. (2009:341)

### 3.3.6 Collaborative Logistics Network (CLN)

The concept of a CLN is based on the principle that shippers and carriers, when working together in a collaborative manner, can reduce their transport costs to take their transport decisions (Ergun et al., 2007a, Ergun et al., 2007b). Transport costs include the empty truck repositioning cost of returning the empty truck to the carrier at the end of each completed transport service, to execute new shipment orders received from other shippers. The definition of CLN is provided by Mavrommati and Migdalas (2002:344) as, “A collaborative logistics network is a web-based system that lets major buyers, shippers and carriers coordinate business activities throughout the supply chain using the Internet.” To elaborate on the importance of CLNs in providing transportation services to improve transport efficiency by using truck driving lanes, it can be assumed that an empty truck generates financially unproductive empty miles. A truck generates empty miles for both the shipper and the carrier when going back empty to the carrier at the end of a completed delivery. To cover this cost of empty driving miles, a carrier tends to shift the
cost to the shipper by increasing freight charges. However, this cost of empty transportation is shifted onto the customer finally from the shipper in the form of increased product prices. Therefore, it is the customer who pays for the truck repositioning cost for each completed empty transport trip. For more information on collaborative logistics networks, see appendix A.

3.3.7 The shared-transportation concept
The primary focus of the shared-transportation concept is largely on the improvement of the low occupancy rate of passenger-carrying vehicles and the eventual recovery from the environmental, financial, and social damage. Daily empty vehicle operations cause such damages, and the implementation of effective vehicle management strategies is necessary. A typical example of this is “ride-sharing”, a type of system that allows a group of travellers to enjoy a car, or van, trip with the intention of the full utilisation of its seats (Chan and Shaheen, 2012). The meaning of “ride-sharing”, such as “car-sharing”, or “van-sharing” or “lift-sharing” as used here refers to a concept of the avoidance of unutilised seats. This meaning is similar to what has been defined by Chan and Shaheen (2012:93), “It is the grouping of travellers into standard trips by car or van”. The phrase “car-sharing” or “bike-sharing” has been used many times as meaning “a short-term vehicle loan” policy in the literature (some examples of studies on ”short-term vehicle loan” are Shaheen et al., 1998, Katzev, 2003, Efthymiou et al., 2013, Rabbitt and Ghosh, 2013). As similar to the first description (not a short-term vehicle loan policy) of ride-sharing (e.g., carpooling or van-pooling) as outlined in this chapter the idea of carpooling started making a sustained decline some time ago. This was because of the continuously changing social norms and values, and the improved fuel economy of cars (for a brief history also, see Ferguson, 1997); although it has started showing an improvement in popularity, particularly in recent years (Chan and Shaheen, 2012). The discussion in that study further explains how ‘ride-sharing’ can allow for many forms of existence (i.e. from acquaintance-based to organisation-based, or on an ad hoc basis) as shown in Figure 27. Associated with these variations of form, a ride-sharing provider, for example, is the differing types of mechanism involved (i.e., services can range from simple telephone communication to more automated computerised systems) to present their services to passengers. Such systems are connected to the Internet. All these variations add value to service providers. For more information on the shared-transportation concept, see Appendix A.
Figure 27. Ride-sharing classification scheme
Source: Adapted from Chan and Shaheen (2012:95)
The benefits that a ride-sharing service provides are numerous and in many ways, may be, superior to other solutions aimed at solving passenger transportation problems affecting society in large. For example, the service reduces the number of cars needed by travellers, and this has further effects on reducing environmental emissions at low cost. The service also reduces the number of parking spaces required for cars. The delivery of a ride-sharing service can also be measured from the perspective of benefits received on a personal level, and this conclusion has been elaborated upon in the study of Chan and Shaheen (2012). For example, travelling in a shared-car, passengers can save money (i.e., transport cost) by sharing travel expenses among a greater number of travellers. The service also saves time by using lanes dedicated for high occupancy vehicles such as buses and taxis. Other ride-sharing benefits include, but are not limited to, receiving preferential parking benefits or other forms of financial or non-financial benefits wherever applicable. Many studies have repeatedly reported on all these ride-sharing outcomes, for examples, see Kumar and Moilov (1991), Beroldo (1990), Burris and Winn (2006), Shirgaokar and Deakin (2005), and Yan and Chen (2011).

Therefore, personal and societal benefits, that an individual can derive from taking advantage of a ride-sharing service, are cited in the literature. Many studies also mention the kinds of barrier that passengers may face during the adoption of ride-sharing practices. At the individual level, two of the primary barriers are lack of flexibility and the convenience of having a car at a passenger’s disposal to go wherever he or she wishes at any time (Dueker and Levin, 1976). Other barriers include a lack of personal space and a lack of the ability to avoid uncomfortable social situations, particularly where publicly available shared-transportation is concerned (Bonsall et al., 1984). The optimisation problem related to this is known as the Car Pooling Problem (CPP). The problem can be classified either as a Daily Car Pooling Problem (DCPP) or, as a Long-term Car Pooling Problem (LCPP). For the differences between them, see Wolfler Calvo et al. (2004). By following similar operational concepts, many ride-sharing service providers are now available in the market with quality solutions, such as those outlined in Nuiride (Kamar and Horvitz, 2009).

3.3.8 Collaborative Transportation Management (CTM)
Supply Chain Collaboration (SCC) has been widely discussed in the literature as well as being experienced by companies. The discussion relates to lack of suitable protocols of collaboration among supply chain partners and the way, in which this leads to greater inefficiency and unnecessary, added cost in the supply chain (Chandra and Kumar, 2000, Jain et al., 2009, Lin and Ho, 2012). As a result of those early academic discussions, along with continued best practice development and subsequent research, many theories and models (e.g., VMI – Vendor-Management Inventory, ECR – Efficient Consumer Response, and JITD – Just-in-Time Distribution) have been suggested in the literature in order to fill the gaps in this area. CPFR (Collaborative Planning, Forecasting, and Replenishment) is one that is popular (as many studies have proved its benefits) in today's supply chain management practices (for a list of such studies, see Thomé et al., 2014). The significance of CPFR can perhaps be best understood by the definition of Sherman (1998:7), “How does CPFR work? It begins with an agreement between trading partners to develop a collaborative business relationship based on exchanging information to support the synchronisation of activities to deliver products in response to market demand.” So, according to this collaboration model, supply chain members are required to cooperate (basically through information sharing that can impact supply chain performance and dynamics, as shown in Figures 28 and 29) with each other to achieve their shared and common objectives (e.g., increasing customer satisfaction and minimising system-wide hidden cost).
Following the fundamental principle of the CPFR concept and its business applications, some other common objectives that the whole supply chain shares with the rest of its members are; on time delivery, assurance of product quality, and responsiveness to the market demand (Kazemi and Zhang, 2013). Because of all of these appealing reasons, supply chain partners should adopt the concept of CPFR in their operations in order to make improvements in their business by increasing efficiency, and improving overall product quality (Chan and Zhang, 2011). To ensure the most successful procedure during implementation planning, the standards of CPFR-based collaborative approach have been developed by Voluntary Inter-industry Commerce Solutions (VICS) (2002). Many of the benefits (e.g., reduce inventories, improve service levels and increase sales) of adopting the CPFR concept have been outlined already by academics and practitioners mainly from the perspective of the competitive retail industry (for examples, see Kim and Mahoney, 2010, Büyüközkan and Vardaloglu, 2012, Jiang and Liu, 2012, Xiaohui and Youwang, 2012, Yao et al., 2013, Kazemi and Zhang, 2013, Li and Chen, 2013).

Despite all of the potential benefits well-documented in many studies, the CPFR model overlooks the fact that transportation (e.g., in the form of distribution) is an important component of the supply chain operations (Chen et al., 2010, Mwangi and Waweru, 2013). To add this essential missing component, Collaborative Transportation Management (CTM) is an extension of the earlier CPFR concept (Chan and Zhang, 2011, Wen, 2011, Wen, 2012). In brief, the new CTM concept brings together supply chain partners (Figure 30), across multiple organisations, in a way to remove the cost burden of freight transport inefficiency from the supply chain (Esper and Williams, 2003, Tyan et al., 2003, Li and Chan, 2012). This is achieved by including the road carrier as a strategic partner. When road carriers are treated and viewed as strategic partners for collaborative information sharing, they help to reduce the transit time for moving goods (e.g.,
between warehouses to the stores). They also contribute to reduce the total transport cost for all supply chain members, while increasing asset utilisation (i.e., reducing deadhead miles), thus reducing operating costs for themselves (Tyan et al., 2003).

![CTM partners to maximise transport benefits](image)

**Figure 30.** CTM partners to maximise transport benefits (e.g., empty miles reduction)

Source: Yuan and Shon (2008:2930)

Among all of these listed benefits of a successful implementation of a CTM programme, in fact, one of the most important, comes from deadhead miles reduction. Therefore, CTM is an effective collaboration technique (which has been mentioned earlier) to reduce the number of empty truck trips, and this has been explicitly advocated in many studies (for examples, see VICS, 2004, Wen, 2011, Wen, 2012). All of these studies have elaborated on the fact that higher asset utilisation can be achieved by accurate forecasting of shipments, which are the core of the CTM process. Load forecasting helps carriers to get an estimate of the upcoming flows of cargo volumes and the number of truck spaces required thereby; and hence carriers can plan their valuable resources and future capacity requirements (Wen, 2011). The same study further advised that forecasting also helps carriers in the formulation of routing, scheduling, and fleet management strategies, based on the expected shipments and their destinations.

The higher the accuracy of the shipment forecasting, the lower the likelihood of change in the carrier's plan to make adjustments for equipment deployment and utilisation scenarios. Shipment forecasting can also be shared with other members of the supply chain in order to keep them informed about the latest shipment updates. Following the same line of reasoning (e.g., Mason and Boughton, 2007), for the integration of transport decisions into collaboration plans, and hence to better use existing transport capacity, Yuan and Shon (2008:2929) have further suggested, “In order to avoid the inefficiency of transportation caused by insufficient interaction and collaboration, trading partners of the supply chain should consider transportation management as part of the collaboration, when dealing with an order, production, and shipment schedule.” If the situation is otherwise, the consequences are going to be catastrophic as warned by Rodrigues et al. (2008:401), “If demand for transport is not managed in a holistic and collaborative way, issues such as empty running, delivery delays, and low-transport capacity utilisation are likely to arise.” Similar ideas of avoiding empty running by efficient use of transport equipment have been supported by some other studies as well (for examples, see Esper and Williams, 2003, e.g., Naim et al., 2006, Rodrigues et al., 2008).
3.3.9 Code-sharing agreements

A code-sharing agreement is a frequent type of the strategic alliance found in the airline companies in the industry (Achim, 2009). The definition of a code-sharing agreement provided by the Federal Aviation Administration (1995:57) is, “…marketing arrangement that permits...a carrier to sell service under its name and airline designator code when the service is provided in whole or part by another air carrier.” Therefore, a code-sharing agreement can be described as an innovative seat-reservation system or a type of practice that is uniformly agreed between air carriers to sell seats on a given flight (under its own code), which is operated by another partner airline (Goetz and Shapiro, 2012). For a passenger, this means buying a ticket (itineraries and services) from one airline (i.e., marketing carrier), but attending a flight operated by another air carrier (i.e., operating carrier) (Hu et al., 2013). A fundamental graphical representation of a code-sharing agreement is given by the study of Gayle (2008). For example, Delta (DL), which is an operating carrier, flies between Atlanta and Minneapolis, as shown in Figure 31. Another marketing carrier, Northwest, can put its code (NW) on this same flight operated by Delta and sells tickets as though Northwest is the flight operator. Thus, the same flight will be shown on the computer reservation system using two different codes.

![Route network diagram for a code-sharing agreement](image)

**Figure 31.** Route network diagram for a code-sharing agreement
Source: Gayle (2008:5)

However, as explained by the study of Orit and Oz (2004), such a joint, but comprehensive agreement (a code-sharing agreement) can be of differing two types; a focus covering parallel operations or, an entirely different concentrate on handling complementary operations. According to the first category (a focus on parallel operations), both of the airlines are operating their flights on the same international route where parallel operations are concerned, and they sign a code-sharing agreement. On the other hand, the other category (a focus on complementary operations) highlights the fact that, both of them are not really competitors as they operate all the flights on different routes and sign a code-sharing agreement to complement the network of
routes. It has been argued in the literature (for examples, see Brueckner, 2001, Orit and Oz, 2004, Bilotkach, 2005) that a complementary network brings positive outcomes to the cooperating airlines, and a parallel network brings adverse welfare effects (for an example, see Park, 1997). The same study further highlights that every commercial flight has a code associated with it and that every code has two parts: an airline identifier and a flight identifier. The airline identifier: this part of the number is a unique code given by the International Civil Aviation Organisation (ICAO) to every air carrier. The flight identifier is a code provided by the airline to each of its flights uniquely to identify the elements (e.g., origins and destinations) of information regarding a specific flight.

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The signing of code-sharing agreements still continues to the present day, and this is evidenced by the establishment of many new agreements between international airlines. Therefore, the potential benefits of code-sharing agreements have been given increasing attention in the literature from the perspective of all involved parties (e.g., airlines, customers and airport authorities). The benefits for airlines are evident: expanding networks (or, increasing global access) without providing investment (e.g., aircraft) and other unprofitable services (Kraats, 2000, Bilotkach, 2007, Rajasekar and Fouts, 2009, LaRoche et al., 2012), avoidance of duplication of operations resulting in reduction of many types costs (e.g., ticket reservation systems, marketing programmes and sales offices), and enhancement of job security for employees (Kraats, 2000). All of these benefits may contribute to increased profitability and competitiveness for each of the participating airlines signed a code-sharing agreement. The advantage from the customer perspective is the minimisation of travelling cost (e.g., the advantage of the frequent flyer programme) (Rajasekar and Fouts, 2009), smooth transitions between connecting flights and more options to choose from the flights that are available (Kraats, 2000, LaRoche et al., 2012), and reduction of ticket prices (e.g., avoidance of double marginalization) (Brueckner, 2001, Brueckner, 2003). The benefits for airport authorities are the improved access to congested airports for airlines (Rajasekar and Fouts, 2009).

To further elaborate on the dynamics of the air transport industry, it is important to note the benefits discussed above, and from that it is evident that one of the most significant benefits is the traffic gain provided to the operating airline (operates the aircraft) because of a code-sharing agreement. This benefit is based on the principle (as mentioned previously) that each participating company has the right to sell seats for a specific flight on behalf of each other (Gayle, 2008). This innovative marketing effort enables the operating airline to make its sale portfolio more visible to customers, and accordingly, the numbers of anticipated customers will increase. These efficiency gains, which are frequently termed as “economies of traffic density” in studies (e.g., Brueckner and Spiller, 1991, Brueckner, 2001, Brueckner and Pels, 2004), through the use of airline resources (e.g., aircraft in particular), are important. This is important when the nature of the air transport industry is subject to change because of many intervening variables (e.g., increases in jet fuel prices and the advent of many budget airlines) (Low and Lee, 2014). To efficiently use its existing resources (e.g., all aircraft flights and their available seats), the study by Low and Lee (2014:23) further argues, “As resources are costly, the importance of efficiency in resource use cannot be understated. Efficiency specifies the ability of the airline to produce the maximum quantity of output (i.e., available passenger kilometres and tons-kilometres) from a specific input bundle.” In other words, efficient utilisation of resources is necessary in order to increase the competitive position of an airline. This goes back to the earlier discussions found in studies (e.g., Rubin, 1973) that are focused on a resource-based view of gaining competitive advantages.
### 3.4 Synthesis of concepts

Table I offers a synopsis of all of these concepts regarding empty vehicle trips, and a key assessment of the significance of each of the concepts contained within the theory.

<table>
<thead>
<tr>
<th>Conceptual perspective</th>
<th>Key concept</th>
<th>Basic insights for empty truck trips</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maritime transportation</strong></td>
<td>The backhaul problem</td>
<td>An optimisation problem to minimise the cost of deploying a set of vehicles while satisfying all constraints and serving the required demands for linehaul and backhaul customers.</td>
</tr>
<tr>
<td>Collaboration in hinterland transport chains</td>
<td>The quality of hinterland access largely depends on the responsible collective behaviour of the many interrelated and diverse actors in the container distribution chain.</td>
<td>The higher extent of collaboration among carriers (the carrier is one of the important actors of the container distribution chain) will result in maximum utilisation of its available resources (e.g., trucks and their spaces) and their related transport capacity.</td>
</tr>
<tr>
<td>Chassis Exchange Terminal (CET) concept</td>
<td>An external terminal connected with the main port to provide the facility of picking up and dropping off containers in the same trip, where each container is placed on a wheeled chassis.</td>
<td>Since every truck visiting the terminal needs to drop off an export container and pick up an import container, this will accordingly increase truck utilisation capacity in two-way moves.</td>
</tr>
<tr>
<td>The street-turn strategy</td>
<td>An empty import container can be used by an exporter without sending it back to an empty port depot.</td>
<td>The adoption of this strategy can reduce the total number of typical truck movements during an import or export process, and hence has the potential to reduce empty truck trips.</td>
</tr>
<tr>
<td>The dry port concept</td>
<td>This is also an external terminal connected with the main port by a high-speed rail connection, where customers can pick up and drop off their import and export containers.</td>
<td>In order to achieve higher truck utilisation rate, if a dry port is used as a consolidation centre, this allows the benefit of a truck picking up an import container every time it drops off an export container.</td>
</tr>
<tr>
<td><strong>Non-maritime transportation</strong></td>
<td>Collaborative Logistics Network (CLN)</td>
<td>Shippers and carriers can reduce their system-wide transport cost by working together in a collaborative manner to make decisions relating to transportation</td>
</tr>
<tr>
<td>The shared-transportation concept</td>
<td>Allows a group of travellers to enjoy a car, or van trip with the intention of full utilisation of the seats that are available.</td>
<td>Shippers can be grouped into common trips. Therefore, shipping using a shared container truck can be beneficial; for example, exporters are able to save money (i.e., transport cost) by sharing shipment spaces between exporters.</td>
</tr>
</tbody>
</table>
Collaborative Transportation Management (CTM) The CTM concept brings together supply chain partners in such a way as to remove the cost burden of freight transport inefficiency from the supply chain by including carriers as a strategic partner.

When carriers are treated as strategic partners for collaborative information sharing (i.e., shipment forecasting), they help to reduce the total transport cost for all supply chain members, while increasing asset utilisation (i.e., reducing deadhead miles).

Code-sharing agreements A code-sharing agreement is based on the concept that each participating airline (including the marketing carrier and an operating carrier) has the right to sell seats for a specific flight on behalf of the other in order to increase traffic density.

This method can work as a marketing tool in an attempt to reduce ‘empty slot’ journeys and to enable the operating road carrier to make its sale portfolio more visible to the customers, and hence customer numbers may increase. The increased numbers of customers are then able to utilise the carrier’s transport services more frequently and efficiently with the help of the marketing partner.

**Table I. Interdisciplinary concepts and their implications for empty trips issue at ports**

### 3.5 Conceptual implications

Logistics and supply chain management is a comparatively new field of study (Maloni et al., 2009, Golicic and Davis, 2012). This field of research is still growing and, in the years ahead, is likely to keep logistics researchers engaged in their many research projects. Such a rising field often sparks further investigations from new perspectives, and hence brings together researchers from different disciplines (e.g., marketing and operations management) to address important issues and research frontiers (Mentzer et al., 2008). Suggesting a similar concern as a requirement for this developing logistics field, many years ago Stock (1990:5) stated, “…many of the business and non-business disciplines have much to offer logistics in terms of concepts, principles, methodologies, and approaches that could be applied to various logistics issues, problems and opportunities.” The same concern is still appropriate in today's environment (Arlbjørn and Halldorsson, 2002, Woo et al., 2013, Karatas-cetin and Denktas-sakar, 2013).

In the spirit of seeking to highlight the conceptual contribution made by this chapter, it has been noted that the issues arising from empty vehicle trips are relevant in many research fields including aviation and airports, and passenger and freight transportation. There is an identical challenge and urgency for all of these research fields, including maritime logistics research (e.g., container transportation); the challenge is to find ways of minimising the negative externalities of empty vehicle trips and hence, to ensure efficiency and effectiveness in overall transport operations. However, all of the research fields outlined suggest slightly, or even completely, different types of existing solutions, or mechanisms, by which the problem can be explored, tested and solved, or at least, so that the driving causes for this empty vehicle performance may be reduced. Taking all these interdisciplinary perspectives into account, and noting the differences among them in the specific policies designed to achieve the desired goal, or in the way the empty vehicle operations are synchronised in each discipline, this chapter provides a review of all the relevant literature that explores aspects of underutilised vehicle capacity and the potential impact the published literature on achieving transport efficiency.
3.6 Managerial implications

System-wide capacity shortages are an issue for many leading port companies in the developed and developing economy today, and can truncate the existence or growth of many, otherwise thriving, container terminals and their critically dependent supply chains (Wan et al., 2013, Türkoğulları et al., 2014, Zhen, 2013). Moreover, this issue presents a threat to truck-based transportation as a part of the container distribution chain, since all port components are connected to each other by means of functional dependency (Cetin and Cerit, 2010). With the use of an effective concept, the improved utilisation of available transport capacity of trucks, could be an alternative solution in order to increase container transport capacity around the port.

The potential concepts highlighted in this chapter are from many interdisciplinary fields, including, but not restricted to, passenger and freight transportation; these can be considered as alternative freight transportation options for container road carriers in order to meet the increasing demands of future transport capacity. Therefore, this chapter provides the conceptual ground for practical ways of understanding and reforming the containerised cargo transportation process for road carriers. In other words, the findings of this chapter have implications for port authorities and transport managers for the reduction in the number of empty trips made by container trucks at times of high pressure, when alternative solutions may be sought that can be explored, tested, evaluated and finally, adopted. Accordingly, this is expected for transport and logistics practitioners at this point to borrow ideas (i.e., the findings of this chapter) from other disciplines, because already logistics has borrowed many theories from other disciplines, including, but not limited to, accounting, management, computing, economics, marketing, mathematics, philosophy, political science, psychology and social science (Stock, 1997); and shaped the important decisions of business managers, who need innovative theoretical support for more potential practical applications.

3.7 Conclusion

The first chapter explores the relationship between empty trips reduction and transport capacity improvement potential and the second chapter looks at capacity improvement broadly. Although there is pressure on port authorities to find efficient ways of expanding container transport capacity by minimising the number of empty truck trips, the underlying problem continues to persist at container terminals. Therefore, this third chapter focuses on the possible solutions proposed in the literature to enable the cost-effective and reliable deployment of empty truck trips. Many other research disciplines are now facing the same challenges concerning the empty trips issue, and some of their concepts may prove to be useful in minimising the number of empty trips for trucks at port terminals.

Despite becoming widely acknowledged, to date, no major literature review, from an integrated perspective, has been published on the subject of the empty trucks problem, a view that unifies the distinctive aspects of many research fields, spanning a range of areas from maritime logistics to supply chain collaboration. Therefore, individual studies carried out so far on the empty trips issue have been mainly constrained by the lack of an integrated point of view, due to the subject having been dealt with it from single, isolated perspectives (non-collaborative mechanisms). In order to make further contributions to this maritime logistics domain, this chapter has been able to cover the research gap by presenting an extensive review of the academic and industry-related papers concerned with the empty trucks problem from a holistic point of view. This chapter is significant, especially for times of economic recession, such as have occurred in the recent past, when practitioners and academics, have become interested in exploring innovative ideas for the capacity management of container distribution process.
Chapter 4: Developing a truck-sharing mechanism to reduce empty trips

4.1 Introduction

The first chapter highlights the importance of developing a deeper understanding of the interaction between the reduction of empty truck trips and transport capacity expansion at ports. However, the chapter does not provide any solutions for empty trips reduction. The second chapter examines capacity expansion at ports but also does not provide solutions for empty truck trips. Following on from these two chapters, the third chapter provides potential solutions (e.g., the street-turn strategy, the dry port concept, and the shared-transportation concept) for empty trips reduction. In other words, the suggested solutions provided in the third chapter have implications for the reduction in the number of empty trips; such solutions may be sought, evaluated, and finally adopted by the maritime transport chain.

One of the empty-truck trip solutions presented in Chapter 3 is the application of the shared-transportation concept (the truck-sharing concept) to maritime logistics. The concept has evolved in more recent times in many research domains. Therefore, for example, the concept is becoming popular in other research areas as car sharing, taxi sharing, and bike sharing. The shared-transportation concept is mostly a collaboration problem as the idea is based on the sharing of a critical resource (e.g., a container truck). However, the third chapter does not suggest any potential collaboration mechanism for sharing a container truck between parties (shippers and road carriers) to increase container transport capacity. This fourth chapter addresses that gap. For that reason, the chapter further extends the application of the shared-transportation concept in addressing the empty trips problem, and hence, develops a truck-sharing mechanism. Therefore, the key research question addressed by this chapter is: Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips?

In this regard, it can be noted that the empty truck hauling problem may occur in ports because of lack of information exchange opportunities between exporters and haulers on possibly matched trips. Their trips information can be shared and trips can be matched from and to warehouses, ports, and truck companies. Therefore, the problem addressed in this chapter is to design an information exchange platform to facilitate collaboration using a truck appointment system of a case study port. Many ports around the world have implemented truck appointment systems, such as Vehicle Booking System (Port of Felixstowe) and Truck Licensing System (Port Metro Vancouver). The objective of the implementation is to handle huge growth efficiently in container truck volumes. However, literature on truck appointment systems is limited (Huynh and Zumerchik, 2010). Therefore, the implemented truck appointment systems may stimulate many interesting questions for the port communities, for example whether or not the implemented systems provide a solution for addressing transport capacity issues. Accordingly, a concern for practitioners is how the functions of the truck appointment systems can be improved to provide a better service for transport capacity enhancement. Hence, this chapter summarises the results of the investigation and evaluation of a newly implemented truck appointment system using a case study approach. It focuses on its implementation, and future improvement potential to address the research question.

This research question aims to introduce a truck-sharing process to improve transport capacity and to reduce truck traffic-related congestion around the case study port and its region. This is important since Davenport (1993) claims that all types of business processes must be evaluated in terms of key processes, and one of the key processes of a container terminal is its external truck operations. This external truck operation is frequently viewed as a major source of emissions, traffic congestion and capacity problems for many container terminals (Huynh and
Zumerchik, 2010). Therefore, a process reengineering approach is adopted in this chapter. While process reengineering (Hammer and Champy, 1993, Hammer, 2010) is a radical approach, business process management adopts a continuous improvement perspective (Davenport, 1993).

4.1.1 Organisation of the chapter
The next two sections provide the literature review and research methodology. The next section then addresses the reengineering and small-scale improvements of truck transport processes at the port gate. The following section proposes a to-be model to increase truck capacity utilisation using the truck-sharing concept, and the last section summarises the main aspects of this chapter.

4.2 Literature review
As far as the researcher is concerned earlier research covering the empty truck problem in the maritime logistics domain is scarce from a perspective, which takes all truck companies into consideration to suggest a promising solution. However, the study of Heide (2010) comes closest to what is attempted in this chapter. The study of Heide (2010) suggested the Chassis Exchange Terminal (CET) concept to increase the utilisation of truck capacity and to minimise the number of empty truck trips. For more information on the CET concept, see Chapter 3, “The Chassis Exchange Terminal (CET) concept”. In contrast, this chapter introduces the application of the transport-sharing concept (the shared-transportation concept) to fill the gap in addressing the empty trips problem. The concept is becoming popular in other research domains like car sharing (Helmeth, 2012), and bike sharing (Lin and Yang Ta-Hui, 2011). For more information on the shared-transportation concept, see Chapter 3, “The shared-transportation concept”.

The empty trips problem is not only limited to container transportation and goes back to the discussions of Pigou and Taussig (1913). The core of the problem is rooted in the imbalance of trade flows. This is widely prominent in freight transport flows (Wilson, 1987). As stated previously in Chapter 1, the problem has been approached in many disciplines, usually based on deciding efficient routes for individual vehicles, such as forest transportation (Carlsson and Rönnqvist, 2007), container ships (Santhanakrishnan et al., 2012) and retail chains (Yano et al., 1987). Typically, analysts take a centralised decision-making perspective to formulate the problem based on available information and makes a decision (Brewer and Plott, 2002) to solve such problems, which are known as backhaul problems. For more information on the backhaul problem, see Chapter 3, “The backhaul problem”. A brief but comprehensive discussion on the subject can also be found in Chapter 1, “Backhauling problem”. However, this may lead to local optimisation (e.g., minimising the total cost of servicing all customers) and benefits one single company. Such local optimisation might be achieved at the expense of other partners in the supply chain because the hundreds of companies operate their trucks in a typical port. On the other hand, this chapter proposes a to-be model to achieve a system-wide optimisation to benefit all involved parties (e.g., especially road carriers and exporters) in the supply chain as a whole. Therefore, most previous studies (including container transportation and other domains) solve the problem by selecting efficient routes for a truck. Conversely, this chapter plans to optimise the benefits of all road carriers to increase container transport capacity.

None of the truck appointment system studies the researcher is aware of, for examples, see Ioannou et al. (2006), Giuliano and O’Brien (2007), Namboothiri and Erera (2008), Huynh (2009), and Van Asperen et al. (2011), have attempted to deal with the empty trips problem. By contrast, this chapter proposes a truck-sharing process integrated with the appointment system.
Therefore, the foremost contributions of this chapter are shown in brief in Figure 32. To sum up, the major contributions are: (1) the suggested to-be process to reduce the number of empty-truck trips, is integrated with the truck appointment system concept; (2) the to-be process is approached from a perspective where all truck operators have an equal chance to get benefits to optimise the whole supply chain in contrast with the typical one company-based optimisation; and finally (3) the working procedure of the to-be process uses the shared-transportation concept.

![Figure 32. Major contributions of this chapter to the literature](image)

### 4.3 Research methodology

As stated previously, the research question for this chapter is: Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips? In order to answer this research question, a qualitative case study approach has been adopted, because a case study approach focuses on understanding the operations of an organisation’s internal situation (Eisenhardt, 1989). Therefore, it enables the in-depth investigation that is required to understand the underlying issue better (Feagin et al., 1991). For example, this particular research question seeks to understand transport processes of a local port in order to develop a truck-sharing mechanism, and the case study approach enables the researchers to understand the processes through using 'how' and 'why' questions (Yin, 1994, Eisenhardt, 1989). As a result, a case study approach is suitable to investigate a complex phenomenon (Yin, 2009). Moreover, a case study has the advantage of using multiple data sources (Feagin et al., 1991). In contrast, experimental or quasi-experimental research methodology is often criticised for decisions concerning data collection and analysis, particularly because they do not reveal details (Stake, 1995). A case study approach is also suitable where little research has been done (Stake, 1994, Ratnasingam, 2003, Hakim, 1994). This also applies to the current chapter's study, where little research has been conducted, particularly from the point of view of supply chain collaboration (for more information on supply chain collaboration issues, see Chapter 5) in order to solve the empty trips problem.
In order to explore a potential collaboration tool (a truck-sharing mechanism) between shippers and carriers, a single case study approach has been adopted. From the literature, it is found that the same phenomena (non-collaborative behaviour in the supply chain, and the occurrence of empty truck trips) occurs in other seaports (for a few examples of similar types of ports, where the empty trips problem occur, see Chapter 1) of the world. Therefore, the adoption of multiple case studies could help in the generalizability of the research results (Patton, 1990, Miles and Huberman, 1994). Nonetheless, this chapter can be regarded as an initial study only and may point the way to further studies in this emerging field of maritime logistics relating to the empty truck trips problem and its potential solution. Thus, a case study approach can help to determine future research needs (Halinen and Törnroos, 2005, Siggelkow, 2007, Simon et al., 1996). The suggested truck-sharing model can be further tested for other ports around the world, and all components of the model can be adjusted for port-specific requirements. Furthermore, the case study approach also came under criticism for lack of rigour. Yin (1984:21) explained, “…too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions.” It also has been criticised for its nature of being difficult to conduct and for producing a large amount data (Yin, 1984). The data collected is expected to be arranged and maintained systematically.

![Process Re-engineering Framework for Maritime Terminals](image)

**Figure 33.** The suggested BPR methodology for maritime terminals

Studies reflect different methodologies for process improvement projects as each methodology is customised to the needs of the project (Klein, 1994). Illustrative examples are available as follows. Adesola and Baines (2005) suggest a methodology termed Model-based and Integrated Process Improvement (MIPI) to support business process implementation. Kettinger et al. (1997) describe the major stages, which are usually performed during process reengineering initiatives and shows the relationships among the stages. Klein (1994) suggests a set of guidelines to direct the choice of selecting the appropriate research methodology. Vakola and Rezgui (2000) develop, implement and evaluate a methodology that incorporates human and organisational issues, and also emphasise the need for continuous improvement, for successful project implementation. Valiris and Glykas (1999) present a holistic and systematic methodology called ARMA by incorporating principles of the management accounting, IS development and organisational theoretic, to cross the limitations of the existing BPR methodologies. For an
example of comparisons and contrasts among suggested methodologies, see Adesola and Baines (2005). The research framework presented in Figure 33 is the outcome of these reviewed studies. This chapter also follows Harbour’s (see Harbour, 1994) suggested method for the BPR model.

4.3.1 Business needs analysis

The case study port is facing many different challenges today such as issues with labour unions, challenges with maritime and hinterland cargo security, congestion problems at connected facilities in the hinterland. The reason is to avoid urgent transport capacity shortage and concerns of increasing the handling productivity at the port. The problem of improving hinterland transport capacity is particularly relevant and important to policy makers in charge of alleviating such problems. Accordingly, the empty-truck trips problem (it can contribute to improving transport capacity) was one of the most important issues on the agenda. Therefore, the researcher attempted to identify the major problems of the port. As stated previously in the methodology section, a case study approach was adopted on the premise that the researcher was interested in analysing a process in depth (Creswell, 2003). A case study is one of the used methodologies in realising the facts in a complex situation (Alavi and Carlson, 1992). This intrinsic case study is exploratory as well as inductive as the researcher wanted to explore the problem (Yin, 2009).

4.3.2 As-is process analysis

The researcher wanted to model and examine several aspects of the current appointment system (as-is) under study. After analysis, the researcher described the as-is process using a flowchart technique to make it as simple as possible. Evans (1993) shows the importance of analysing existing business processes to identify weaknesses in the system. This chapter has analysed a number of truck hauling processes to discover the flaws and suggested a reengineering approach.

4.3.3 Data collection

The data collection phase concentrates on the particulars of truck hauling and arrival processes, using a combination of in-depth interviews, observations, documentation, and site visits to the port. The primary data were collected to bring a complete picture to events such as the truck appointment system and dispatching operation. This helped to triangulate the data by providing a higher level of confidence in the data collected and analysed (Cohen et al., 2007). In total, three one-hour interviews were conducted for each of the respondents. Initially, interview questions were developed. Port staff involved with ATAS development and BTAS implementation phases were then selected in an organised manner. Staff knowledgeable about the operational procedure of the developed system and its limitations were given priority during the selection.

The interviewer’s perceptions were unbiased because interview questions were redesigned many times and cross-checked by other researchers in the same research domain. Unstructured questions were occasionally asked if an interviewee’s response and explanation encouraged raising more questions. Such questions were not previously considered important regarding the truck process under consideration. Illustrations and clarifications of specific scenarios of the truck dispatching processes were required to be provided by the participant. These illustrations helped to gain an understanding of issues of the appointment system that had not crossed the researchers’ minds. Detailed information was collected and recorded to facilitate cross-checking of the facts with the written notes. Written notes were taken during each session. Once cross-checking was completed, each session was verified and later analysed. In addition, the observational method was used to gather complementary information about different types of truck capacities around gates. The researchers’ interaction with the appointment system was thus
improved as suggested by Stake (2000). The data collection phase also involved secondary sources, which consisted of publicly available data on port operations, and newsletters. Secondary sources also involved an examination of company documents and research reports.

4.3.4 Assess to-be options
A literature review supplemented the data collection phase. The purpose of the review was to explore ways to resolve the empty trucks problem. Few options are available to address the problem from a decentralised perspective to optimise the entire supply chain operations in contrast with the single-company based solution, such as backhaul problem. One of the options is to establish a dry port connecting the port with its hinterland through a high-speed rail network (Cullinane et al., 2012). Carriers can drop off their containers in the dry port as if those were left in the main port to avoid congestion at the port gates. Another option, is the choice to implement a street-turn strategy (Deidda et al., 2008), which allocates empty containers to export customers and loaded containers to import customers. For an example, according to this strategy, a full container will be emptied at the importer’s warehouse and then it will be given to the exporter instead of going back to the usual empty depot. Chassis Exchange Terminal (CET) entitles collecting containers using trailers during nights and exchanging these containers with export containers during days (Dekker et al., 2012). The shared-transportation option uses the concept of sharing a vehicle with multiple customers. All these concepts are discussed in the first chapter.

4.3.5 Select the optimal
The researcher explored the advantages and disadvantages of each alternative before making a final decision. For example, the port has already established a dry port, which is not popular among importers and exporters because of the slow rail transportation. Freight transportation using rail is slow because of the geographical characteristics of the country. Similarly, the street-turn strategy may not be proved effective to reduce the number of empty-truck trips. The reason is an empty trip happens when there is no container at all on the empty slot of the truck regardless whether the container is empty or full. Further, the development of the CET requires a substantial piece of land. Land is a scarce resource in many container terminals (Liu et al., 2001, Cheng-Ji et al., 2011) including the terminals of the case study port. The more a port authority effectively utilises its resources, the more capacity it can get out of its facilities and operations. Many studies also support the idea of having more port capacity with higher utilisation of its resources (see Van Hee et al., 1988, van Hee and Wijbrands, 1988, Legato and Mazza, 2001). By taking all these constraints and prospects into account, the researcher selected the shared-transportation concept to achieve a system-wide optimisation. This maximises the total number of containers that can operate on the transport network by using all available trucks.

4.3.6 Review/redesign
The review phase is out of the scope of this chapter. Sometimes the final stage of the framework may involve the communication of the solution to the port executives for mutual agreement. This also involves the reformulation of the problem. For an example, setting the strategy might be easier than the implementation. Putting the solution in place to achieve the desired objectives can be the challenge since the policy makers can start to see the problems. Reviewing may provide a chance to consider that there may be another feasible solution. Under such circumstances, the researcher may suggest other better alternatives.
4.4 Study of a port
The port under study is the country’s leading port company, and it is the most significant because of the value of trade handled each year. The value of handled trade is more than 10% of the GDP of the economy. Most importantly, this is the largest container port by volume and occupies a very significant portion of the total containerised trade market. For example, annually it handles approximately 890,000 TEU (Twenty-foot Equivalent Unit). The port, like other ports around the globe, is surrounded by the environment of high complexity and affected by the immediate supply chain networks (Cetin and Cerit, 2010). Activities are often carried out in a disorganised way, with high costs, poor customer services, and sub-optimisation of resources (Paixão and Marlow, 2003). These conditions force the ports to adopt strategies such as ‘Business Process Reengineering (BPR)’ to maintain competitive advantage (Paik and Bagchi, 2000).

Therefore, this chapter clarifies the major evolution and development of truck transport processes (i.e., from a conventional truck transport process to BTAS-Basic Truck Appointment System, and then to ATAS-Advanced Truck Appointment System) at the port gates. The selected port reengineered its truck hauling process several times, from the conventional to BTAS and at later stages to advance ATAS. These improvements help overcome the limitations of the old processes and increase the overall gate- or transport-capacity. The outcome of the initial process reengineering was to reduce truck turnaround times from almost 4 hours to approximately 25 minutes. Process reengineering practices can be used in ports to increase the quality of service (Hu et al., 2011) and to deal with a variety of problems in terminal management and the container transportation system. For example, Choi et al. (2006a) develop an automated gate system based on RFID technology to make port gate operations more efficient. Zhong and Yin (2010) show that the application of Computing, Communication and Controlling (CCCT) in a port can increase the throughput of containers by 4% and lower operating costs by 14.78%. Major Indian ports have reengineered transportation processes to incorporate best practices to optimise the process flows (Government of India, 2007). Therefore, the case study port is continually searching for improvements in transport processes that may lead to leaps in performance improvement. Such reengineered and improved processes are described here.

The conventional truck hauling process is one of the oldest processes that has survived in the port system over times. The system was operational up to 2008. The process flow is referred to in the “previous truck hauling process” subsection. It is common to do a flow analysis of processes before BPR (Earl and Khan, 1994). Process flow helps to identify the problem areas before redesigning the existing ones (Kim and Kim, 1998). Process flow analysis shows that the problem of a conventional system depends on the way it is operated. Since the truck arrival rates are not pre-advised, there is a mismatch between demand (i.e., number of truck arrivals per hour) and supply of capacity (i.e., gate capacity per hour). This resulted in long queues of trucks waiting to be served and delayed turnaround times. Truck turnaround time is one of the most important performance measures of port efficiency (Lubulwa et al., 2011). It measures the amount of time taken by a container truck from the time it arrives at the port terminal until it exits. In some cases, the standard turnaround time is 25 to 30 minutes.

In 2007, the port experienced container trucks waiting an average of four-and-a-half hours during peak hours. There are many reasons behind this. The long queues of trucks get more critical during the early hours of the day since truck operators are motivated to exchange containers in the early morning. The objective is to allow the trucks to be used in some other activities during the rest of the day. Huynh (2009) also expresses a similar concern. Moreover, the compensation received (cartage cost is adjusted to cover this) from the exporters discourages the truck companies from finding a solution. Most importantly there is no common interest
among stakeholders, such as truckers, exporters, and freight forwarders, for a probable solution. The reason is the absence of a contract. To bring consistency in turnaround times to achieve world-standards, the port authority planned to reengineer the conventional truck hauling process. The objective was to reduce truck turnaround time and to improve customer service. Mohanty and Deshmukh (2001) suggested that BPR could be considered as a problem-solving approach to bring significant improvement in the service level. Therefore, the port authority introduced a truck appointment system around 2008. It is termed the ‘Basic Truck Appointment System (BTAS)’ in this chapter. The system is still operational at the port. The description of the BTAS process flow is given in the ‘as-is truck hauling process’ subsection.

The final output of the BTAS is reengineering the truck hauling process using technology. The significance of technology in process reengineering is suggested by O'Neill and Sohal (1999). The internet-based appointment system reduces the possibility of reservation of the same timeslot for an excessive number of trucks. The reservation is important to discourage exceeding the available capacity of the port assets (e.g., gate system and straddle carriers), and to maintain a minimum service level (Guan and Liu, 2009a). The main idea behind BTAS application is capacity management (i.e., matching demand and service). Capacity is managed through matching loading equipment capacity (i.e., the limited number of straddle carriers and operators) with the stochastic nature of truck arrivals (Huynh, 2009).

Since the introduction of the system, the average truck turnaround time became 25 minutes, as shown in Figure 34. Along with reducing the truck turnaround time (Huynh and Walton, 2008), the BTAS helps importers and exporters with inventory planning, labour utilisation, and space management. The system provides a specific arrival or delivery timetable for containers at the port. It also helps trucking companies to increase truck utilisation (Giuliano and O’Brien, 2007), and assists the port to position containers optimally in the yard to minimise reshuffling (van Asperen et al., 2011). BTAS benefits all parties in the supply chain including freight forwarders.

Although BPR encourages dramatic changes (Champy, 1995), TQM (Total Quality Management) inspires incremental changes based on existing processes (Love and Gunasekaran, 1997). This is clearly evident in the context of this case study. Here the port reengineered its entire truck hauling process with radical effects on truck turnaround time (i.e., from almost 4 hours to 25 minutes). To achieve such remarkable results, incremental and small improvements would not have been sufficient. Conversely, after such significant changes, TQM can play a role in continuous improvement (Zairi, 1997). BTAS needs further small-scale improvements. According to the port authority, BTAS still has limitations.
One of BTAS’s limitations arises from the misuse of the system by road carriers. For example, the present appointment system (i.e., BTAS) allows truck operators to book an appointment without cross-checking the container information in the database. However, ATAS only allows reserving a timeslot if all container information is matched with the container announcement message (COPARN). COPARN is an EDIFACT (Electronic Data Interchange for Administration, Commerce, and Transport) standard EDI (Electronic Data Interchange) message. The message includes export booking information, such as vessel and voyage information, cargo type, number of containers and type of containers. The message is sent from the shipping line to the container terminal operator and depot operator. Therefore, in ATAS, prior to booking an appointment for cargo delivery for export, some basic information about the cargo needs to be provided in order to be matched. Once the provided information is validated against the container, the carrier can make an appointment. This prevents misuse of the system by road carriers. Another limitation of the BTAS is the manual gate process. In ATAS, a truck company has the ability to obtain a gate-card (i.e., a Personal Identification Number-PIN) online. The facility allows the truck driver to go directly to the gate and enter the designated area of the container terminal. The driver just needs to scan the driving licence and to enter the PIN at the gate kiosk to facilitate a paperless entry without any manual interference.

BTAS also has the limitation of failing to cross-check booked timeslots by other stakeholders, such as exporters and importers. This has been overcome with the new ATAS. Lastly, the new appointment system was developed to ease the process of adding more functions in the future such as OCR/RFID (Optical Character Recognition/Radio-frequency Identification) to make gate entry faster. These functions will assist by continuously increasing growth in container volumes and truck arrivals. For applications of RFID technology at the entrance gate of container terminals, see Hu et al. (2011) and Shi et al. (2011). The study of Choi et al. (2006b) explores different technologies applicable to automated gate system. For these reasons, the port completed planning the introduction of ATAS. It is termed the ‘Advanced Truck Appointment System (ATAS)’ in this chapter. The system is not yet operational at the port. The description of the ATAS process flow is referred to in the ‘upcoming truck hauling process’ subsection.

The primary incentives for developing a new ATAS are to provide fairer access to appointment slots and to automate gate entrance compared to the BTAS. However, there is no feature incorporated in the newly developed system (compared in Table II) to solve the empty-truck hauling problem. According to the January 2011 statistics, more than 7,000 trucks received only one empty container (irrespective of the size) from one of the two terminals. These trucks did not bring any empty or laden containers to the port. In another example, for the same period and terminals, the number was 2,459 trucks. These trucks delivered only one laden container to the port without transporting back any empty or laden containers with them. Similar inefficiency is also observed in arriving, or departing trucks having only one TEU although they have two TEUs capacity. Table III shows the empty trips problem at the port. The huge numbers of empty trips show scope to improve the transport capacity for the port.

<table>
<thead>
<tr>
<th>Truck process</th>
<th>Appointment system</th>
<th>Container info cross-checking</th>
<th>Automatic gate entry</th>
<th>RFID functionality</th>
<th>Truck-sharing service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional process</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>BTAS</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>ATAS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>ATAS-based TSS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table II. Feature comparison of truck hauling processes
The transport capacity improvement decisions within the port are important because road traffic congestion is developing as a serious problem for the port and a national problem for the port region. The port is located in the central business district and roads surrounding it have to be capable of carrying the huge volume of freight that passes to or from the port each year. Here 87% of the landside containerised movements are carried by road and generate approximately 3000 truck movements per day. Furthermore, the long-term forecasts of TEU growth rate over the years, 6% p.a. in particular, look alarming. The huge growth rate will require a huge investment in port and transport infrastructure to avoid bottlenecks. Finally, the airport, the country’s second-largest cargo port by value, is located within the same region. The airport depends on the same regional land infrastructure to provide transport solutions. These combined pressures may burden the local transport system around the port. Here the port-related data sources are omitted because of the confidential nature.

Many other important variables also demand additional transport capacity from the port leading to congestion that may cause deterioration of travel conditions for passengers in the port region. Capacity issues are also contributing towards increasing traffic delays for cargoes at some of the port’s transport routes. Huge growth in the container freight transportation system resulted in environmental problems as well (Giuliano and O’Brien, 2007). Traffic congestion is thus considered a problem because of lost income, time and pollution.

<table>
<thead>
<tr>
<th>Container number (Empty container)</th>
<th>Truck trips</th>
<th>Container number (Laden container)</th>
<th>Truck trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Delivery (without any receive)</td>
<td>7063</td>
<td>1 Delivery (without any receive)</td>
<td>6849</td>
</tr>
<tr>
<td>1 Received (without any delivery)</td>
<td>3707</td>
<td>1 Received (without any delivery)</td>
<td>2459</td>
</tr>
<tr>
<td>2 Delivery (without any receive)</td>
<td>796</td>
<td>2 Delivery (without any receive)</td>
<td>651</td>
</tr>
<tr>
<td>2 Received (without any delivery)</td>
<td>759</td>
<td>2 Received (without any delivery)</td>
<td>490</td>
</tr>
</tbody>
</table>

**Table III.** The Port’s empty-truck trips in January, 2011
Source: The Port

Due to the evolving shortage of transport capacity and the further deterioration of the situation, the port authority is looking for opportunities that might resolve the problem. There is pressure to find efficient ways of expanding transport capacity. Within this changing maritime domain, a reengineering approach is suggested in this chapter to redesign the empty-truck hauling process to extract more capacity from the transport system. The purpose of the suggested to-be process is to reduce the number of empty-truck trips compared to the as-is process. Improving efficiency in resource allocation (see Guan and Liu, 2009b) and increasing the utilisation of truck capacity (see Heide, 2010) are deemed important to achieve that objective.
Figure 35. Conventional truck dispatch process
4.4.1 Previous truck hauling process

The process (Figure 35) involves the communication of a freight forwarder request for transport service to a truck company. The request is to provide both empty container pickup to delivery to the warehouse and laden container delivery to transfer goods from the warehouse to the port. The road carrier initially receives an assignment in the form of a letter of instruction or a fax. The letter includes information regarding exporter identification (e.g., name, address and contact info), vessel details (e.g., vessel name, voyage number, estimated time of arrival and departure), container size and type, number of containers, and the pickup and delivery address of the empty container. After approving the request, a profile is created, and appropriate data are keyed-in. The truck operator asks for an empty container from the ocean carrier.

Once the assignment details are in a mode to employ routing and scheduling operations by allocating resources, the dispatcher informs the driver. The driver is informed of container collection and delivery locations along with specific time limitations, container pick up details (e.g., identification of depot operator, yard location, container type, size, and number) and empty container release order. Arriving at the port gate, the trucker submits the release order form to the gate clerk to facilitate the creation of the pickup ticket. The driver drives to the empty stack and submits the pickup ticket to the yard clerk. The yard clerk instructs the equipment operator to load the empty container onto the truck.

The truck driver arrives at the out-gate and submits the pickup ticket and the tally sheet (i.e., any damage to the container) to the gate clerk. The gate clerk processes the EIR and allows the trucker to leave the facility after signing the report. The trucker takes the empty container to the warehouse in which loading of the cargo is carried out sequentially. Once loading is completed, the truck with the packed containers now moves to the port gate with an entry permit. The gate clerk checks container details for damage and seal number, and issues a drop-off ticket. This ticket is important in directing the truck to the export container-stacking area. The trucker discharges the container, confirms all details at the exit gate, issues the EIR and leaves the port.

4.4.2 As-is truck hauling process

The new process is typically triggered by the importers and exporters. The role is transferred to port-recognised truck companies to participate in the same process of exportation for empty container pickup and laden container delivery. Truck companies need a user name and password to enable access to BTAS and to facilitate the collection of any charges for the port. After logging in, the truck driver continues with a slot booking. The slot booking must be created at least fifteen hours before arrival and also requires details of the container that the driver is exchanging. Only one selected user of any truck carrier is allowed to make appointments within three minutes. This is important, to ensure impartiality of access for all truck carriers. The user first selects the type of booking (import, export or both) to enable it to specify the date and to select the zone for which to make the booking. A terminal operator can determine the slot limits per zone to match the capacity of the terminal to maintain an adequate service level as shown in the ‘available column’ of Table IV. The truck driver arrives within the booked appointment time and proceeds directly to the terminal, either via the express kiosk or with a card number. That is given at the road office. There is a penalty for non-arrival at a booked slot. Since both BTAS and ATAS are appointment-oriented processes and thus a bit similar, the procedure is explained in detail in the ATAS description.
To export a cargo, according to the ATAS process, there are five steps that need to be completed sequentially for an empty-container pickup and a laden container delivery. The process is depicted in Figure 36. Initially, the exporter, the freight forwarder, or the trucker requires an ‘empty release pre-advice’. This helps to acquire a PIN for paperless processing at the terminal gate. The exporter needs to enter the ‘empty release number’ and ‘empty depot name’ in ATAS ‘empty release pre-advice’. T

table IV. 24 hours BTAS export appointment slots
Source: BTAS manual

4.4.3 Upcoming truck hauling process
To export a cargo, according to the ATAS process, there are five steps that need to be completed sequentially for an empty-container pickup and a laden container delivery. The process is depicted in Figure 36. Initially, the exporter, the freight forwarder, or the trucker requires an ‘empty release pre-advice’. This helps to acquire a PIN for paperless processing at the terminal gate. The exporter needs to enter the ‘empty release number’ and ‘empty depot name’ in ATAS to automatically populate container details. Container details are ‘line operator’, ‘container length’, ‘available quantity of empty containers’, ‘remaining quantity of empty containers’. The pre-advising procedure is thus completed. The objective of pre-advising is to ensure that a valid reason exists for arriving at the terminal; once this is completed, appointments can be made. To simplify describing the export process using the ATAS platform, the focus is on ‘export’ (e.g., to deliver a full container to the terminal against an export booking) and ‘empty release’ (e.g., to collect an empty container from the terminal against an empty release order) quota type.

Figure 36. ATAS laden container delivery process
An ‘empty-release slot appointment’ can be created by the nominated truck carrier only. Once an appointment is created, a PIN is generated. Upon receiving a valid card number, the trucker proceeds straight to the terminal gate, scans the driving licence at the gate kiosk and enters the terminal yard. Without having a gate card, a ‘self-service kiosk’ is also available for a driver to manifest a truck to receive a gate card number. After entering the terminal, the driver scans the driving licence at the exchange grid kiosk. Then the driver enters the lane designated to be occupied by the designated truck. The action sends a signal to the yard equipment to carry an empty container for the truck to upload and to leave the port.

Soon after completing the first phase of the ATAS process, the exporter or freight forwarder creates an ‘export pre-advice’, a necessary condition to nominate a truck carrier and to deliver a laden container to the port. To initiate the pre-advice procedure, the exporter is asked to provide information on ‘vessel visit’, ‘booking reference number’ and ‘line operator’ to find the corresponding COPARN Message details. Finally, the exporter nominates the preferred road carrier and closes the pre-advice stage.

At this point, the appointment has a ‘confirmed’ status. This means that all pre-advice information is completed, and container details are provided and valid. The carrier then needs to manifest the truck online before arriving at the terminal gate and associate the appointment with the driving licence number. After searching for the appointments created so far using the ‘confirmed slot appointment’ facility of the ATAS, road carrier selects a specific container to manifest to a truck and includes the ‘driver licence number’, ‘truck ID’ and ‘fleet number’. A ‘gate card number’ is generated to gain entry into the port when presented with the driving licence and the truck is given the status ‘truck not arrived’. The driver scans the driving licence at the exchange grid kiosk after arrival, then enters the lane designed to be occupied by the truck. This sends a signal to the yard to discharge the full container from the truck to load on the vessel.

4.5 To-be truck hauling process

The insights expressed in developing the to-be model working procedure reflect an adaptation and integration of the basic ideas of earlier shared-transportation articles and case studies (for example: Wolfler Calvo et al., 2004, Kelley, 2007, Morency, 2007, Thaler and Teredesai, 2009, Agatz et al., 2010, Martino et al., 2011). Such studies explore the concepts of shared-transportation (car-sharing, and lift-sharing). Many similarities can be drawn between carpooling companies and container transportation firms. Both are characterised by poor coordination among the corresponding stakeholders, high fixed costs for operations, stochastic demand for service, and a limited quantity of slots that generate costs if they remain empty.

The transport-sharing applications allow users to save money by sharing seats. Therefore, transport-sharing applications may have major similarities with the proposed model that facilitate sharing empty-truck slots. However, several other variables have been taken into consideration during model development because of the diverse container and truck characteristics (size, weight, and capacity) of freight transportation. These variables may vary significantly from port to port and be more complex than other types of shared-transportation (e.g., car-sharing) since many other types of shared-transportation systems are not dedicated for cargo.

This chapter proposes the Truck-sharing Service (TSS) that incorporates a key step named ‘slot-share’ in the ATAS to reengineer the empty-truck hauling process to gain dramatic improvements in reducing the number of empty-truck trips. Such a radically updated process will help to advance the port’s performance to utilise its available transport capacity fully. This constitutes a significant change in the as-is process that requires a process reengineering approach: (i) a modification in the practice of the as-is process that could significantly affect the
usage rate of the underutilised truck capacity (e.g., a significant change in procedure). (ii) A major amendment in the intended use of the truck appointment system. The phrase “could significantly affect the usage rate of the underutilised truck capacity” and the use of the adjective “major” refers to changes to achieve major performance improvements.

The study of Hammer and Champy (1993) emphasises the selection of performance measures for identification of the reengineering process (also, Davenport and Short, 1990). Based on that, in this chapter, the number of empty-truck trips and the truck capacity utilisation ratio are considered two vital performance measures. To achieve efficiency in truck operations, some of the procedures of the current truck hauling process have been changed, and some of the new ways to accomplish objectives of this chapter have been added. The study of Khan (2000) expresses similar concern in the reengineering of the air cargo-handling process.

4.5.1 TSS operating procedure

The dynamic truck-sharing system will offer a systematic matching facility. If some exporters have similar departure and destination locations, they could share container trucks. Container trucks can be shared as long as empty slots are available. Here, by a dynamic truck-sharing system, an automated system is referred to, such as the ATAS. ATAS is assumed to be provided by the truck-sharing service provider (e.g., the port). The objective is to successfully match up exporters and truckers to share empty-truck slots even at short notice.

TSS users such as a truck operator can offer an empty slot to share with an exporter or vice versa. The TSS structure consists of components to store information on the user’s (profiles and preferences of the exporters and the truckers), trips and locations (origins and destinations) into a database. The users of the TSS, especially the truckers, are private independent companies. Currently, more than 250 truck companies are registered at the port but their operational procedure is completely decentralised. Since the truck operators are independent and decentralised in nature, participation in the TSS arrangements depends on their preferences. TSS must match drivers’ preferences with exporters’ requirements for sharing a trip. For example, a driver may have a preference for a maximum deviation from the shortest route to pickup or drop off any empty or full container. The driver may also have a preference for the maximum number of assignments or stoppages to share an empty slot. Therefore, the TSS should provide alternative selection to the users (truck operators and exporters). Users can advertise to share a trip or delete a formerly created invitation if it is not accepted by the other party. A user can view the full list of past and present invitations, or view the invitations of other users. If a user accepts an invitation, the user then provides details of the departure and destination points of the trip, type (B-double, Super B-double, Long B-double or Road Train) of the container truck, capacity (2 TEU or 1 FEU) of the container truck, ETA (Estimated Time of Arrival) to pick up the first container (full or empty), ETD (Estimated Time of Departure) from the origin and the maximum allowed distance of deviation from the main route to pick up another container.

The matching of a sharing slot is performed with a query against the database, and conditions are developed to create a working procedure for the TSS. There may be many conditions: (a) both the exporter and the trucker are departing or arriving in the same direction. Destinations might be approximately the same or a little different. (b) Created appointments to arrive at the port fall into the same time zone and should have an analogous schedule to reach the destination. (c) The exporter is closer to the location of the trucker than the total distance from the port during arrival at the port gate. (d) The exporter is located within an acceptable and preferred radius from the trucker. (e) The sharing task should benefit all the corresponding parties from a financial perspective. (f) The truck and the container characteristics are taken into
account during matching. (g) Most importantly, the needs of each other (exporters and truckers) are discovered. Taking into account these constraints, TSS creates a channel of interest around an empty slot offering truck’s primary origin and destination route. TSS also checks the candidate exporters that fall within that channel range based on their departure and arrival locations. In creating the channel, the route calculation is performed by the TSS using “Dijkstra’s Algorithm”. This selects the shortest path between the source and the destination. For an application of the algorithm in real-time shared transportation, see Sghaier et al. (2010). Although such applications in truck-sharing are appealing, they are outside the scope of this chapter. Finally, the matched exporters are sorted by distance from the truck location. The exporter with the least distance is selected to communicate the offer of the empty slot. For the selected exporter, TSS calculates the savings from sharing slot and emissions. TSS also exchanges the results with the exporter. Conversely, if there is no match found, the exporters can subscribe for notifications.

The matching decision is communicated to the user using a web-based application interface. The web-based interface can be the ATAS; ATAS can use an SMS or an e-mail service. The matching decision provides an estimated time of the truck arrival. Hence, the application interface also provides updated matching information to the exporters, along with storing user-provided information and collecting trip data. The trucker receives a map generated using the Google Map API, plus the contact information of the exporter. The TSS also sends the identification (e.g., container or seal number) of the exporter to the trucker to match and to verify the exporter if it becomes necessary. The trucker picks up (drops off) the container from (to) the exporter at the agreed time and location. The TSS can also guide the trucker to the appropriate location of the exporter and the destination via the interior navigation system of the truck.

4.5.2 TSS basic functions

DFD (Data Flow Diagram) is used to show the basic functions of the TSS. DFD helps to split the total system into more understandable processes (Zarei, 2001). The primary functions (Figure 37) of the TSS can be viewed as a combination of: (a) user authentication: to verify the user with a public identifier (username) and a private identifier (password) prior to providing access to the service; (b) user profiling: a profile of users, consisting of exporters and truck operators, created based on their preferences and past trip histories of slot sharing (e.g., number of accepted slots, number of offered slots, user ratings); (c) user interactions: users can offer, edit and delete an empty slot as a truck operator and accept or share an empty slot as an exporter; (d) user status: the system provides the function of evaluating performance of truck drivers and operators based on their past behaviours of participation in shared trips; and (e) system administration: administrators can set route calculation algorithms, and other useful analytics such as changing the layout, modifying the user communication (i.e., interaction) options, and many others.
Figure 38. ATAS laden container delivery process: Integrated with TSS structure

4.5.3 System integration

The complete process is depicted in Figure 38. It takes laden container delivery as an example. Here, only one more step (i.e., slot share) needs to be completed compared to the earlier ATAS. After completing the pre-advising procedure, the exporter may become interested in sharing available empty slots. Instead of selecting and booking a new appointment by the nominated trucker, the exporter forwards his interests in sharing an empty slot, and the trucker provides information to offer one. The platform stores provided information (profiles, preferences, origins, and destinations) of the users (exporters and truckers) and matches candidates for a trip share. If there is no match found, the exporter can subscribe for notification in the future. If more than one match is found, the exporter with the minimum distance from the truck location is
selected to offer the empty slot, and the results of sharing-slot benefits (carbon emission and costs) are exchanged. After receiving the map, the trucker picks up or drops off the container from or to the exporter at the fixed time and location. TSS charges service fees. However, if the exporter decides to avoid sharing empty slots, the rest of the procedure is identical to the ATAS. The same five steps (pre-advice, appointment, manifest, gate and terminal) need to be completed as described in details in the ‘upcoming truck hauling process’ subsection.

Depending upon the functional requirements of an integrated system (appointment system and TSS), the specific components required may vary from port to port. A typical example is Figure 39, where components of the appointment system are adapted from Navis LLC (2003). The flow-chart notation is used because of its simplicity as suggested by Winkelmann and Weiβ (2011). Both of the systems are required to be highly integrated with the Terminal Operating System (TOS) to simplify operations, to deliver excellent service, and to reduce operating costs. It may include a user interface, an administrative interface, three rules-engines, a database, a web portal, existing systems of the TOS and a database. Users can see, create, book, modify and cancel existing shared slots. Users can also book appointments by making a phone call to an IVR (Interactive Voice Response) based system. The web portal does many important tasks such as verifying users, setting options to limit user access and confirming a security check. The rule engines applies business rules to users and system administrators such as maximum number of appointments per hour, minimum number of containers required to share a container truck, the authority of administrators in the system and the allowed maximum distance of exporters to minimise transportation costs. The truck-sharing engine performs a matching of sharing slot with a query against the whole database with conditions. The truck-routing engine performs route calculations using ‘Dijkstra’s Algorithm’ to select the shortest path to the source and the destination. The database stores all appointments and slot-sharing information.

**Figure 39.** Components of the integrated truck appointment system and TSS
Source: An extension of Navis LLC (2003:13)
4.5.4 TSS benefits

A dynamic truck-sharing system may provide two unique benefits, such as maximising total transport capacity and minimising total Vehicle Miles Travelled (VMT). Total transport capacity represents the total number of containers (TEUs and FEUs) of the port that the combined services of all trucks can transport to facilitate containerised cargo exportation and importation. Proper utilisation of all available slot capacity should result in an increased number of containers transported using the same number of trucks. This can increase the road-side transport capacity of the port. Total VMT represents the total miles driven by all port trucks to pick up and drop off containerised cargoes and empty containers to and from the port. Appropriate utilisation of available slot capacity helps in reducing the total vehicles miles driven by all participating truck drivers travelling to their destinations. This is important from all perspectives (such as economic, environmental and social sustainability) as it helps to reduce pollution and congestion. This also helps to reduce the transportation costs of all concerned parties (e.g., road carriers and exporters).

In summary, the to-be system has the potential to generate many benefits for the stakeholders of the port. For example: (1) sharing container trucks in the port territory should increase overall transport capacity; (2) exporters pay only part of the rate thus saving money and reducing transportation costs; (3) drivers earn more as two or more exporters will share the same truck and the truck will enjoy full capacity. Most container truck costs are not variable usually; and (4) fewer container trucks on the road means less congestion and pollution. The study of Heide (2010) for the port of Rotterdam shows that reducing empty trips can save road carriers 17 million kilometres per year. This is equivalent to saving euro 25.5 million a year.

4.5.5 Model generalizability

The to-be model developed here is designed to be applicable to other ports of the world. There are two key reasons for the generalisation capability of the process. (1) The proposed transport model provides an abstract representation of the important elements that are required to create an effective container truck-sharing service. This keeps the window of customisation open for further development and adaptation of the basic to-be model in the future. Customisation should be based on the unique operating characteristics of a port. (2) The model as proposed uses a truck appointment system as the formal foundation of the model. Many ports of the world use such a truck appointment system, such as Port of Rotterdam, Port of Hamburg and Port of Singapore. Although there are significant differences in the manner truck appointment systems are designed or implemented, the basic operating rules for proper function are the same. This offers a comparatively easy way to integrate both the container truck-sharing service and the truck appointment system. Most importantly, the to-be model is generic in nature as it incorporates only a standard matching process as a middle layer with the current system. The middle layer manages a profile matching process without any port-specific information. Port-specific profile attributes and related values can be added. However, in order to use this model in other ports of the world, the model needs to reconfigure the matching profiles.
4.5.6 Model implementation

Many BPR projects have failed to achieve performance improvement targets (Shin and Jemella, 2002). In reality, only 30% of the projects have achieved the desired breakthrough (Bashein et al., 1994), and BPR is plagued by high failure rates (Abdolvand et al., 2008). Some well-thought-out strategies need to be taken into consideration for the successful development of the ATAS-based TSS structure and its real-life implementation. These strategies are similar to those that have been adopted by the case study port during BTAS implementation and ATAS development. For example, a working group should be formed to plan the basic and customised (comparable to the local shipping business) working procedures of the TSS. The working group may consist of the Road Transport Forum (represents trucking businesses on local and regional issues), road carriers and port representatives, since the internal or external customers must initiate a business process reengineering project (Childe et al., 1994). The further implementation plan may be accelerated by arranging a series of counselling meetings with the stakeholders: shipping companies, freight forwarders, customs agents, empty depot operators, road carriers and statutory authorities to resolve raised concerns and to avoid future conflicts. The result of the meetings will reassure all concerned parties the benefits that a reengineering process would bring for all. If the counselling meetings become successful, an initial trial of the basic system may be implemented for a short period to fine-tune the process to cope with the local transportation environment. This trial system may include all carriers interested in volunteered participation to measure and observe the daily operation of the new system. To make local haulers accustomed and primarily experienced with the new innovative system, the daily operating rules should function in a flexible way during the first couple of months. In the meantime, the port authority should collect useful real-world data and feedback from the trial and flexible system to make the process practically adjusted and smoothly workable for road carriers, exporters, importers and terminal operators. While, the implementation plan for any port will be situation dependent, it will likely follow a similar framework to the above proposed for the case study port.

4.5.7 Post-implementation support

A problem associated with process reengineering is that such drastic efforts of performance improvement can focus too narrowly without taking a holistic view of the welfare of the whole organisation (Neilson and Couto, 2003). As a result of these issues associated with a BPR project implementation, Davenport (1993) suggests adopting a continuous process improvement perspective (Doebelei et al., 2011). Such an adoption of a BPM philosophy is a less aggressive way to shift to a process-oriented thinking. Although little academic contribution is available for assisting managers to embedding BPM in the organisation (Bruin and Doebelei, 2008), the building of a BPM governance system is crucial for the successful deployment of BPM (Doebelei et al., 2011). Organisations should enable a process-oriented approach through empowerment of process owners, embedded reward systems and alignment of organisational structures (Doebelei et al., 2011). Corporate culture also contributes to everyone’s positive attitudes and behaviour towards continuous improvements (Guimaraes, 1999). The study of Ravesteyn and Batenburg (2010) surveys the success elements for a BPM-system implementation, and the study of Antonucci and Goeke (2011) investigates responsibilities for a successful BPM initiative. These suggestions can smooth the process of rolling out from BPR to BPM-based change and can help to develop an understanding of the elements of a successful BPM deployment in the port.
4.6 Conclusion
The first chapter outlines the position that many ports of the world are currently facing the problem of transport capacity shortage; it also establishes the relationship between the reduction of empty truck trips and transport capacity improvement potential. The second chapter explores capacity improvement generally. The third chapter, by identifying the consequences of capacity shortage at seaports and the corresponding supply chains, provides a list of potential solutions for the reduction of empty trips. This is based on an extensive literature review of academic and industry-related papers. One of the key findings of the third chapter is the potential for using the truck-sharing concept (the shared-transportation concept) for container truck transportation. This fourth chapter further applies and extends the suggested truck-sharing concept and develops a truck-sharing mechanism with the potential to reduce the number of empty-truck trips in order to increase container transport capacity. This chapter also notes that the lack of collaborative arrangements among supply chain partners, especially among the exporters, importers and truckers, encourages inefficient use of limited amounts of container truck capacity and triggers the empty-truck trips problem studied here. The traditional method (BRPB-Vehicle Routing Problem with Backhauls), to solve the problem, works well under the assumption of a centralised decision maker of a carrier. Such a solution may become ineffective in a supply chain setting where many carriers are involved. This chapter adopts a case study approach to suggest a mechanism (TSS-Truck-sharing Service) from a supply chain perspective to minimise the number of empty-truck trips.

The specified case study setting is important because it is in a growing economy with a 6% TEU growth rate where almost 87% of the landside container transfer is carried by the road. Besides, currently, at least 70% of the truck trips happen without carrying any container (i.e., empty or full) at all or carrying only one container while the truck has a two-container equivalent capacity. The appropriate step is to adopt the TSS to reduce the number of empty trips to improve the system-wide transport capacity along with bringing environmental benefits by reducing the trucking industry’s carbon footprint. The implementation can also bring significant societal benefits by reducing traffic congestion and air pollution around the port gates and the surrounding city. Carriers should also realise the economic benefits of transportation-sharing since the rate will be divided among all participating clients (e.g., exporters and importers).

Managerial implications of this chapter are that additional functions can be added to the proposed process to make it more robust and integrated with features in the future to overcoming transportation capacity shortages. Transport capacity shortage is a problem in many container terminals of the world. The proposed process can be further developed, configured and tested for other ports to overcome the few limitations that the current chapter acknowledges.
Chapter 5: Exploring truck-sharing constraints to reduce empty truck trips

5.1 Introduction
From the solutions suggested in the third chapter, the fourth chapter applies and extends the truck-sharing concept (the third chapter introduces the concept of shared-transportation through a literature review). The objective is to develop a truck-sharing mechanism with a potential to reduce the number of empty-truck trips to increase transport capacity. However, the implementation of the truck-sharing model depends on the truck-sharing constraints that have not been taken into account in the fourth chapter. To fill that lack, this fifth chapter aims to explore the challenges of truck-sharing and effective ways of dealing with them in order to reduce the problem of empty trips, which will thus lead to transport capacity expansion around port gates. The key research question to be answered in this chapter is: What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges?

To focus on the implementation of such a truck-sharing mechanism, this chapter argues that the quality of hinterland access depends on the coordination and collaboration of many actors (e.g., freight forwarders, transport operators, and port authorities) (Langen and Chouly, 2004). Such coordination problems (particularly, lack of horizontal coordination) appear in port-related transport services, resulting in underutilisation of assets (Van Der Horst and De Langen, 2008), inefficient operations, and revenue losses. Therefore, contributions to the literature describing collaboration challenges or impediment issues are a necessity. The reason for this is to support and establish coordination between hinterland transport chains, particularly among road carriers. As opposed to a climate of non-cooperation, collaborative efforts among road carriers should result in a higher degree of success in truck utilisation for all participating parties. Hence, a cooperative scenario may be superior to a non-cooperative scenario in which some road carriers may be left behind in the making of profits.

As discussed in the literature review section of this chapter, prior research that explores the challenges for container-truck utilisation in addressing the empty-truck hauling problem is scarce. This is true especially in the maritime logistics domain. Therefore, a practical perspective on truck-sharing constraints in the transportation sector is considered important. The reason is to establish collaborative efforts among road carriers for the purpose of achieving higher utilisation of container trucks. However, such an expected practical application and perspective requires an exploration and recognition of the constraints. These constraints hinder truck-sharing opportunities and discourage collaboration among road carriers to reduce the number of empty trips of container trucks. Such constraints and challenges are the focus of this chapter.

As stated previously, however, as yet, and as far as the researcher is aware, there is no study that has attempted to provide a conceptual or empirical justification for the constraints of truck-sharing collaboration. Such limitations should be addressed to fill this gap, from both theoretical and practical perspectives. Therefore, this chapter’s key research question addresses the challenges mentioned above (i.e., collaboration obstacles for truck-sharing). This research question also advances the body of knowledge by exploring general industry trends and by suggesting a collaboration framework to overcome the challenges in the container transportation industry of New Zealand. It is crucial to offer suggestions to overcome the challenges explored in order to optimise benefits of the supply chain members. Conversely, sub-optimisation may occur when the supply chain members focus on their welfare rather than on the integration of actions to the supply chain (Cooper et al., 1997).
To sum up, the goals of this exploratory research are to identify and describe the challenges that carriers face when dealing with truck-sharing initiatives and to take a look at ways of coping with these challenges. For the sake of brevity, this chapter only considers horizontal collaboration (e.g., collaboration among road carriers). The meaning of collaboration adapted and defined in this chapter is the cooperation between independent companies to share resources in order to meet the needs of customers in a better way (Narus and Anderson, 1996).

5.1.1 The organisation of the chapter
This chapter is organised as follows: the next two sections provide the literature review and research methodology; this is followed by an analysis of contemporary trends in the container transportation industry. Thereafter, truck-sharing challenges are described within a collaboration framework. The managerial implications of this chapter are then discussed. This section is followed by the final one which summarises the main aspects of the chapter.

5.2 Literature review

5.2.1 Truck-sharing constraints
To date, as far as the researcher is aware, only a few studies reviewing the factors hindering truck-sharing engagements have been published. Therefore, only three papers were found that attempted to explore the challenges (e.g., McKinnon, 1996, McKinnon and Ge, 2006, McKinnon et al., 2010). A brief description of each of these studies is presented here.

In his study, McKinnon (1996) reviewed the role of the factors constraining return loading and offered suggestions. These suggestions might be useful in eliminating the obstacles to full utilisation of vehicles in arrival trips. McKinnon’s study presents the results of interviews with senior logistics executives to explore the major constraints. For the purposes of this chapter, the factors are grouped together in eight categories as shown in Figure 40. First, in order to maintain a reputation for delivering on time to the firms that purchase their transport services, the outbound distribution service of finished goods tends to be of greater importance to road carriers than the arrangement of supplies for inbound backloading. The reason is to comply with a range of important requirements. Second, since many carriers (large, medium-sized and small) fail to align the calculation of inward and outward trips, many opportunities for backloading pass completely unnoticed. Hence, these opportunities are not calculated for by competitive and profit-seeking road carriers. Third, the incompatibility of transport vehicles and consolidated products can limit the number of grazing opportunities for the loading of supplies and equipment for return journeys on the same day. Fourth, the most necessary task relating to costs and benefits, to collect handling equipment is another important constraint to the use of total vehicle capacity on return trips. Fifth, the individual uncertainties of each operation at the suppliers’ premises, causes backloading operations to be unreliable and renders them difficult for carriers to perform smoothly. Sixth, the transport capacity available for carrying vehicles is frequently distressingly inadequate to support the collection of supplies available for backloading. Seventh, if there is a wide geographical difference between the premises of the delivery and collection points, it is difficult to match the locations and timing for the collection of supplies for backloading. Finally, many of the traditional scheduling systems for routes do not have the facility to allow for a diversion from the main route of distribution in order to allow for the collection of materials for return loading. This problem may require the analytical analysis of transport routes and their surrounding areas.
Factors inhibiting return loading

- Requirements of the outbound delivery service
- Internal management structure
- Incompatibility of vehicles and products
- Need to recover handling equipment
- Unreliability of backloading operation
- Inadequate transport capacity
- Poor matching of locations and schedules
- Limitations of the route scheduling system

36% of firms 29% of firms 24% of firms 12% of firms 12% of firms 10% of firms 6% of firms 4% of firms

**Figure 40.** A list of the factors constraining full loading of vehicles in return trips
Source: Adapted from McKinnon (1996)

Following a similar approach in a list of comparable factors, a study by McKinnon and Ge (2006) also lists, and describes the factors constraining the backloading of trucks. The factors have been grouped together in six categories as shown in Figure 41. First, managers generally give greater or even maximum importance to the quality and optimal timing of the outbound distribution of finished goods (e.g., from the delivery point of plant to the point of sale) than they do on the inbound arrival of supplies. These supplies are considered to be less important. Second, the reliability of quick assembly is uncertain and delivery operations of goods can be delayed; thus, depending upon the nature of backloading operations, delivery can be risky. Third, carriers may be simply unaware of the possible demands of backloading services or locations. This happens (and is a phenomenon that typically occurs) because of the lack of transparency in administration and proper communication in the road haulage market. Fourth, effective coordination between departments and companies could help transport managers to realise the many backloading opportunities available to them. Fifth, the non-standard condition of vehicles of many shapes and sizes, and the many different types of goods being carried make backloading difficult for carriers. Finally, it is vital to have support from a number of facilities and resources that would allow drivers to drive the trucks, in order to conduct backloading operations.

**Figure 41.** Factors constraining the backloading of trucks
Source: Adapted from McKinnon and Ge (2006)
Factors affecting the utilization of truck capacity

Market-related
- Demand fluctuations
- Lack of knowledge of loading opportunities
- Health and safety regulations
- Vehicle size and weight restrictions
- Unreliable delivery schedules
- Just-in-time delivery
- Goods handling requirements
- Limited capacity at facilities
- Incompatibility of vehicles and products
- Poor coordination of purchasing, sales and logistics

Regulatory
- Health and safety regulations
- Vehicle size and weight restrictions
- Unreliable delivery schedules
- Just-in-time delivery
- Goods handling requirements
- Limited capacity at facilities
- Incompatibility of vehicles and products
- Poor coordination of purchasing, sales and logistics

Inter-functional
- Health and safety regulations
- Vehicle size and weight restrictions
- Unreliable delivery schedules
- Just-in-time delivery
- Goods handling requirements
- Limited capacity at facilities
- Incompatibility of vehicles and products
- Poor coordination of purchasing, sales and logistics

Infrastructural
- Health and safety regulations
- Vehicle size and weight restrictions
- Unreliable delivery schedules
- Just-in-time delivery
- Goods handling requirements
- Limited capacity at facilities
- Incompatibility of vehicles and products
- Poor coordination of purchasing, sales and logistics

Equipment-related
- Health and safety regulations
- Vehicle size and weight restrictions
- Unreliable delivery schedules
- Just-in-time delivery
- Goods handling requirements
- Limited capacity at facilities
- Incompatibility of vehicles and products
- Poor coordination of purchasing, sales and logistics

Figure 42. Classification of the constraints on vehicle utilisation
Source: McKinnon et al. (2010:199)

Following a different approach, the study by McKinnon et al. (2010) identified the constraints (Figure 42) on vehicle loading and classified them into five categories. These categories are market-related, regulatory, inter-functional, infrastructural and equipment-related. They explored ten constraints on vehicle utilisation that had been derived from McKinnon (2007). For example, ineffective design of packaging and equipment can result in poor use of vehicle capacity. Similarly, incompatibility of vehicles and products can also contribute to limited utilisation of vehicle capacity. Some vehicles are designed to carry only particular commodities and are unable to load certain specific categories of goods. There are also safety rules that prohibit the height to which truck loads can be stacked; this lessens the full utilisation of capacity.

Many similarities can be drawn between general freight trucks and container trucks. Some of these similarities are, such as high fixed costs for daily operations (especially as these fixed costs are associated with truck trips), vehicle routing with stochastic demand for transportation services, and a limited quantity of transport slots which generate costs if they remain empty during each trip. Significant differences can also be realised between these two categories of trucks. For example, a container truck is involved in six times in each import process as shown in Figure 43. In each of these movements, a typical container import process may generate many completely unutilised or partially utilised truck trips (Theofanis et al., 2007).
Here, for the sake of brevity, it is assumed that a typical container truck has two capacity slots for transportation, and all that containers are twenty-foot long. (1) In the import process, initially the most environmentally harmful unutilised (i.e., none of the two slots of a container truck are used) slot transportation may happen during the driving of an empty-truck (i.e., with chassis only and no container attached) from the trucking company to the port in order to pick up a laden container. (2) Another partially unutilised (i.e., only one of the two slots of a container truck is used) truck movement may next take place when it picks up a laden container from the port and delivers it to the importer’s warehouse. This movement happens despite the fact that the truck can transport two containers at a time. This failure, to fully utilise each of the transportation slots, can accelerate port congestion and increase carbon emissions. (3) Then the truck leaves wholly empty from the warehouse after unloading the container. This can create another
completely unutilised (i.e., not a single container on it) trip although it could have loaded two empty or two full containers for another firm and taken them back to the trucking company or another warehouse. (4) The road carrier then assigns another truck to move the empty container from the importer’s warehouse to the port. This can create another completely unutilised (i.e., not a single container on it) trip although it can load two containers for another firm back to the warehouse. (5) The truck leaves the container at the port’s empty depot before departing the port territory. The arrival of the empty truck to the port creates another unutilised truck movement. (6) Finally, the truck leaves empty from the port territory after unloading the empty container at the empty depot. This may also create another empty slot trip for the road carrier.

**Figure 45.** The contributions of research question (truck-sharing constraints) to the literature

Hence, container trucks have fundamental similarities with the general-purpose trucks that transport non-containerised loads. However, several other variables have to be taken into consideration in order to explore the constraints associated with containerised transportation using container trucks. (1) One reason for this relates to the diverse characteristics of container trucks and other interrelated vehicles (size, weight, and capacity) used for freight transportation. These variables may vary significantly from port to port and be more complex than other types of general freight trucks. Many other types of non-containerised trucks are not dedicated for container transportation. Therefore, they (as stated in all similar studies) include many of the factors relating to general freight truck transportation, but exclude the constraints that are related exclusively to container freight truck transportation. (2) It is also important to note that, in a containerised truck trip, empty trips may happen in both fronthauling and backhauling as shown in Figure 43. To the contrary, the use of general trucks contributes to the increase in empty trips during backhauling, as opposed to the use of container trucks, as shown in Figure 44. For more information on the movement of general trucks and empty trips, see McKinnon et al. (2010). Literature ignores the factors affecting the fronthauling of container trucks (Figure 45).
5.2.2 The collaboration framework

The collaboration framework presents a gap in research because of the contribution of freight transportation to the supply chain and maritime logistics. It is important to fill in order to address hinterland coordination problems among carriers. From a practical perspective, the initial output of this research question is the real-life outlook for the collaboration opportunities in the transportation sector. This initiative is intended to be complementary to the existing practices of the road carriers. These practical perspectives aim to be an aid with which to guide transport companies towards greater mutual assistance. Various types of explanation and new prospects for theoretical or process frameworks have been offered in the supply chain literature. These are for organising successful collaborative efforts and actions in order to keep pace with, and respond to, new opportunities (Fugate et al., 2009). For example, Simatupang and Sridharan (2005) proposed a framework (Collaborative Supply Chain Framework-CSCF) to examine the key elements of supply chain collaboration in order to initiate and improve mutual effort and gain. The five features of the suggested framework include: a collaborative performance system; incentive alignment; information sharing; decision synchronisation; and the integration of supply chain processes. Each of these features assists in the adoption of a collaborative approach to relationship management, which is an assembly of strategies designed to assist companies increase profits. These features are tightly related to each other and share a dynamic relationship in their contribution to the achievement of collaborative gains for quality objectives. For example, accurate information sharing enables effective decision-making that mitigates the impact of individual (as a single company) disasters; decision synchronisation assists contributions to a collaborative performance system in product-service system innovation.

Kampstra et al. (2006) addressed some of the common misunderstandings in the collaboration process for bringing together well-suited companies. In order to contribute to the closing of the research gap, and, in addition to closing of the gap between research and practice, this chapter explains important issues. These issues are, such as the role of collaboration in the supply chain, the levels of collaboration that are necessary, the potential for collaboration and priority assessment techniques. The presented framework in the study can be used to identify the financial implications of the outcomes stemming from collaboration networks that have an effect on the innovative performance of companies. The study by Bowersox et al. (2003) presented a framework to assist organisations in adopting a collaborative approach to the pooling of their resources. The aim of the framework is to achieve mutual gain and the realization of the benefits ensuing from a collaborative mindset. Although the literature pertaining to supply chain collaboration is extensive from both business and academia, the studies are not based on differences in perspective (Kampstra et al., 2006). Therefore, the literature ignores the specific perspectives and more refined implications of addressing the problem of empty truck trips. These implications are likely to be different from other “all-purpose” collaboration application contexts in the supply chain literature. Hence, the suggested framework in this chapter offers a different perspective from that of other, already existing, studies by positioning itself to focus solely on the collaborative aspects of road carriers. This is particularly true for the instances in which the prospect of empty truck trips may occur due to the absence of any cooperative arrangements between the key players (such as road carriers and their customers) in the transportation industry. The contributions to the literature of the suggested framework are shown in Figure 46.
5.3 Research methodology
As stated previously, the research question for this chapter is: What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges? In order to answer this two-part research question, this chapter employs an exploratory qualitative methodology, given that the purposes of the chapter are to explore truck-sharing constraints in the transportation sector for the achievement of higher utilisation of container trucks and to find effective ways of dealing with those for the purposes of the reduction in the numbers of empty truck trips. By adopting a qualitative research approach, this chapter gains rich real-life insights into truck-sharing constraints and ways of dealing with those challenges. This is something that a quantitative approach would not have provided (c.f. Eisenhardt and Graebner, 2007, Saunders et al., 2012). Therefore, qualitative research helps to collect data from organisations and provides the type of valuable insights, which may not be possible to gain in a case study or in quantitative style research (Min et al., 2005). Put another way, in explaining the issues pertaining to relationship management (insights into truck-sharing constraints), a qualitative research approach is appropriate. This appropriateness has been explained by a study by Chia (2005). In another instance, along the same line of importance in explaining the value of qualitative research in relationship management, Fugate et al. (2009) studied the way that relationships between companies improve their performance. The reason is to address capacity constraints in the transportation industry. To answer their research questions, Fugate et al. (2009) chose an exploratory qualitative methodology, because earlier supply chain collaboration literature had primarily focused on behavioural aspects (e.g., trust, risk-bearing commitment and penalty).

Moreover, a qualitative approach allows a better understanding of the truck transportation strategy utilised by each road carrier's transport manager and the larger social context of today in which truck-sharing initiatives can occur. Thus, “deeper understandings, meanings, and insight of the human experience” by adopting a qualitative research approach has been supported by studies. For further clarification, see Richards and Morse (2013), Robson (2011), Merriam (2009), Denzin and Lincoln (2005), and Myers (2008). Therefore, in brief, according to these studies, a qualitative research approach is also useful for gathering and analysing exploratory data (Goulding, 2005). It has the flexibility to ask why, how or when, and to use probing questions to encourage participants to talk spontaneously about the area of interest. Probable areas of relevance for the research questions in this chapter are: examples of collaborative
arrangements among road carriers and common reasons for their failure; obstacles to efficient resource sharing (e.g., container trucks); and the trends affecting the container trucking industry. Furthermore, this research approach is deemed relevant as little is known (for more information on the related truck-sharing literature, see Chapter 4) about the key challenges of practicing truck-sharing initiatives amongst the carriers. The study by Rubin and Babbie (2012) supports this characteristic of a qualitative approach where little information is known about the particular issue being considered. The same conclusion has been supported by other research. For further examples, see Maxwell (2013), Merriam (2009), and Crosby et al. (2011). A comprehensive list of the benefits of the qualitative research approach can be found in the study of Ochieng (2009). For these reasons, this chapter has taken a similar approach to that of many qualitative studies.

In this chapter, the semi-structured interviews (for important characteristics of semi-structured interviews, see Myers and Newman, 2007) provided valuable complementary information for understanding truck-sharing constraints. The study by Barriball and While (1994:330) describes the advantages of semi-structured interviews, “…they are well suited for the exploration of the perceptions and opinions of respondents regarding complex and sometimes sensitive issues and enable probing for more information and clarification of answers.” This feature of the qualitative research methodology is important for this study, as the qualitative interviews allowed the transport managers of carriers to describe, in great detail, the story of constraints that cause them to deviate from the truck-sharing initiatives, rather than the researcher having to choose from a generic list of some of the primary reasons for their non-cooperative behaviours. The same conclusion concerning semi-structured interviews has been supported by other studies. For examples, see DiCicco-Bloom and Crabtree (2006), Corbetta (2003), and Gray (2004). Hence, semi-structured interviews have the benefit of ensuring flexibility in asking questions that inspire further discussion. In brief, these semi-structured interviews, called in-depth interviews, provide a comfortable and relaxed environment for the respondents to freely discuss their ideas and opinions (Davis, 2000, Cooper and Schindler, 2006, Stokes and Bergin, 2006).

Semi-structured interviews have the added benefit of being able to ask sensitive questions (Hair et al., 2003). Apart from these benefits, the researcher has more control in the selection of an interviewee based on his knowledge and experience (Stokes and Bergin, 2006). Most importantly, semi-structured interviews provide the possibility of building trust with the researcher, and this improves the quality of the data (Davis, 1997). However, the major disadvantage of semi-structured interviews is the perception (e.g., how respondents perceive the interviewer and the reality) of a respondent who contributes to the research findings (by interpreting the experiences of a participant) (Denscombe, 2007, Bryman, 2012).

Accordingly, generalizability of the findings is not the goal of a qualitative research approach (Mannerkorpi and Gard, 2012). Therefore, Maxwell (1992:52) further confirmed, “Qualitative studies are usually not designed to allow systematic generalization to some wider population.” The study by Ochieng (2009:17) explicitly expresses the same concern with qualitative research, “The main disadvantage of qualitative approaches to corpus analysis is that their findings cannot be extended to wider populations with the same degree of certainty that quantitative analyses can.” Although one limitation of the qualitative research is the fact that the results cannot be generalised, but the results found can be used as the basis for future quantitative studies (with well-defined variables). Therefore, qualitative research has proved to be a complement to quantitative studies (Crosby et al., 2011). Another problem with the qualitative approach can be researcher bias, which results from personal perceptions concerning such matters as data collection, interpretation, and conducting research (Kincl, 2007). Therefore, in
brief, in qualitative research, there is no universally acceptable approach to doing it (Brink and Wood, 1998). The study by Anderson (2010) provides the limitations of the qualitative research approach, these are that: it is dependent on the skill of the researcher; it is also prone to researcher bias; it presents findings with less scientific rigour; it takes a long time to collect, analyse, and report on the data, and has an influence on the responses of the subjects. Taking all these limitations into account, the study by Ryan et al. (2007:5) summarises the potential and limitations of the qualitative approach, “Proponents of qualitative approaches emphasise the value-laden nature of naturalistic inquiry; a commonly heard criticism is that qualitative research is subjective, anecdotal and subject to research biases.”

5.3.1 Respondent selection

For the purpose of the current chapter, and given that a qualitative approach was adopted, the in-depth interviewing of transport managers (of road carriers) was adopted as its main method of data collection. Therefore, the unit of analysis was company managers at all levels (mid-level to top-level) amongst road carriers; the purpose of this was to represent their unique perspectives in regard to truck-sharing constraints, and the potential mechanisms to overcome those challenges. Accordingly, individuals were identified from managerial and professional backgrounds (most of the respondents were selected from, at least, managerial level), ensuring adequate knowledge in transportation planning, policy making, modelling, monitoring and decision making. Therefore, the participants were chosen based on a match with the explicit eligibility criteria: involvement in all areas of transportation (e.g., freight transport assessment). Thus, the interviews helped to bring together participants from varied and diverse backgrounds, leading to the involvement of an operational manager, a transport and business development manager, a transport operations manager and a general manager. In brief, respondents were selected from mostly managerial level positions (top and middle management) to guarantee sufficient knowledge on all the essential branches (e.g., freight transport evaluation) of the transportation industry. These respondents were considered by the researcher to be in the best position to gain access to information in regard to truck-sharing opportunities and constraints.

Because of its confidential and sensitive nature (e.g., managers giving insights into their current industry situations, policies and reforms) of the data collected, the focus group interview approach was inappropriate for the research purpose. Furthermore, since an in-depth discussion with each selected participant was necessary for the description of his/her personal opinions on truck-sharing constraints and opportunities, a Delphi survey could not be undertaken.

The basic interview questions were re-designed many times using the literature to ensure that the interviewer’s perceptions were as unbiased as possible. For an example of this, see the study of Theofanis and Boile (2007), which helped the researcher to gain understanding and insight into the complex issues facing the container transport industry. Therefore, the study of Theofanis and Boile (2007) provides useful information pertaining to the container transport industry. In addition, interview questions were cross-checked by other researchers from the same research domain. In total, eight semi-structured interviews were conducted. After eight detailed interviews, no new data appeared to be emerging that would necessitate the conducting of any further interviews. Since the sampling approach of the participants follows a purposive sampling strategy (respondents knowledgeable about the topic under question), the idea of them (respondents) being representative of the wider transport industry, is less important in this instance. Therefore, the study by Marshall (1996:523) confirmed, “Qualitative researchers recognise that some informants are 'richer' than others and that these people are more likely to provide insight and understanding for the researcher. Choosing someone at random to answer a
A qualitative question would be analogous to randomly asking a passer-by how to repair a broken down car…” A sample of some of the questions asked is provided in Appendix D.

Initially, the researcher contacted one of the executive officers at National Road Carriers (New Zealand’s leading transport association), which provides services that assist New Zealand transport businesses. From a list of members, the executive officer sent requests to potential interviewees. The researcher also contacted some interviewees via email. This list (names, positions, email addresses, and phone numbers) was provided by the Ports of Auckland. In most cases, the email addresses and telephone numbers of participants were also available on company websites via the internet. This helped to cross-check the information (email addresses, and phone numbers) provided by the Ports of Auckland. Several of the respondents who had shown interest in participation were finally selected after their respective positions had been reviewed by the researcher. Initially, a copy of the advertisement form, the consent form (to sign), and the project description sheet (to ensure that each participant was presented with exactly the same background information), were sent to the participants by email. Mobile calls and emails were sometimes used to send reminders to those who were yet to respond to the initial invitation.

5.3.2 Data collection
A combination of structured and semi-structured questions was used for the interviews; the approach to asking questions was adopted to resemble the method usually employed for the determination of transport conditions in the transportation industry. Another important reason for following such an approach is that a blend of structured and unstructured questions can be a well-organised approach that also fulfils the promise given that the researcher would explore both the depth and richness of the collected data. In this chapter the unstructured questions described were those which had not previously been considered relevant in regard to the issues of collaboration and truck-sharing constraints that were under consideration. Therefore, to bridge the conceptual gap, unstructured questions were composed during the interview sessions; sometimes such questions enquired as to whether or not, an interviewee’s response and explanation raised further questions and inspired further discussion of similar types of concern.

<table>
<thead>
<tr>
<th>1st phase</th>
<th>An overview of the interviewer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd phase</td>
<td>Description of the interview process</td>
</tr>
<tr>
<td>3rd phase</td>
<td>What are the rising trends in the industry?</td>
</tr>
<tr>
<td>4th phase</td>
<td>What are the truck-sharing constraints?</td>
</tr>
<tr>
<td></td>
<td>An introduction of the interviewee</td>
</tr>
<tr>
<td></td>
<td>Assurance of anonymous reporting of findings</td>
</tr>
<tr>
<td></td>
<td>How are they affecting your business?</td>
</tr>
<tr>
<td></td>
<td>How do you collaborate with other carriers?</td>
</tr>
<tr>
<td></td>
<td>How may they affect truck-sharing initiatives?</td>
</tr>
<tr>
<td></td>
<td>What are the obstacles to collaboration?</td>
</tr>
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</table>

**Table V. Interview protocols**

To further confirm the rigour of the research process during the data collection activities, in particular cases, the illustration and clarification of specific scenarios of collaboration and industry trends were required to be provided by the participant. These illustrations helped the researcher to gain an understanding of the issues pertaining to collaboration opportunities and
challenges that had not previously been considered when formulating the questions. To reflect the competencies sought by an interviewer for an interview session and post-interview actions, detailed information was collected and recorded. Each interview was transcribed using a professional transcriber. Again, each transcription was cross-checked by the researcher with the audiotape. In some instances, the records helped to facilitate the cross-checking of facts with written notes. Written notes were taken during each interview session and, in particular, for those participants who objected to the recording of certain discussions (e.g., those requiring confidential or sensitive answers and comments). The interview protocols, at which an attempt was made to follow the course of each interview, as shown in Table V, both improved the quality of the interviews and provided suitable phrases that could be used in future interviews.

5.3.3 Data analysis
The qualitative data analysis steps are described here. (1) First the researcher read the transcript and listened (to assess the emotions that might be involved) to the tape. Both activities occurred simultaneously. (2) The qualitative data collected and the categories (are also known as themes, ideas or simply concepts) devised in a study help to answer the research question. Therefore, the evaluation and categorisation of the interview results have been used as ‘findings’ in subsequent sections. These categories can be known (e.g., pre-set categories) to the analyst or unknown (emergent categories). However, in this study, many of the categories are known to the analyst beforehand, because two of the important categories (what are the truck-sharing challenges and how to best overcome those challenges?) are closely related to the research question. Therefore, selected categories were used to extract and categorise the interview data in this study. (3) Since the categories were known a priori, it was possible to sweep through the available data from each of the transcripts, and highlight (by writing or circling with a pen) words, phrases, sentences and paragraphs in order to identify relevant segments of text. For example, the analyst circled words or phrases describing the truck-sharing constraints for a road carrier. (4) As a result, a number of codes or labels were used to assign meaning to pieces of highlighted data, and it was necessary to sort them into appropriate categories. Therefore, the analyst read the transcript, devised categories for grouping interview statements, and placed the participant's statement in the proper category. (5) During coding, the analyst had a list of all the codes that were already developed. The reason was to have the same codes across different transcripts. (6) Finally, the findings of the categories obtained through the qualitative data analysis of the interview transcripts were reported using descriptive narratives that included visual displays (e.g., Figure 47).

During this whole process, wherever considered important, the themes were reviewed many times in order to fill the information gap and to fine-tune the information in cases where there was an excess of information. Thus the researcher employed a “back and forth approach” as suggested and exploited by Fugate et al. (2009) to analyse the interview results and support those with examples from the literature (the supply chain collaboration literature and the hinterland coordination studies) in order to enable the building of the conceptual model that had been deduced to overcome the challenges encountered. Only those articles contributing to the overcoming of obstacles to collaboration were reviewed for the examination. For example, the study of Simatupang and Sridharan (2002) recommended a process to measure performance in a collaborative setting. For more information on these types of study (that measure performance in a collaborative setting), see Section 5.6 of this chapter. Thus, the data for this chapter came from the combining of the interview results with information from subject-specific articles. The choice of contents is justified by the purpose of the chapter. This is considered as a proper process for this chapter as the methodology is qualitative and that the collected data are subjective.
5.4 The container road carrier industry

The form of road transport (that carried around 84% of New Zealand’s total domestic freight in 2008) is still the main freight transport mode (Upton, 2008). It is alarming that New Zealand’s heavy vehicle kilometres on road transport networks are growing at a faster rate than in the USA, the UK and in many Western European countries (Mackie et al., 2006), with the probability of an increase in empty running. For a number of important reasons, a deviation from the targeted acceptance of empty running can occur in the container transportation industry, and this can be influenced by many different factors. These factors arise from a carrier’s immediate (micro) and distant (macro) environment that influence the performance of the carrier, and each of the factors may be interrelated. For example, a shortage of truck drivers, which is a macro-environmental factor of importance, may have an adverse effect on the reduction of empty trips (McKinnon and Ge, 2006), and shape a road carrier’s strategic direction. An attempt is made here to explain these factors, which can be the variables that influence a road carrier to exploit its competitive advantage fully, and at the same time, can be increasing trends in the industry. The trends offer a company (e.g., a road carrier) both opportunities and threats to respond (Ghuman, 2010). Such unique traits make the container transportation industry different from other sectors.

5.4.1 Driver shortage problem

Driver shortage is an issue within the transportation industry of New Zealand (Oliver et al., 2003). Reasons include the fact that many drivers are inspired to move from New Zealand to Australia because of the presence there of gold and coal mines. Even pay rates are better, along with bigger and better trucks and longer driving distances. One of the reasons for the driver shortage is the cost of anybody leaving university to get a truck and trailer licence. Many years ago, the cost was around $140. Many school leavers would just obtain a truck and trailer licence. Now a licence costs around $2,500. Similar issues of capacity constraints in regard to drivers have also been observed in the US (Schulz, 2008). The driver shortage problem, combined with other constraints, may have an adverse effect on the achievement of the backloading of trucks and the utilisation of full capacity (McKinnon and Ge, 2006).

5.4.2 Truck appointment system

Another key factor shaping the industry’s structure is the design and implementation of the truck appointment system. Many ports around the world have implemented truck appointment systems such as the Vehicle Booking System (Port of Felixstowe), Truck Licensing System (Port Metro Vancouver) and Vehicle Booking System (VBS, Ports of Auckland). The reason is to handle growth efficiently in a container truck volumes. Literature on such systems is limited (Huynh and Zumerchik, 2010). Before the VBS, the trucks arrived randomly at Ports of Auckland (POAL) and no booking was required. If a number of trucks arrived at the same time, the port simply had long queues. At other times of the day, when all those trucks had left, there was no work. However, the implementation of such a system is still considered problematic for the road carriers because an appointment system means an inherently rigid flexibility on arrival at the port territory. The problems with inflexibility in the port system and its subsequent consequences in truck-sharing success are discussed in detail in ‘A collaboration framework’ below.
5.4.3 Diverse types of customers
The types of trucking customers vary and hold different kinds of expectations about service quality. The different types of customers and their diverse needs are an issue of discussion among road carriers. The first type is the customer that carriers have had for a long time. The second type of customer has many expectations of the carrier, especially regarding service quality. Finally, there is the itinerant (flipping) customer that goes from one carrier to another to make savings on their rate of payment, even though it might not equate with quality of service. Truck-sharing helps to reduce the transportation rate for participating customers (exporters or importers). The reason is that each party pays a portion of the total fare and thus the fare is divided among them based on the number of kilometres they have travelled. It is expected that ‘flipping’ customers would co-operate with the truck-sharing plan to save money. The research findings indicate that all other customers approve of the necessity for quality of service for quick delivery or the receiving of containers. Thus, they do not care much if the truck rate goes down, but they are expecting to keep a stable quality of the service.

5.4.4 Assorted value added services
Value added services are frequently considered to be part of the internal environment. The internal environment is comprised of the resources and distinctive competencies of a road carrier. Intense competition among firms in the industry affects their profitability, and value-added services add value to the standard service offering. Therefore, to win competitive business, large carriers try to offer value added services on the top of the rate-based competition. During the interviews, some road carriers suggested that they could promote or support initiatives to provide value added services, such as truck-sharing. They can do that with the full support of other carriers. Many large clients would be interested in using truck-sharing service in order to achieve carbon reduction targets because they look for the most effective ways of reaching their goals in carbon saving. Full utilisation of the available slots for a container truck helps in reducing the total vehicle miles driven by the truck driver in travelling to his destination. This is important from an environmental and social sustainability perspective as it helps to reduce carbon emissions. Usually, a truck emits many times more carbon dioxide per ton per km than other transport modes (Kim et al., 2009).

5.4.5 Utilisation of driving productivity
The industry has a trend of employing company drivers, owner drivers, or a mixture of both. Owner drivers are paid on a per trip basis and work hard. The reason is that profits are divided between the owner-driver and the carrier. The driver gets the greater share of profit. Therefore, the turn-around time for company drivers tends to be higher than that of the owner drivers in the port. It is also interesting to note that while both types of drivers are employed by the carriers to a greater or lesser extent, they may have different views towards truck-sharing. Company drivers are not much interested in a truck-sharing event. It is an extra effort for them, although the payment is the same. The payment is on a per-hour basis. Conversely, owner drivers want to maximise their income with the trucks they have. Truck drivers earn increasingly more money, the more they utilise and share the same truck for transportation with other clients.
5.5 The challenges of truck-sharing

A container truck may look like this: it has two slots in (for transporting two containers to the port) and two slots out (carrying two containers out of the port). This example only relates to the technical side of a truck. Constraints on sharing a truck are not limited to one issue; the situation is much more complicated than that. To broaden the picture, one needs to acquire a far wider view of truck-sharing constraints. Therefore, this section examines many of the potential variables that hinder truck-sharing arrangements. The challenges are listed in Figure 47.

5.5.1 Trust

The single most important thing, which carriers can do to encourage truck-sharing between one another, is to recognise the contribution of trust in relationships. Relationships develop based on the foundation of trust (Welch, 2006). Therefore, trust is necessary for effective collaboration and communication among supply chain members (Lee and Billington, 1992). To recognise the importance of trust as an indispensable part of relationship management, many respondents have argued that the success in alleviating the majority of empty truck trips depends on the extent of mutual trust among them. To clarify the occurrence of absence of trust among road carriers in detail, one respondent provided an interesting illustration. To move a container from Wiri’s inland port (i.e., a dry port) to somewhere in Auckland costs around a hundred and eighty dollars. In Australia, for the same move, it is about five to six hundred dollars. The rate is low in New Zealand because of the absence of trust among carriers. Since the profit margins are small, the collaboration of carriers would provide a smarter way of doing business. If a carrier can avoid two hours of empty running time, then there is a cost saving. However, such collaboration of effort tends to fail, especially among competitors (Asawasakulsorn, 2009).
5.5.2 Container weights
New Zealand’s exports are heavy. Timber, meat, paper and scrap steel are all heavy export commodities. However, import products are quite light in weight, such as televisions and clothes. So, for exports coming into a port, it is hard to get 2 TEUs on trucks. But Ports of Auckland (POAL) has provision for this for imports going out. If a carrier has containers going to a warehouse, such as one full of televisions or one full of clothing items, it can get 2 TEUs on a truck. In another instance, sometimes a POAL has two TEUs containers coming in containing the personal possessions of people moving overseas. These are light, and thus carriers can load two TEUs onto a single truck.

5.5.3 Dangerous Goods (DG)
Carriers carry explosives and dangerous goods. Dangerous goods have classes, based on their properties, from class 1 through to class 9. These classes include class 1: explosive; class 3: flammable; class 6: toxic; class 8: corrosive; class 9: eco-toxic; amongst others (Ministry of Transport, 2008). Carriers are prohibited from carrying classes 1A and 1B together. So, although one container may weigh only two tons, carriers cannot carry anything else on board the truck. The container is light, but it has to be carried separately. Although there are few instances where this occurs, however it does limit the number of truck-sharing possibilities.

5.5.4 Customer demands
One of the problems for carriers with their clients is a lack of understanding about what is required according to the logistics of a container. For example, a ship arrives, and the carrier has no control over when a container is likely to be unloaded. Then, because of the booking system, carriers have to book it. Carriers all try to do the best they can for their customers; this depends on how demanding clients are. Most customers want their containers as soon as they can get them to allow for a continuous flow (e.g., JIT concept). Such a propensity encourages empty vehicle running (McKinnon, 2000). The tendency reduces the truck-sharing possibilities to a minimum since anything that would restrict delivery means that carriers must have different priorities for them. Carriers prioritise customers based on the availability, and the location.

5.5.5 Site limitations
Truck-sharing initiatives must be able to overcome the site limitations of shippers. For example, vital things are major considerations when a container is going to be lowered to the ground, such as how solid the ground is and how big the storage capacity is. For information on storage capacity at company premises, see McKinnon et al. (2010). Typically their concrete is not strong enough to take a truck. Individual trucks can only take certain loads. Carriers may also have technical issues that may be caused by the layout of a property. For an example, when a carrier has a customer whose driveway is steep, and only one of its large trucks can get up the driveway to deliver the load. Site limitations are associated with container size, hazardous materials and height problems. In addition, clients might misjudge the size of the site or may not realise that a container truck can only offload from the right side. Few trucks can load from both sides.
5.5.6 Customer location

Usually, customers have many warehouses in different locations, and so their pickup locations are diverse. They can be north, south, east or west. For example, one customer may say that he wants his container delivered at seven o’clock in the morning, and he is based on the North Shore. Another client may say that he wants his container at seven o’clock, and he is in Otahuhu. Then the carrier has dissimilar geographic locations, which will make truck-sharing plans unfeasible. If the locations are in the same area at the same time, the carrier can send one container truck for both sites. Therefore, the exact geographic positions of cargoes govern the reduction of empty deadhead miles in the case of two or more shipment matching (Odijk, 2009).

5.5.7 Driving hours

Fatal crashes regularly happen because of driver fatigue, which is true for transportation vehicles, such as container trucks. Drivers are not allowed to work more than 13 hours per day (NZ Transport Agency, 2010). When they reach 13 hours, they must take a break of at least 10 hours before driving again. Moreover, there is a requirement for a 30-minute standard break every 5½ hours. Although vital, such limitations might worsen driver shortage situation, and thus it becomes increasingly difficult to process the requests of truck-sharing due to the scarcity of available drivers. Hence, restrictions on working hours may increase empty running on roads (McKinnon et al., 2010). Similarly, the study of McKinnon and Ge (2006) predicted that the application of the EU Working Time Directive to mobile workers in 2005 might reduce delivery flexibility and have a negative effect on the backloading of trucks.

5.5.8 Truck capacity

Container trucks’ capacities and mechanical restrictions that differ from others: they may use working methods that have been changed over time. The absence of a standard truck and its handling equipment makes truck-sharing difficult for carriers. Hence, McKinnon and Ge (2006) argued that the lack of standard processing equipment may work as a resource constraint on backloading chances. There are four types of truck that are most regularly available. The first one is a small truck; this can carry a twenty foot container. The second one is a scaly that can take a forty foot container or two the twenties. This type of truck has no swing lift and because of this it can carry a much heavier weight. Then there is swing lift truck that has a forty foot container capacity or two the twenties. This is a truck and trailer unit. The fourth type of truck is a mini swing that can carry two twenty foot containers and one forty foot long. This truck has an additional swing located halfway along it. There are other types of truck; for example, high productivity trucks with a trailer that have the advantage of having the ability simultaneously to carry one forty foot container and a twenty or three the twenties.

5.5.9 Port operating hours

It is important to permit additional flexibility in the schedule for backloading (McKinnon and Ge, 2006). Many of the carriers operate 24 hours a day. The Port of Tauranga and the Metroport operate 24 hours a day and 7 days a week. Ports of Auckland is a lot more restrictive as it operates twenty four hours per day, seven days a week for unloading ships. However, from Monday to Friday its road office for Fergusson container terminal is open 24 hours on weekdays but is only open from 7 am to 3 pm on Saturday and Sunday. The Ports of Auckland close one of their container terminals at 3 pm every day. For example, the Bledisloe container terminal remains open from 7 am to 3 pm every day and is closed Saturday and Sunday. Thus, Ports of Auckland does not operate twenty four hours per day, seven days a week for truck deliveries.
Usually, a decrease in timing flexibility in scheduling in the workplace leads to an increase in the empty running of trucks (Odijk, 2009). To make it easier for carriers to pick up and drop off containers for truck-sharing, the rules of operation of the Ports of Auckland need to be adjusted.

5.5.10 Export cut-off times
The cut-off time for container delivery at the port is based on the expected arrival and departure times of container ships. Thus, the operational aspects of the carriers are executed to support the servicing of all vessels arriving or departing. Because a carrier has a deadline for arriving at the port, export close of times makes a difference to when a carrier can pick up a container. Thus, a carrier does not have the option of dropping off the container at a particular time to fit in with someone else. Thus, a carrier has an export close-off time, which is a disruption to truck-sharing.

5.5.11 Competition
Respondents argue that carriers make more money from the container transportation service in Australia than they do in New Zealand. The Australian carriers’ commercial flexibility is much greater than that of carriers in Auckland because in Auckland the transportation rate is so low. There is not enough profit margin. For example, a carrier has to pick a container up with a truck, and cart it somewhere for two hundred dollars. The carrier picks it up and carts it for eighty dollars and lifts it for another forty dollars. There is not much money left with which to manoeuvre because of the full cart and the full swing. The rates are very low because of the intense competition among carriers. The intense competition discourages collaboration among carriers, which is an essential component for improving load factors (McKinnon et al., 2010). It is hard to convince carriers that working together in a collaborative environment will mean that two carriers get the benefit of three, not just one on one.

5.5.12 Demurrage and detention
In the case of imports, demurrage is charged for before the unpacking of the cargo and an arrest fee is charged following the unpacking of the cargo and until the return of the empty container (Song and Dong, 2012). Similar terms and conditions also apply to exports. The detention issue is about an empty move. If the carrier does not return the empty container quickly, then there is a penalty. Several years ago, clients had five days to move a container out of Ports of Auckland; now they have three days after which a substantial penalty fee is charged. Customers used to have twenty-one days before they were given a penalty for empty containers; now this length of time has been reduced to seven day's grace. It is a lot more restrictive, and the penalties are considerably higher. Formerly, the detention fee for a container was NZ $20 a day. Currently, it can be up to NZ $450 a day for a job that might pay carriers NZ $200 to NZ $250. Restrictive hours and their associated penalties limit the flexibility of hours for transport operations; such flexibility is required for a successful truck-sharing event.

5.5.13 Documentation
To enable the picking up of a container for truck-sharing, many documents are required to be processed prior to being given to the carrier. The accuracy and timely delivery of the documents are crucial. Currently, document processing occurs electronically. Thus, carriers are not necessarily provided with physical documentation but, nonetheless, evidence of clearance has to be available. “Cartage advice” informs what the customers want, where they want the freight to go, the nature of the container, its port of origin and the weight of it. Customers give the carrier an MAF (Ministry of Agriculture and Forestry) clearance sheet, because MAF authorises it.
Customers also give the carrier a customs delivery order, which means that customs are satisfied and that customs duty has been paid. The last piece of information, which customers will give the carrier is a PIN (Personal Identification Number). This PIN means that shipping lines have been paid. If clients do not send the carrier the correct information, the carrier has to wait for shipping holds. Some clients are good at executing their obligations; however the carrier has to follow up to obtain completion with other customers.

5.5.14 Lack of coordination
Lack of coordination among supply chain members results in poor performance, such as higher transportation costs (Lee et al., 1997). An interesting example of this is the coordination problem among the Ports of Auckland and the corresponding carriers. After joining the NZL Group, the Ports of Auckland established a subsidiary company, “Conlinxx”, to take over the Wiri facility (i.e., a dry port). Conlinxx’s offer to all the carriers was that if any carrier took a full container into the port but did not have one to come out, Conlinxx would pay $60 to bring that empty container back to Wiri. The actual cost of moving a full container out to Wiri was about $100. Conlinxx trialled the scheme about some years ago, without success. One of the few reasons was that independent carriers had no desire to work for one another due to problems of lack of coordination in operations, decision-making and their objectives. For example, road carriers being independent companies, might have conflicting goals, such as the goal of gaining market share; this might not be well-suited with the goal of increasing profit.

5.5.15 Truck appointment system
From a carrier’s perspective, one of the disadvantages of the POAL’s truck appointment system is the lack of flexibility. Flexibility is the capability to vary without penalty in terms of time, effort, cost or performance (Upton, 1995). Carriers only wish to arrive at their destination and do not want for yet another constraint in the process requiring them to be at the POAL at a particular time. Lack of arrival flexibility at the POAL reduces truck-sharing opportunities among carriers. In the past, carriers might have been able to move 300 containers in a night. Now with VBS, this is not possible, because there are insufficient slots, and carriers are restricted to the times they can enter the port. Currently, it is harder for carriers because they need to manage those time slots to move containers, and carriers are always faced with the problem of insufficient slots.

5.5.16 Container categories
There are two types of container: namely those with empty, and those with full, containers. To transport the containers, two kinds of trucks are available: empty trucks and full trucks. The empty trucks are smaller; they have small trailers, and they can carry empties only. Typically an empty truck runs with the capacity of about eight tons. On the other hand, bigger trucks can take up to around thirty tons. These two different types of fleet do not work together because empty trucks cannot handle the weight that full containers have. If full trucks carry those empty containers, then that is wasted cartage. There are big differences in the capital cost of the equipment and the type of equipment that would be used for empty trucks compared to full trucks. Thus, empty trucks can only share the truck for empty containers as they have different properties. Such separate and unique characteristics between full and empty containers limit the maximum number of truck-sharing possibilities among carriers. Moreover, carriers transport refrigerated containers, which have to be moved separately because they need motor power to keep them running. It is easier to match containers of equal size and type, but reefer containers are not matched simply (Odijk, 2009).
5.5.17 Empty depot location
Empty depots are located in many geographical areas, each with its characteristics, such as its proximity to other places (Ahadi, 2002). Since most of Auckland’s empty depot locations are in dissimilar places, they are difficult to match for truck-sharing. For example, The Ports of Auckland are in the city and carriers travel ten to fifty kilometres to deliver a full container. A carrier might pick up two twenty-foot containers. One empty truck will go to CSL Otahuhu (empty depot), and the other empty truck will go back to the city. Then the carrier is in a situation in which the truck takes the container into CSL Otahuhu. But the empty depot rejects that container since the quota is now full, and they want it to be delivered to Metrobox (empty depot). The truck goes in and gets redirected to Metrobox to dispose of it. Thus, the situation might become complicated for truckers. So, unreliability of collection and delivery locations can discourage backloading tasks in the transportation industry (McKinnon and Ge, 2006).

5.5.18 Costs
When calculating costs for a shared container truck, there are several internal cost factors to take into consideration since double handling may be involved. Every time a carrier takes a container on or off, it is regarded as two swings. When a carrier runs its swing lift truck, it uses diesel, costs time and involves maintenance costs. A swing lift operator may take about ten minutes to do one swing. A less-skilled operator may take half an hour per swing. So, a truck driver puts the container on the truck, drives the truck, swaps it off and then somebody else swaps it back on the truck. Now if the truck has no swing lift, it needs the help of one. Thus, if the truck driver brings a truck out with no swing lift then he needs another truck to swing it off unless there is a forklift or a hoist. Not all trucks can swing containers on, and that is where other issues come in. A swing lift is more expensive than a scaly. A scaly has no swing lift, but it can take heavier loads because of the absence of a swing lift. Since truck-sharing involves swinging multiple containers on and off, the calculating of cost is complex.

5.5.19 Performance measurement
Performance measurement is critical for measuring the efficiency of the truck drivers. Efficiency indicates the extent of resource utilisation to accomplish objectives (Sumanth, 1984). The GPS tracking facility has assisted carriers. Carrier have been looking at how often a driver idles, how often he brakes and his average speed. It is hard to figure out the performance of a driver when the dispatcher is from another company. This happens when a truck is being shared with another carrier. Moreover, the way, in which a person dispatches, affects the performance of drivers. If the dispatcher is less skilled, drivers are not going to do much work. If the dispatcher sends the drivers to the wrong places, or if he does not organise matters efficiently, a carrier cannot rate its drivers without bias. If a carrier does not have the same dispatcher all the time, it may not be possible to figure out the average over time. Thus, performance measurement becomes difficult.
5.5.20 Traffic congestion
Traffic congestion in Auckland City and the hassle of picking up multiple containers during peak hours causes major difficulties that may reduce truck-sharing initiatives to a minimum. Since the congestion affects strict delivery schedules and the productivity of assets, transport managers are reluctant to secure backhaul opportunities (Heriot-Watt, 2007). Traffic congestion in the Auckland area is a problem and causes loss of income, time and causes pollution (Sankaran et al., 2005). Nine o’clock in the morning is a peak on the motorway since many people are going to work. Twelve o’clock is a peak because it is lunchtime. Three o’clock is another peak time as children are being picked up from school. Five o’clock is another peak because it is the start of the homeward rush hour. These are regular peaks in traffic, but sometimes these are hard to predict. Sometimes there can be a traffic spike, caused by Christmas or other holidays. This may occur suddenly at two o’clock because people are leaving work early because of the holiday; such spikes occur randomly. Carriers can adopt strategies to avoid contributing to traffic congestion. For example, the carrier would have more time to improve vehicle use if the customers could receive deliveries at off-peak hours (Stock and Lambert, 2001). For other strategies to handle congestion, see Sankaran et al. (2005).

5.5.21 Holidays and events
A carrier also has issues such as the occurrence of holidays and events which disrupt the schedule. The ports are closed during holidays and events. For example, POAL ceases its business activities during a strike. The complex nature of these happenings may have unexpected consequences, such as limiting truck-sharing possibilities or hindering the attention necessary for the truck-sharing opportunities of carriers.

5.5.22 Relationship with drivers
A client may not want someone else coming in as a driver because they have a relationship with a particular driver. Hence, the minute the carrier puts someone else in and replaces the driver the client wanted, the carrier upsets the relationship with a regular customer. Almost every carrier has a couple of drivers whom customers like. Customers just like them because those drivers understand them, they help with unloading, and they help in ways beyond the expectation of the client. The customer is even ready to pay for a favourite driver if the driver is on holiday, to come and do a job during his time off because the client likes the driver. Since some customers do not want unfamiliar drivers to work for them, the clients may be reluctant and unwilling to work with an unknown driver in a shared-transportation event.

5.6 A collaboration framework
For road carriers, there is no commercial benefit in running empty. Some truck-sharing happens among road carriers, but this not an extensive practice. Carriers may share loads and exchange backward and forwards, but they do not share everything. There is load sharing as far as constraints allow as mentioned above. In some cases, there are technical issues (e.g., cargo carrying capacity) involved with a container truck and other constraints that cannot be controlled. This is one of the reasons a significant amount of “structural empty running” will always remain (McKinnon, 2000). It should also be noted that some constraints can be changed, treated, or modified for better truck-sharing results such as, building a foundation of trust among trucking companies. The suggested framework recognises, develops, and suggests, the essential elements of collaboration among road carriers in order to consider the interaction among the necessary elements that lead to effective company decision-making; decisions that can result in the
reduction of the number of empty trips. The propositions offered might not fully solve the empty running problem. However, McKinnon (2000) states that a small decrease in empty trips can be expected to have dramatic effects on several critical environmental conditions and benefits.

<table>
<thead>
<tr>
<th>Exogenous</th>
<th>Excluded</th>
<th>Endogenous</th>
</tr>
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<tbody>
<tr>
<td>Carrier</td>
<td>Customer</td>
<td>Port flexibility</td>
</tr>
<tr>
<td>Competition</td>
<td>Site limitations</td>
<td>Truck appointment system</td>
</tr>
<tr>
<td>Driving hours</td>
<td>Customer location</td>
<td>Demurrage and detention</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Documentation</td>
<td>Export cut-off times</td>
</tr>
<tr>
<td>Dangerous goods</td>
<td>Container weights</td>
<td>Port operating hours</td>
</tr>
<tr>
<td>Truck capacity</td>
<td>Customer demands</td>
<td></td>
</tr>
<tr>
<td>Container categories</td>
<td>Relationship with drivers</td>
<td></td>
</tr>
<tr>
<td>Empty depot location</td>
<td>Costs</td>
<td>Carrier</td>
</tr>
<tr>
<td>Traffic</td>
<td></td>
<td>Performance measurement</td>
</tr>
<tr>
<td>Holidays and events</td>
<td></td>
<td>Trust</td>
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<td></td>
<td></td>
<td>Coordination</td>
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Table VI. Boundary determination for truck-sharing constraints

5.6.1 Variable selection
When adopting a shared-transportation framework for the development purpose, it is vital to take into account the truck-sharing constraints. Table VI provides an idea of boundary for those important constraints taken into consideration. Variables are based on the transcription of the interviews and the objectives of the chapter. For example, variables, as endogenous factors, that decision makers are likely to monitor and manage are considered to be the most important candidates for selection and inclusion in a framework. It also has been taken into account that endogenous factors may have the highest impact on potential policies for truck-sharing and transport capacity management. This is to ensure that transportation services needed to maintain a minimum level of service standard are available to the companies that buy transport services. For example, carriers repeatedly report that more trust and proper coordination among road carriers would be likely to cause a reduction in the number of empty-truck trips. There is also the expectation of greater flexibility from the port authority in regard to the truck appointments system, its charges, and timing. A few variables have been excluded although they are only slightly related to the research purpose, for example, “customer demand”. Customer demand may not be much influenced or controlled by the preferences of the port authority or carriers. These might be candidates for inclusion in other studies into which they might fit better than in this chapter. The rest of the factors are treated as exogenous variables. For more information on selection guidelines of endogenous and exogenous variables, see Richardson (2011).

5.6.2 Port flexibility
The truck-sharing constraints of port-related attributes have been reported many times by carriers as important obstacles to making and finding a truck-sharing event. Research findings suggest that these constraints may be significantly related to the carrier’s flexibility. The study by Chan and Zhang (2011) defines carrier flexibility as the fine-tuning of planned delivery capabilities to match variable customer demand. The definition of carrier flexibility adopted in this chapter is the adjustment of planned delivery capabilities to match the changing uncertainties of the external environment to handle many problems such as traffic congestion or driver scarcity.
Usually, carriers give great importance to flexibility (Quinn and Rohrbaugh, 1983). The reason can be justified by the burden of lack of flexibility, as in port-related constraints providing additional obstacles for road carriers. For example, it is especially applicable to the running truck appointment system at the Ports of Auckland; carriers offer mixed reactions to the effectiveness of the appointment system. Giuliano et al. (2006) expressed similar concerns and noted that the success of the appointment system depends on the operating policies of specific terminals. The presence and properties of such a system can restrict a road carriers’ engagement in port operations and increase stress, despite the possibility of reducing the truck turn-around time.

The completion time of a task may vary widely in the container transport industry and may be difficult to predict accurately. Sometimes it may take between 10 and 20 minutes to drop off a container. This dropping off may be an issue, in which drivers may sometimes take longer than expected to discharge a container. Hence, each task may run for an amount of time that varies, from a minimum of a few minutes to half an hour. Truck drivers are punctual of necessity. However, drivers may also arrive either earlier or later than their scheduled appointment time to attend the reserved slot. For instance, 41% of trucks come either early or late to visit their bookings in January, 2012 (Ports of Auckland, 2012). A detailed picture of the variable nature of truck arrivals is shown in Table VII. The appointment system is in place to help road carriers to maximise the truck turn-time benefits while increasing the risks associated with arrival flexibility of truck drivers at the port.

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</thead>
<tbody>
<tr>
<td>Early for booking</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
<td>18%</td>
<td>18%</td>
<td>19%</td>
<td>20%</td>
</tr>
<tr>
<td>Late for booking</td>
<td>20%</td>
<td>23%</td>
<td>22%</td>
<td>21%</td>
<td>21%</td>
<td>21%</td>
<td>21%</td>
</tr>
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**Table VII.** Random nature of truck arrivals at the port
Source: Ports of Auckland (2011)

Increased flexibility may contribute to the avoidance of financial loss (e.g., demurrage and detention charges) and should be a vital part of a road carrier’s profitability. The extent of flexibility and adaptability is normally used to assess organisational effectiveness (Steers, 1975). However, due to the scarcity of resources, the port system still appears to be rigid in its dealings. It is difficult to ease this situation. For example, land is a scarce resource in many terminals (Liu et al., 2001, Cheng-Ji et al., 2011). So, McKinnon and Ge (2006:398) assured, “Efforts are, nevertheless, being made to tighten delivery schedules through the proliferation of booking-times at industrial and commercial premises and introduction of heavier penalties for failing to arrive within narrow time windows. These trends may discourage further growth in backloading.”

To summarise, the function of flexibility in the port system is intended to provide convenience and to enable the system to accept uncertainties (e.g., traffic congestion) in the external truck operations without the triggering of a penalty. The possession of greater flexibility in port operations is a powerful tool for the creation of further opportunities for truck-sharing events and a reduction in the number of empty truck trips around the port territory. Although the flexibility offers benefits for truck-sharing, no system is without its challenges. Challenges can be overcome through the awareness of flexibility and the justification of cost and benefits analysis. Hence, before the consideration of the investment, decision makers (here, the port authority) should first cautiously assess the impact of increased flexibility on profitability or efficiency (He et al., 2011). Opportunities for flexibility may come from many different sources. The port authority can consider one form of flexibility: timing flexibility in scheduling, such as
in demurrage and detention, export cut-off times, and port operating hours, as shown in Figure 48. In these cases, flexible work schedules could operate to meet the needs of carriers towards creating, building, and retaining a positive attitude for truck-sharing. In particular, backloading is feasible only when a schedule is sufficiently flexible (McKinnon and Ge, 2006).

![Diagram](image.png)

**Figure 48.** Flexible port policies as a driver for truck-sharing

### 5.6.3 Performance measurement
Addressing flexibility issues in port operations is important. Some other carrier-related variables (four major factors that have been frequently reported by carriers) as referenced in the boundary determination table, can also help to drive more effective collaboration towards truck-sharing. Joint performance measurement is one of those critical carrier-related variables that can be designed, developed and implemented for better truck-sharing outcomes. Therefore, analysis of joint performance measurement is an important component; it has been included here to cultivate a more positive attitude to truck-sharing among road carriers.

Carriers need to understand how to make joint decisions for specific needs and to work effectively by establishing and improving collaboration and making use of all the available information. Many authors address the importance and support the idea of joint performance measurement for collaboration (for an example, see Min et al., 2005). Most previous studies of performance management are single-company oriented (i.e., within the organisation) (Beamon, 1999). However, many of the interview respondents stated that it is important to measure the performance of the participating road carriers in a truck-sharing arrangement. The reason is to explore the areas where attention and improvement are required and especially to quantify the efficiency and effectiveness of the individual driver of the respective road carrier. The study by Neely et al. (1995) expressed similar concerns. A Performance Measurement System (PMS, for more information, see Papakiriakopoulos and Pramatari, 2010) for evaluating truck-sharing performance is expected to have a profile of users. The users are exporters, importers and truck operators. The profile can be based on their preferences and past trip histories of slot sharing (e.g., number of accepted slots, number of offered slots, user ratings). The PMS can evaluate the performance of truck drivers based on their past participation in shared trips. The carriers can use those data for performance measurement. By sharing performance data, carriers can explore possible bottlenecks and can take action to improve those areas to influence overall performance.

However, one of the obstacles to successful implementation of a collaborative performance management system is the complexity of developing suitable performance measures (Busi and Bititci, 2006). A performance measure is a single or composite piece of information given to the company management with which to compare and contrast the quality of an outcome (e.g., a truck-sharing event). For example, a few respondents provided specific examples for developing
such variables of interest in a truck-sharing PMS as shown in Table VIII: reduction in the number of empty trips of a truck, carbon emission savings, capacity utilisation of a truck and cost saving. Many studies emphasise that a PMS should have both financial (e.g., cost saving) and non-financial data (e.g., capacity utilisation of a truck) (Kaplan and Norton, 1995).

<table>
<thead>
<tr>
<th>Performance measure</th>
<th>Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty trips</td>
<td>Number of empty trips reduction by a truck</td>
<td>Daily</td>
</tr>
<tr>
<td>Emission savings</td>
<td>Emission savings for reducing empty trips by a truck</td>
<td>Daily</td>
</tr>
<tr>
<td>Capacity utilisation</td>
<td>Number of slots remaining empty in each trip</td>
<td>Daily</td>
</tr>
<tr>
<td>Cost saving</td>
<td>Cost saving for truck-sharing in a trip</td>
<td>Daily</td>
</tr>
</tbody>
</table>

Table VIII. Expected performance measures in a truck-sharing PMS

One interview respondent provided an example of the way in which a PMS can be designed in a collaborative truck-sharing environment. The idea was also supported and discussed thoroughly by some of the other respondents. Carriers can monitor the performance of their truck drivers because trucks have GPS units that give managers live data on fuel burning, carbon emission savings, the level of force used in braking, how much wasted drivers time has been incurred and truck slot utilisation. All can be accomplished electronically using telematics, which is useful to enable, expand, and optimise collaboration with improved connectivity for better transport management (Mason et al., 2007). Therefore, due to the superior visibility of transport operations, telematics makes it easier to communicate with the driver and the base to organise backhauls (Department for Transport, 2003a, Department for Transport, 2003b). For example, for every job that is allocated to a truck number, managers can see live KPI reports on how well a truck driver is doing compared with somebody else. The manager publishes that data on a big screen every day, so the drivers can see live at lunchtime how well or poorly they are doing. For instance, the number of deliveries they did for the period. If it is 8:30 pm and drivers started at 5.00 am that morning, one driver might see that he has done one job although everyone else has completed five. Automatically he can see how his performance compares with that of others. Only a few large carriers measure the performance of truck drivers in this way; this could be copied by other carriers for measuring the performance of truck-sharing events in a collaborative culture. Performance management of a driver would be important in working jointly in a truck-sharing arrangement and would have an impact on the business in a competitive environment.

The study of Simatupang and Sridharan (2002) recommended a generic process to measure performance in a collaborative setting. According to Papakiriakopoulos and Pramatari (2010), that generic process involves (1) design of the PMS, (2) presence of a common information sharing and resource allocation system for all involved parties to support the PMS, (3) availability of incentives and (4) continuous improvement of performance measures. To sum up, it has been briefly discussed here how PMS for a truck-sharing event works as a way of recording the performance of the drivers on container trucks using telematics. It also discussed the way in which identifying variables can be used to access the performance of drivers in order to updating the overall performance of a truck-sharing event. But, the last two decisive factors of the study of Simatupang and Sridharan (2002) are beyond the scope of discussion of this chapter.

5.6.4 Trust
The majority of respondents believed that the presence of trust among carriers is essential to truck-sharing success due to the competitive market structure. Following the importance, lack of
trust among partners is the reason for less success in dyadic relationships than intended (Sahay, 2003). Sufficient trust needs to exist to overcome the risk that one party will not exploit the weaknesses of another party (Svensson, 2004). A mechanism should be in place to encourage road carriers to follow, assess and establish trust among them. However, Naesens et al. (2007) argue that a specific context-oriented model on how to establish and sustain trust is not available in the supply chain management literature. Thus, the question arises as to how a road carrier can develop trust for mutual benefit. One respondent explained how trust develops between a larger carrier and a smaller carrier in the container transportation industry.

![Figure 49. A relationship-building model for road carriers](image)

5.6.4.1 A trust building model. Building trust is like making many small deposits in the bank account as part of long-term planning. Trust takes time to develop and establish among larger and smaller carriers as can be seen in Figure 49. Sometimes some larger carriers pull resources from smaller carriers and exert influence and bargaining power (for more information on bargaining power, see Cool and Henderson, 1993, Handfield and Bechtel, 2002) because of the relative size of the larger carrier. It starts off at the beginning of the year when a larger carrier might have an urgent job that they cannot cover using their trucks. Some of them have close relationships with a few smaller carriers. They will utilise whatever fleet those smaller carriers have available to assist them. In other cases, the larger carrier will phone around other companies (especially, the smaller carriers with whom they do not have any direct competition), ask the charge for the job and plan to start a working relationship with assessing the costs (e.g., charges to be paid to the smaller carrier) and benefits (e.g., payments about to be received by the larger carrier). This is called calculative trust as carriers decide to form the relationship based on a cost-benefit analysis (Paul and McDaniel, 2004, Ghosh, 2008). The involved parties aim to maximise their gains and minimise their losses in their transactions (Kramer, 1999).

The other company, if they are sufficiently rational, economically, will see the advantage of the volume that the larger carrier is offering and the benefits that may be accrued. Smaller carriers lose money if trucks are running empty on one leg of the journey. For every kilometre that a truck is running empty, deadheading costs are generated. If the larger carrier finds an advantage after one or two trips, the smaller carrier will benefit from an increase in volume. That is how such a project starts, and it grows from that. This is called competence trust, which is based on the belief that the smaller carrier is capable of doing what it says it can do (Butler and Cantrell, 1984, Butler, 1991, Paul and McDaniel, 2004). It is rational to form a collaborative relationship if the road carriers (i.e., parties) perceive the capabilities (e.g., technical, operational or financial) of each other (Ghosh, 2008).
There are some smaller carriers that see no benefit in such an undertaking, and they prefer to avoid them. Such attitudes are slowly disappearing in the industry; this is a good sign for all carriers. There will always be large carriers in the market, and it is better to start a relationship that is explicitly based on rational trust, which is the degree to which one carrier experiences a personal attachment to another carrier (Paul and McDaniel, 2004). It develops, perhaps, because of good will trust (Sako, 1992).

5.6.4.2 An illustrative case study. This case study presents the way in which two road carriers (one larger and another smaller) created new service markets by truck-sharing with each other and together developed mutual trust. The reason is to earn profits in the competitive market of container transportation in Auckland. The larger carrier would sometimes contact dispatchers at the smaller carrier, to inform them that one of their trucks was at the site, and whether they (the smaller carrier) had any opportunities of their trucks running empty one way. If the smaller carrier were in this position, then the larger carrier would say something like ‘...got a truck going now, coming off empty, and could we put a container on your empty truck to get it out to here, or wherever your truck is going...?’ or vice versa. On the other hand, if the smaller carrier’s truck were out somewhere, the smaller carrier would call the larger carrier, and the more major carrier would find work out there. This is because of the high volume of trucking space that more major carrier has and that it can work in many locations. It is an excellent opportunity for both the smaller and the larger carrier. The larger carrier uses set transporters at certain times. Thus, on a day when the larger carrier may only utilise two or three providers, something happens such as the port closing down for a week, then the larger carrier needs all the work it can find. Idle trucks cost the larger carrier dearly. They rely on the smaller carrier to save money. The reasoning is obvious. The larger carrier does not want to give away all its advantages. If the smaller company is aware of something that will benefit them as well, they will benefit from the opportunity. The relationship between the smaller and the larger carrier is based on trust.

5.6.5 Coordination
Road carriers do not operate in isolation. If a carrier does not find a partner company with whom it can share resources, it faces a number of problems, such as the failure to improve service delivery for customer satisfaction. Conducting business in isolation can prove harmful to business profitability over time. However, it takes time to build a quality relationship.

Currently, many carriers in the industry today have been in the business for a long time. Carriers are selective of which customers or information, they will let other carriers have access to because they have to make sure that they have a contract and proper coordination procedures in their actions, objectives, decisions, and information. The act of merging these elements together is called coordination (Ghosh, 2008). Proper coordination of road carriers is important. It helps to achieve supply chain goals (Simatupang et al., 2002) and to realise optimal performance because most companies (i.e., the road carriers) are independent organisations with conflicting business objectives (Zimmer, 2002). Such conflicting goals can overlap; although, in most cases, they do not align with the general business objectives for each of the collaborating road carriers. This may lead to higher transportation costs as a result of a lack of proper coordination among them (Lee et al., 1997).

A coordination mechanism ensures that decentralised and independent organisations can act like a centralised one (Zimmer, 2002). The study by Simatupang et al. (2002) suggested four different modes of coordination: logistics synchronisation, information sharing, incentive alignment and collective learning. Some respondents emphasised their view that it should be the
information sharing leading the process of coordination for all carriers. Some examples are given here to illustrate that information sharing provides the necessary mutual gains for the carriers. These are examples of the type of information sharing that frequently takes place among them. What all these given-examples show, other than how different types of information coordination efforts have been used to help each other in the delivery of operations, is that further opportunities exist for the increase in coordination among carriers and the potential to gain further efficiencies in truck-sharing.

5.6.5.1 Information sharing. Carriers regularly share relevant information with each other, and the larger carriers have access to a variety of high-tech tools to facilitate information sharing on a structured basis. The importance of sharing information is considered as an essential component of collaboration (Mason et al., 2007). The overall supply chain performance is optimal when information is shared in an integrated environment in order to facilitate the dissemination of information to decision makers (Shah et al., 2002). A sufficient amount of sharing of relevant information ensures the proper coordination of activities among carriers. Many of the real world examples of information sharing applications in the literature are viewed from the perspectives of manufacturers and retailers (for examples, see Simatupang et al., 2002). Very few examples come from the container transportation industry. Therefore, an attempt is made here to deepen the understanding of the nature and importance of information sharing among carriers.

Sharing information allows carriers to keep informed of new changes in the environment, such as recent changes in Road User Charges (RUC) in New Zealand. Whereas, beforehand, a truck driver could buy a road user licence for the tonnage that he had on his vehicle. A driver could buy a 15 ton sticker or a 20 ton sticker, depending on the weight carried. The government changed the rules. If a vehicle could carry 25 tons, then it must display a 25 ton label at all times. Road carriers did not lower the RUC’s. There was considerable information sharing among carriers about what the carriers were doing and how they were doing it. For example, whether a carrier should go for 6 wheelers or whether a carrier should go for 8 wheelers and the weight they could carry. There was a frequent amount of sharing information about what they were doing. They asked questions such as ‘Are we doing it better?’ and ‘Which is the best configuration to use?’ Such information sharing continues to takes place among carriers.

Another excellent example of information sharing is the VBS. The vehicle booking system at the port gave rise to a lot of communication between different carriers. They began talking to each other: discussing such matters as the downside of their business, how it was to be managed, how many more people would be required to manage it and what would be their anticipations. So, RUC and VBS were the two most popular topics of conversation amongst carriers. The goal of such sharing and dissemination is to facilitate the distribution of relevant, timely, and classified or unclassified information (Wang and Strong, 1996).

5.6.5.2 A truck-sharing scenario. The users of a truck-sharing service are assumed to be independent. However, private trucking companies with different business objectives, courses of action, and aims can vary from carrier to carrier. Typical objectives are profit maximisation, market growth, and customer satisfaction. Along with such diversified objectives, the road carriers have decentralised organisational structures in which daily operations and decision-making responsibilities are delegated to organisations. Around two hundred and fifty trucking firms are registered to continue with business operations at the Ports of Auckland.

A truck-sharing event requires extensive information sharing among these large numbers of decentralised road carriers and their diverse customers (exporters or importers). For example, it
requires the provision of preferences (e.g., a maximum deviation from the direct route to pickup or drop off any empty or full container and the highest number of stoppages where the driver will stop the truck) of the drivers and the requirements (e.g., departure and destination points of the containers) of the exporters. So, truck-sharing needs proper data sharing selection mechanisms and a complete knowledge of the issues, such as cost, risks involved, and quality of shared data. Addressing these concerns affects the degree of success in relationships (Ghosh, 2008).

5.7 Managerial implications

Given the importance of exploring and describing container truck-sharing constraints, the objective of this chapter was to investigate the feasible truck-sharing opportunities and their limitations. In order to increase understanding of the influences affecting road carrier motivation towards shared-transportation, the findings of this chapter provide insights. These insights have implications and are relevant to business practitioners in the container transportation industry:

- Just relying on a road carrier’s success by depending on the firm’s assets (e.g., number of container trucks) may not be sufficient to enhance its profitability and competitiveness in the long run. Collaboration is the key in most cases. Many issues negatively affect a collaborative truck-sharing initiative and a majority of those are completely out of the road carrier’s control, such as the impractical expectations from a carrier of a customer, the presence of different container types and the site limitations at the premises of the shippers.

- The chapter provides examples of operational inflexibility for carriers; these may result in poor collaboration in achieving the desired results of successful truck-sharing, such as the possibility of running out of time to attend the booked slot of the appointment system; creating dissatisfied customers by imposing demurrage charges; failing to reconcile export cut-off times; or the slowing down of operations because of strict port operating hours.

- The collaboration framework is developed based on the exploration of the roles of port flexibility and the impact of developing a joint performance measurement system, and establishing trust and coordination among road carriers for truck-sharing success.

- One of the few already operational examples of successful collaboration efforts among road carriers is evident in the industry for truck-sharing. Such a real-life example is based on developed trust to earn profits in a competitive market. This is an interesting result as it implies that further opportunities, to increase collaboration among road carriers, may exist; and added efficiencies may be potentially realised and achieved by helping carriers to follow the given relationship-building model towards developing rational trust.

5.8 Conclusion

The first chapter concludes that, to a certain extent, the empty trips problem represents an opportunity to solve the transport capacity shortage problem at container terminals. Therefore, the previous chapters focus on different aspects of the empty trips issue using the truck-sharing concept to increase container transport capacity. In particular, the third chapter suggests promising solutions (e.g., truck-sharing concept) to reduce empty truck trips; the fourth chapter develops a truck-sharing mechanism. However, to focus on the implementation and practical aspects of such a truck-sharing mechanism, this chapter notes that earlier studies have either ignored the exploration of obstacles to the practicality of truck-sharing initiatives or have not been planned to observe and suggest a collaboration framework to overcome the inherent constraints in truck-sharing initiatives. In accordance with that significant fact, the findings from
the supply chain collaboration literature and maritime logistics studies confirm that there is a gap in the literature. There is little empirical support for explaining the existence of coordination problems among carriers to mitigate or lessen the problem of empty truck trips.

In order to fill this research gap in the supply chain collaboration literature and maritime studies, the objectives of this chapter are to explore the application of truck-sharing challenges and a successful way to deal with them to help practitioners gain knowledge of shared-transportation. This is facilitated by: (1) understanding the industry trends (opportunities and threats) affecting the trucking industry; (2) considering collaborative arrangements between road carriers and non-controllable constraints in maximising truck utilisation to include more collaboration and effort towards truck-sharing success; and (3) exploring the roles of some significant truck-sharing constraints that can be changed, treated, or modified for better truck-sharing results, such as building a foundation of trust among trucking firms, or sustaining coordination among road carriers. Based on the idea of real-life obstacles to container truck-sharing initiatives, and integrated with earlier research, this chapter was conducted through the interviewing of carriers since truck-sharing success requires supply chain collaboration.

Research findings of this chapter show that port-related attributes, such as improving flexibility in the truck appointment system, demurrage and detention, export cut-off times, and port operating hours, have been reported many times by interviewees as main constraints against truck-sharing. Secondly, although addressing flexibility issues in port operations is important, developing a joint performance measurement system can also help to drive more efficient collaboration towards truck-sharing. Thirdly, interviewees have mentioned that, due to the competitive market structure in the transportation industry, the presence of trust among carriers is essential to truck-sharing success. Lastly, some objectives of the carriers do not align with the business objectives for each collaborating carrier. The non-aligned objectives may lead to higher transportation costs as a result of lack of appropriate coordination among them. These truck-sharing constraints can be adjusted for better truck-sharing results. Thus, the proposed framework has the potential to be used at ports in the maximisation of truck-sharing efforts.

Since the evolving system-wide capacity shortage is a problem facing many ports of the world, the full utilisation of the empty slots of container trucks has the potential to increase transport capacity. Therefore, the identified truck-sharing constraints can be further tested for other ports of the world to fine-tune them for particular contexts and to make these claims applicable to a broad range of scenarios. Hence, a limitation of this chapter is the context-based findings, which reflect the container transportation industry of New Zealand (NZ).

However, some of the findings seem to appear particularly applicable to New Zealand’s situation. For example, as stated before in Section 5.5, the lack of trust between carriers may be a problem for truck-sharing initiatives. So, the presence of comparatively more seaports in New Zealand, relative to population, can make the transport industry more competitive as well as decreasing trust, and therefore decreasing the truck-sharing potential. Specifically, New Zealand has a total of 13 commercial ports. Conversely, Australia which has five times more population than New Zealand, has only 6 container ports. Such a competitive transport market (and associated truck-sharing challenges) may be a distinctive situation applicable to New Zealand.

As stated previously, other findings such as the presence of a physical characteristics of a truck may make a truck-sharing task difficult. Therefore, these are the specifications (truck types in Europe: Euro 1, Euro 2, Euro 3; truck types in NZ: b double, super b double, long b double) of a truck that can vary from country to country. Still, however, they exist to a certain extent in all countries. In this sense, limited generalizability may be possible. Therefore, more quantitative studies are required for a more comprehensive understanding on truck-sharing constraints.
Chapter 6: Measuring truck-sharing benefits to reduce empty truck trips

6.1 Introduction
Since an evolving system-wide capacity shortage is a problem facing many of the ports of the world, the full utilisation of the empty slots of container trucks has the potential to increase transport capacity. Therefore, the first chapter argues that a potential way of increasing road-side transport capacity is to lessen the number of empty truck trips in order to facilitate the transfer of an increased number of containers using the same number of trucks. The third chapter suggests promising solutions for reducing the number of empty truck trips, and the fourth chapter extends the truck-sharing concept from the alternatives provided; the chapter also develops a truck-sharing mechanism. The truck-sharing mechanism developed in the fourth chapter is referred to as Truck-sharing Service (TSS). In other words, the fourth chapter proposes a reengineering of the truck appointment system (for information on truck appointment systems, see Giuliano and O’Brien, 2007, Huynh and Walton, 2008, Namboothiri and Erera, 2008, Guan and Liu, 2009) to introduce a dynamic truck-sharing process. The process proposed, in contrast with one-company-based optimisation, is the development of a transportation model to achieve the system-wide optimisation (to account for all road carriers in the trucking industry). The aim is to facilitate the maximum number of containers that can be transported using the same number of container trucks. Hence, the suggested model aims at maximising the utilisation of container trucks entering/leaving the port gates. It is important to note, that although the fourth chapter has examined the empty trips problem from a supply chain perspective in order to suggest a promising solution, it has not quantified the benefits of the proposed truck-sharing model.

Therefore, to quantify the effect of the truck-sharing model on the potential for the improvement of transport capacity and its related carbon emission saving possibilities, the research question to be answered in this chapter is: How will the case study port’s transport capacity be affected by different scenarios? Hence this chapter simulates the truck-sharing model to observe whether, by comparing different scenarios, the selected port’s transport capacity will be affected. In designing scenarios, this chapter analyses the truck-sharing model as a to-be process compared with the appointment system as an as-is process. Comparisons are performed to reveal the compared impacts on: the utilisation of empty-truck capacity, the number of empty-truck trips, carbon emission savings, and the throughput of containers at the gate entrance of a port. In this chapter, for brevity, “the case study port” is hereafter termed “the port”.

In brief, the simulation is important in order to justify the rationale that the truck-sharing concept has the potential to improve transport capacity. To achieve this research objective, a case study approach is adopted in this chapter; this draws upon both primary and secondary data sources. The chapter outcome will provide insights into the potential benefits of truck-sharing. Empty-truck hauling is not a new issue in the freight and transportation industries; evidence of empty truck running is available from many of the world’s container terminals, as stated before.

6.1.1 Organisation of the chapter
The rest of the chapter is structured as follows. The following section reveals the relevant literature. The methodology is then described, and a case study is explored. The points described in the next section represent the implications of this chapter. The final section provides a brief synopsis of the findings of this chapter.
6.2 Literature review

6.2.1 Relevant literature
As discussed in Chapter 4, academic research that addresses the empty-truck trips problem from a supply chain perspective (in which all truck operators have an equal chance to contribute to the optimisation of the whole supply chain) is still scarce in contrast with the typical one-company-based optimisation. For an example of single-company-based optimisation approach, see Carlsson and Rönnqvist (2007). The objective is to optimise its internal resources and leverage on its capabilities to meet the business needs. Conversely, on the empty container management problem, extensive studies have been conducted (for examples of the empty container management problem, see Großkurth et al., 2011, Dang et al., 2012, Xu et al., 2012). However, it should be noted that both problems (empty container management problem and empty trips problem) are focused on the improvement of asset utilisation in order to achieve a higher level of performance in operations. Accordingly, to close the research gap that exists in the literature on issues related to empty trips, the research that is most closely related to the objective of this chapter was written by Dekker et al. (2012). This research, described in Chapter 3, introduced a Chassis Exchange Terminal (CET) concept from a regional-level cooperation perspective and presented a simulation study to better understand the behaviour of the proposed system. A review of the simulation results of the study confirms that the concept minimises the number of empty-truck trips, increases utilisation of truck capacity and reduces the environmental impacts. That study presents a model that allows individual (separated from each other for joint decision-making) carriers to participate in the port-oriented transport process (e.g., import and export). However, the suggested model relies on structural mechanisms (requiring significant capital investment) to increase the utilisation of truck capacity. For example, the development of the CET requires an area of land; land is scarce in many of the terminals of the world (Liu et al., 2001, Cheng-Ji et al., 2011). For more detailed information on the CET concept, see Section 3.3.3, “The Chassis Exchange Terminal (CET) concept”.

6.2.2 Major contributions of this chapter
In order to demonstrate to port stakeholders the benefits they can gain from implementing the truck-sharing idea; this research measures the potential of the truck-sharing concept using a process simulation approach. Process simulation helps to find the optimal solution to the original problem (Islam and Ahmed, 2012). Following the increase in the importance of simulation modelling for the quantification of the proposed benefits, the application of Business Process Simulation (BPS) is increasing in the service sector (Greasley, 2004), such as in: ports, hospitals, banks, hotels and call centres. The reason for this is that, for example, in the case of a port, it is difficult to test alternative configurations of the port processes without simulation because of the complexity of the connected, interdependent and stochastic port variables. Therefore, the quantification of the reengineering effects is considered one of the important reasons for justifying the application of simulation into process modelling (Doomun and Nevin Vunka, 2008). This fact is clearly evident from an examination of the growing number of case studies in many other disciplines beyond ports, as shown in Table IX: Greasley and Barlow (1998), Verma et al. (2000), Aksu (2001), Greasley (2003), Greasley (2004), Lam and Lau (2004), Shim and Kumar (2010), Bertolini et al. (2011), Groznik and Maslaric (2012), to name but a few. In all of these studies, the reason for the use of simulation is to evaluate the alternative process configurations produced by, or for, the decision makers (e.g., port authorities and transport managers) (Chase et al., 1998, Fowler, 1998).
<table>
<thead>
<tr>
<th>Study</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greasley and Barlow (1998)</td>
<td>A case study of a reengineering project of a police force</td>
</tr>
<tr>
<td>Verma et al. (2000)</td>
<td>A case study of a redesigning function of a bank</td>
</tr>
<tr>
<td>Aksu (2001)</td>
<td>A case study of a reengineering task of a hotel</td>
</tr>
<tr>
<td>Greasley (2003)</td>
<td>A case study of a reengineering project of a police force</td>
</tr>
<tr>
<td>Bertolini et al. (2011)</td>
<td>A case study of a reengineering project in a hospital</td>
</tr>
<tr>
<td>Groznik and Maslaric (2012)</td>
<td>A case study of a reengineering task of a supply chain</td>
</tr>
</tbody>
</table>

**Table IX. Examples of application of simulation in process modelling**

The truck-sharing idea is considered here as a potential mechanism for sustained improvement in transport capacity and carbon emission reduction. However, Just like the simulation studies mentioned in the above subsection to justify the importance of process simulation in reengineering approaches, further analyses were conducted among these studies to confirm the research gap. For example, as far as the researcher is aware, the use by the carriers or port authorities of the truck-sharing model, has never been measured or simulated under the conditions assumed (a collaborative scenario as opposed to a non-collaborative scenario) and in accordance with the procedures (the truck-sharing idea) suggested in this chapter. In supporting this assertion made here by the researcher, Huang et al. (2008:247) further confirmed and stated, “Little work has been done in container terminal capacity analysis using simulation”. This quotation implies that the application of simulation modelling in port capacity management demands further research in order to drive more productivity gains at container terminals.

![Figure 50. Major contributions of this chapter to the literature](image-url)
While further narrating different aspects of the literature review in the earlier paragraphs of this section, an attempt has also been made here to explore another research stream relevant to the objective of this chapter. These are studies related to the truck appointment system, since the truck-sharing model has been developed based on the application of the slot booking system. Therefore, the truck-sharing model is appointment system dependent and takes into consideration the operating rules of the port. The fundamental theory behind any truck appointment system is the matching of service demands to all available capacity at the port gate or yard entrance. However, to the knowledge of the researcher, none of the research studies has attempted to deal specifically with the issue of developing or testing simulation models that address the empty truck hauling problem and use the idea of integrating the truck appointment system and shared-transportation. For example, to justify the fact, see the research papers that are truck appointment system related: Ioannou et al. (2006), Giuliano and O’Brien (2007), Namboothiri and Erera (2008) and Asperen et al. (2011). In contrast to these studies mentioned here, in this current chapter, the researcher tests and analyses simulation results to justify the degree of effectiveness (potential benefits) of the truck-sharing model in reducing the number of empty trips. In examining all these issues altogether, a picture of the research situation of the existing knowledge is derived as a connected whole and the advice of closing the gap is proposed to show the contributions of this chapter in the literature (Figure 50).

![Figure 51. Examples of asset utilisation in many types of service industries](image)

### 6.2.3 Mechanism of the reduction of empty-truck trips

Of course, the impact of the empty trucks problem is not just limited to freight transportation; it has also had prolonged exposure and is widely visible in human passenger transportation (Peetijade and Bangviwat, 2012). For example, as stated previously in Chapter 3, airlines use code-share agreements to help fill thousands of empty seats on costly flights and to realise maximum potential revenue (Abdelghany et al., 2009). The use of code-sharing agreements by air companies confirms that, even in the capital-intensive and competitive airline industry, collaboration happens and is now a focus for the sharing of assets and the improvement of asset
utilisation to reach full profit potential (e.g., sales offices and facilities) (Czerny, 2009). Taking that as an interesting example, there may be more similarities than differences between the airline industry and the trucking industry, such as high fixed costs for operations and a lower proportion of variable costs, constrained service reliability under stochastic customer demand due to fluctuations in demand, and a limited quantity of slots that generate cost if they remain empty throughout the day or during each service period. For similar reasons to those in the airline and trucking industry, many ocean carriers in the sea-cargo industry (such as Sea-land and Maersk) have formed alliances with the aim of realising mutual gains by reducing the number of empty container movements. Such a reduction will lead to improved asset utilisation and the enhancing of performance levels (Kempf et al., 2011). The illustrations from such industries provide examples of the way in which asset utilisation initiatives by collaborative engagement can be used to improve financial benefits (Figure 51).

Because of its operational complexity and the involvement of many independent carriers both large and small, the issue of empty truck running is expected to be solved in a planned manner. A certain amount of operational complexity arises here due to the degree of self-interest of some carriers which results in the avoidance of benefits for the efficiency of the whole supply chain (Dowd and Leschine, 1990, Maloni and Jackson, 2005). In addition to the whole operational complexity issue, mutual trust is another issue of concern as companies may not be keen to share the information necessary for collaboration. Despite these obstacles to the achievement of specific system-wide benefits, as stated previously in Chapter 4, a possible approach is the development of an information exchange centre; this would be used to interchange facts for service demand and service capacity to enable recognition of the many possible matches for truck-sharing initiatives. Although the shippers, whether exporters or importers, may be unknown to each other, their cargo destinations may share similar routes. Hence the shippers could share the same truck in the drive to gain full capacity in order to develop collaboration practices. So, the idea of sharing information among carriers and shippers is regarded as a contributing factor towards the effective reduction of empty trips (Peetijade and Bangviwat, 2012). The successful operation of an information exchange centre could be facilitated by the establishment of an internet-based collaborative initiative.

As stated previously in Chapter 3, examples of collaborative logistics networks that are internet-based collaborative initiatives are: Nistevo, Transplace and One Network Enterprise (Özener and Ergun, 2008). For example, after successfully joining Nistevo’s network to form a collaborative partnership with other companies, Georgia-Pacific’s empty running was reduced from 18% to 3% (Özener, 2008). This percentage reduction corresponds to a yearly saving of $11,250,000. Such load matching services include a range of items from the customary telephone and fax services to the more recent web-based facilities that have become common. Examples of these include: online auctions, bulletin boards, and tendering services (Lewis, 2002). For more information on collaborative logistics networks, see appendix A. However, the study by McKinnon and Ge (2006) suggested that there is a gap because of the absence of any systematic valuation of effects of such load sharing services on the reduction of empty trips. In order to close the gap that exists in the literature, this chapter contributes further with its objective of exploring the effects of measuring the benefits of load matching on empty trips to the port.
6.3 Simulation methodology

The research question for this chapter is: How will the case study port's transport capacity be affected by different scenarios? From a methodological point of view, there are alternative approaches to answer this research question. For example, researchers may interview experts in the overall understanding of the truck-sharing benefits to the port and the environment following the implementation of the truck-sharing concept. An expert has a specialised knowledge in a particular area or discipline (Littig and Pöchhacker, 2014). It would be difficult, though not impossible, using this approach to quantify the welfare of those (road carriers and the port) affected by the truck-sharing concept. Another potential approach would be to use pilot studies or controlled experiments within an organisation (such as a road carrier). However, the problem with this approach is that it requires considerable amount of resources and is quite time consuming in some cases (Kellner et al., 1999). Therefore, the other alternative is to carry out a simulation of a process. This argument has been confirmed by the study of Höst et al. (2001).

In order to answer this research question, a simulation methodology has been adopted; this is because computer-based simulations are graphical visualisations of processes that can be dynamically observed, statistically analysed, and reconfigured into many different process scenarios (Paul et al., 1999, Bosilj-Vuksic et al., 2003). A successful simulation can be used to conduct experiments for comparing and contrasting alternative scenarios (Lin et al., 2002, Harmon, 2003, Mashhour, 2010, Suzuki et al., 2012). Therefore, alternative scenarios are compared against the baseline model for the analysis of time, cost, and the resource aspect of a business process to aid in business decision-making and optimise operational performance (Bhaskar et al., 1994, Aguilar et al., 1999, Jaklič et al., 2003).

Many studies further show the importance of process simulation to address process improvement issues: analysing process dynamics, creating accurate dynamic models, taking into account the uncertainties of random variables of the process, and evaluating reengineering projects to assess cost, cycle time, serviceability and resource utilisation. The study reported by Robinson (2004) listed several other potential benefits of computer-based simulations: allows the experimentation with new ideas without taking any risks; helps to cultivate better understanding of a system, and provides a way to communicate ideas (the to-be process) with others. A more detailed list of benefits can be found in the study of Banks (1998), and Banks (2005). These benefits have also been confirmed by many other studies in the literature. For examples, see Pegden et al. (1995). Paul et al. (1998), Hlupic and Robinson (1998), Hlupic et al. (1999), and Sierhuis et al. (2003). Because of these unique benefits, simulation modelling is one of the most widely used methodologies for measuring system performance in management science (Law and Kelton, 1991). Therefore, Maria (1997:7) assured, “Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilisation of resources, and to optimise system performance.”

In brief, the following are the circumstances under which simulation is the appropriate tool to use: (1) simulation enables the study of complex systems, or subsystems of a complex system; (2) many types of organisational, informational, and environmental changes can be simulated using the models, and the effects of those changes can be measured and evaluated; (3) valuable knowledge is gained during these simulation runs, and this knowledge can be of importance in improvement of current organisational processes; (4) simulation allows the researcher to interactively change the values of the input variables, and this procedure helps to identify the most significant variables that represent the dynamics of the process; (5) simulation runs can be used to test analytical models, and their results; (6) simulations can be used to test alternative
scenarios, and a simulation run helps to do an experiment based on what-if analysis; and (7) simulations can be used for learning purposes without interfering with the current process. These points have been discussed extensively in the literature. For an example, see Banks et al. (2009).

A brief description of each situation is listed in the study of Banks and Gibson (1997) along with suggestions as to when, and when not, to use a simulation. For example, some situations when simulation should not be used include: the problem can be solved by using common sense; the problem can be solved analytically, and the problem can be solved by performing direct experiments on the real system. The most widely used varieties of simulations are: discrete-event simulation; system dynamics; hybrid models (combining two or more simulation approaches), and agent-based simulation. The basic differences between system dynamics and discrete event simulation can be found in the study of Tako and Robinson (2009), and the following table (Table X) presents the differences. An illustration of the differences between these three approaches can be found in Table XI.

As noted, however, the literature on the application of SD to seaports is limited (Cheng et al., 2010). A potential weakness of the SD methodology, is of course, that caution should be used when interpreting SD models, because it is also easy to make a dynamic hypothesis based on incorrect or inadequate information and lack of technical expertise (Jackson, 2000, Schieritz and Grobler, 2003). Apart from these weaknesses, small models developed by system dynamics may have limitations: policy makers may lose their trust in the developed model if they do not see specific variables; and modellers may underestimate the importance of including feedback loops and causal relationships among variables in the model (Ghaffarzadegan et al., 2011).

Here, in this chapter, a Discrete-event Simulation (DES) methodology has been used to establish a quantitative relationship between empty trips reduction and transport capacity expansion. Time plays an important role in discrete-event simulations that allow system quantities to change at discrete time points (Paul et al., 1999). The study by Maria (1997:7) further clarified the application of the DES, “For instance, in an M/M/1 queue – a single server queuing process in which time between arrivals and service time are exponential – an arrival causes the system to change instantaneously.” The reason to use a discrete event simulation methodology is an attempt to account for the fact that the concept of “Queuing theory-waiting line problem” can successfully be applied to seaports (El-Naggar, 2010). Queuing theory is one of the operational research methods where entities (e.g., container trucks) arrive at random times and make demands for servicing (Hess et al., 2007). This resembles a seaport system well. For example, this chapter uses case study data to capture truck queuing patterns and to analyse truck processing time at the entry gate of the marine container terminal. In other words, the container terminal is a good example of a queuing system where trucks must wait for resources (e.g., road office processing) to become available. To portray a similar situation in which the application of the DES is an appropriate method, the study by Karnon et al. (2012:703) explained, “…demand for particular resources and their priority status in a queue may be influenced by their attributes. For such scenarios – the very problems for which it was developed – DES is clearly an appropriate choice.” The study by Diefenbach and Kozan (2008) expressed similar concerns. For a detailed list of the benefits of using the DES methodology for process modelling, see Hlupic (2001). Another strength of the discrete-event simulation methodology is the ability to deal with such stochastic operations being observed at discrete points during time spent at ports (Kornfeld and Kara, 2011, Trunfio, 2011).
nature of problems modelled

Feedback effects

System representation
Complexity
Data inputs
Randomness
Validation
Model results

| Nature of problems modelled | Tactical/operational | Strategic | Sweetser (1999), Lane (2000) |
| Feedback effects | Models open loop structures – less interested in feedback | Models causal relationships and feedback effects | Coyle (1985), Sweetser (1999), Brailsford and Hilton (2001) |
| System representation | Analytic view | Holistic view | Baines et al. (1998), Lane (2000) |
| Complexity | Narrow focus with great complexity & detail | Wider focus, general & abstract systems | Lane (2000) |
| Data inputs | Quantitative based on concrete processes | Quantitative & qualitative, use of anecdotal data | Sweetser (1999), Brailsford and Hilton (2001) |
| Randomness | Use of random variables (statistical distributions) | Stochastic features less often used (averages of variables) | Meadows (1980) |
| Validation | Black-box approach | White-box approach | Lane (2000) |
| Model results | Provides statistically valid estimates of system performance | Provides a full picture (qualitative & quantitative) of system performance | Meadows (1980), Mak (1993) |

Table X. Examples of views expressed in the literature regarding the comparison of DES and SD and the system dynamics approach (SD)

Table XI. Difference between three simulation models

Most importantly, this chapter points to a specific component (the container transport process) of a container terminal to increase container transport capacity through truck-sharing initiatives. Conversely, a system dynamics simulation is more suitable for the abstractive-level manipulation of a system (Borschchev and Filippov, 2004); therefore, it is not considered further in this chapter. In contrast, as stated before, discrete-event simulation can quantify port operations to analyse port infrastructure utilisation in detail (Hayuth et al., 1994). Hence it can account for the port performance in terms of the operational level (Orehovački et al., 2007, Sumari et al., 2013). In
order to better understand the limitations of other methods, it is also clear from the literature that analytical models are not sufficient to analyse port performance (Steenken et al., 2004). Similar concerns have been expressed by the study of Ramani (1996). After taking those limitations into account, reviews of simulation studies of terminal operations using DES methodology are also available, for example, see Petering (2010) and Petering (2011). Hence DES is a good option for simulating terminal operations (Cartenì and Luca, 2012).

However, the “weakness” of the discrete event simulation methodology is the special knowledge, extensive time, and financial resources required to apply this approach (Banks, 2005, Le Lay et al., 2006). Apart from this limitation, discrete event simulation approaches (including other simulation approaches) do not allow for the automatic optimisation of a business process (Montevecchi et al., 2012). The simulation analyst proposes multiple alternatives to choose the best one for further implementation. Another potential weakness is its inability to deal with human behaviour where agent-based simulations (often overlooked in practice) can be a better alternative than DES (Sumari et al., 2013). Therefore, to explain the benefits of adopting agent-based simulations, the study by Karnon et al. (2012:703) stated that agent-based simulations are an extension of DES, and further confirmed the benefits of adopting agent-based simulations, “…provides more detailed representation of interactions between agents.” So, there is a growing interest for the application of this technique to different problems; the reasons can be classified into broad categories: system components are interdependent on each other and work together; the system is too complex to model accurately by other approaches, and computational power is usually available to adequately model the system under consideration (Macal and North, 2005).

6.3.1 The simulation software

Arena is a discrete event simulation software and a number of studies have already used it to imitate the stochastic and dynamic nature (i.e., state changes with time) of port operations; such as, Thiers (1998), Bruzzone and Signorile (1998), Lee et al. (2003), Kozan (2006), Dragović et al. (2006), Legato et al. (2009) and Guldogan (2010). The benefits are obvious and claims are made in the existing literature, either implicitly or explicitly, by simply placing icons in sequence on a computer screen and adjusting their various properties. This comparatively simple but essential software tool allows ease of parameter changing and modification, and fast and accurate model building for informed decision making (Greasley, 2005). Therefore, this chapter uses Arena 13.0 for model building, testing and analysing (for more information on applications of this software, see Kelton et al., 2009). Such an adoption is appropriate in this chapter as the application of Arena in modelling transportation systems is also increasing (Kelton et al., 2007). This chapter aims to make a simulation model that would signify a real-life transportation system. This justification confirms the usefulness of the Arena software used in this case study.
### Process simulation framework for maritime terminals

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Formulation</td>
<td>This is the phase of determining the needs and problems of the seaport. The analyst should follow these issues in more depth in a series of follow-ups and select the most challenging one.</td>
</tr>
<tr>
<td>Objectives Setting</td>
<td>The analyst should determine objectives that are related to solving the problem on hand and logically link the objectives to clients’ problem.</td>
</tr>
<tr>
<td>Conceptual Model Formulation</td>
<td>When modeling seaport systems, it is always better and easier to start with the simplest conceptualisation. The simplest conceptualisation can then be made more complex.</td>
</tr>
<tr>
<td>Data Collection</td>
<td>This involves the collection of data to identify operating procedures and probability distributions for random variables.</td>
</tr>
<tr>
<td>Model Translation</td>
<td>Model translation means translating the operating procedures of the process into a simulation package, such as ARENA.</td>
</tr>
<tr>
<td>Verification &amp; Validation</td>
<td>Model verification is like debugging the constructed model. Validation ensures that the built model is a realistic representation of the actual system to satisfy objectives of the research.</td>
</tr>
<tr>
<td>Interpretation</td>
<td>This involves comparing changes in as-is process and to-be process.</td>
</tr>
</tbody>
</table>

**Figure 52.** The process simulation framework adopted for use in this chapter
6.3.2 Application of DES in process reengineering

The application of DES to assess prospects for process reengineering is not new. For example, a group of studies have advocated the use of DES to test and evaluate the dynamic and stochastic process reengineering opportunities, such as in: Gladwin and Tumay (1994), Hlupic and Robinson (1998), Giaglis et al. (1999) and Greasley (2003). Following the importance of the application of DES in process reengineering projects, a comprehensive literature search has explored some of the suggested or adopted research frameworks on the methodology of process simulation; Greasley and Barlow (1998), Chaharbaghi (1990), Warren et al. (1995), Welgama and Mills (1995), Greasley (2003), Lam and Lau (2004), and Doomun and Nevin Vunka (2008). None of these frameworks has been fully adopted in this chapter. However, the research framework presented and discussed in Figure 52 is the step-by-step integration and outcome of the DES-related studies reviewed in this chapter. The framework is designed in order to create an action plan for developing a simulation methodology for the accomplishment of the research objective and the answering the research question posed in this chapter.

6.3.3 Brief description of the referred DES studies

Herewith a brief description of each of these studies referred to in Figure 52, for example, Greasley and Barlow (1998). These researchers presented a five-step framework to focus on suggestions for BPR implementation in simulation modelling based on recommendations presented in the study of Davenport (1993). To build valid and credible simulation models, Chaharbaghi (1990) provided a strategic outline and confirmed recommendations for structuring in three phases (definition, communication and, model construction) for simulation modelling. Warren et al. (1995) developed a concept map for use by simulation analysts that summarised eight steps and the associated principal activities of successful simulation modelling. The objective is to assist in supporting decisions and evaluating the options available for promising process reengineering projects. Welgama and Mills (1995) explored and described the methods of addressing the design problems faced by a chemical company in Australia for changing their system to the JIT (just-in-time) manufacturing. In order for readers to comprehend the overall effect of manufacturing system change, the authors have followed a structure that is more or less the same as that used for other studies. For example, it can be divided into parts that range from problem definition to the analysis of results and interpretation.

To accomplish his objectives Greasley (2003) presented a case study of the custody-of-prisoner process pertaining to a police force and used a business process simulation to imitate the prisoner custody process. The author followed a specific series of steps to develop and complete the analysis of the simulation results. The study by Lam and Lau (2004) developed and followed a structured simulation methodology to ensure that all necessary aspects had been covered in approaching and evaluating the results of a call centre restructuring project. The authors claimed that the organised simulation methodology could be applied to other organisations as well for the comparison of alternative business process reengineering opportunities. Finally, the purpose of the study by Doomun and Nevin Vunka (2008) was to develop a framework for Business Process Modelling, Simulation and Reengineering (BPMSR) projects. The framework can be used by companies to model, simulate and reengineer business processes in an efficient way.
6.4 Case study: Truck arrival process at a port
The port studied is known to be one of the largest import-export gateways in the country. It is a vital piece of economic development since it handles volume equivalent to more than ten percent of the country’s GDP. The port’s contribution is based on the value of handled trade each year. It is the largest container port in the region with an annual cargo volume exceeding 890,000 TEUs.

6.4.1 Step 1: Problem formulation
The port is under increasing pressure to handle high container volumes and to raise port capacity. Similar to other ports and as outlined in Chapter 1, there are many reasons for this, such as the current trend for large-scale manufacturing to be re-deployed to low-cost countries (Pallis and de Langen, 2010), and the rising levels of GDP among countries (Chao and Lin, 2011). These contributory factors facilitate trade expansion and concurrently increase the volume of container traffic volume worldwide. Hence, the most important reason behind the making of capacity expansion decisions is influenced by the huge growth rate in containerised cargo. For instance, the significant six percent growth rate that has occurred over time looks alarming and asks the port authority to look for solutions.

As stated previously in Chapter 1, such capacity shortage can occur at any part of the linked-capacity influencing components of a container distribution system since many different parties are involved (Cetin and Cerit, 2010). A small problem with any of these components can affect the overall smooth flow of containers. For example, according to a study conducted in the region of the location of the case study port, in the 1990’s, the state of California expanded its port capacity to deal with the increase in the size of container ships. The ports serving the Californian region failed to update their transport infrastructure. This oversight created bottlenecks in the transportation network of the container distribution system due to transport capacity shortage.

One way to cope with their growing number of containers in order to avoid the transport capacity shortage problem is to increase the number of container trucks. However, the possibility of adding more trucks is limited by specific constraints due to the port’s unique geographic location and features. For example, the port is located close to the CBD (Central Business District) and typically generates almost 3,000 truck trips per day. In addition, road travel is the main means of transport for the port and almost 87% of landside cargo haulage is transported by road. The road system around the port gates is thus already highly utilised by most internal cargo and passenger traffic. The high level of road system usage creates difficulties in planning for the accommodation of any future volume increase in container truck traffic. Road traffic congestion is already a severe problem for the port region and its surrounding environment. A local study found that, between the years 2006 and 2007, the level of congestion of the road transportation increased from .48 minutes of delay per kilometre to .55 minutes of delay per kilometre. The same rate of delay per kilometre was still in evidence up to the year 2009 and the same situation continues to prevail. Congestion problems make it difficult for the port system to allow further truck volume without the re-location of the port to an alternative site. This would not be a solution of choice due to the feasibility of replacing expensive, and already built, port facilities.
6.4.2 Step 2: Objective setting

The gradually growing number of containers transported using an increasing number of freight trucks in terminals creates traffic congestion, air pollution, road accidents and increased energy consumption (Perakis and Denisis, 2008). Among the growing number of trucks, the latest port data, for container truck usage in the region of the port gates, shows an abundance of under-utilised empty trips. For examples, see Table XII. Such under-utilisation of available truck capacity fails to absorb the gradual increase in container numbers and leads to inefficiency in the container distribution chain. Consequently, the inefficient utilisation of such a vital resource results in the non-achievement of the maximisation benefit for the supply chain. For example, full utilisation of all the available empty slots on container trucks would lead to a greater number of containers being hauled using an identical number of container trucks. This achievement is feasible through the re-thinking of truck-sharing initiatives. Truck-sharing through partnerships between shippers and carriers may increase the landside transport capacity of the port. Landside transport capacity represents the total number of containers that all container trucks are able to transport in order to facilitate the import and export of goods. Therefore, truck-sharing is important from the economic, environmental and social sustainability viewpoints since it helps to reduce pollution, congestion, and transportation cost, for all involved parties in the supply chain.

<table>
<thead>
<tr>
<th>Container number (Empty containers)</th>
<th>Truck trips</th>
<th>Container number (Laden containers)</th>
<th>Truck trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Delivery (without any receive)</td>
<td>7745</td>
<td>1 Delivery (without any receive)</td>
<td>7258</td>
</tr>
<tr>
<td>1 Received (without any delivery)</td>
<td>4181</td>
<td>1 Received (without any delivery)</td>
<td>2899</td>
</tr>
<tr>
<td>2 Delivery (without any receive)</td>
<td>839</td>
<td>2 Delivery (without any receive)</td>
<td>742</td>
</tr>
<tr>
<td>2 Received (without any delivery)</td>
<td>890</td>
<td>2 Received (without any delivery)</td>
<td>654</td>
</tr>
</tbody>
</table>

Table XII. The port’s empty-truck trips for February, 2011

Source: The Port

6.4.2.1 Modelling boundary. Boundary determination is a part of the objective-setting phase. In order to comprehend and limit the scope of the simulation modelling project, the determination of the boundary of the system is important (McCarthy, 2004, Clegg, 2006). However the scope of the boundary can vary according to the goal(s) of a process reengineering project (Fowler, 1998, Evans et al., 1999). To facilitate this analysis, a broader mapping of a port’s stakeholders may include: exporters, importers, truck operators, freight forwarders and shipping lines. All those mentioned may be involved from the beginning to the end of the export process and, to a certain extent, can sometimes be responsible for the associated truck trips. However, with the exception of the road carriers, the involvement and inclusion of all of these parties is beyond the scope of this chapter. Further, in this chapter, by setting a focus on the process reengineering aspects of the truck hauling process, the researcher is interested in finding out the reasons for the occurrence of truck trips and the number of times truck trips are involved in an export process.

Road carriers are primarily responsible for processing transportation requests to or from the port. Requests made to a carrier for cargo transportation can be divided into two types, including the type that simply focuses on exporting. A typical container exporting process may generate many completely unutilised or partially-utilised truck movements with every export cycle. In
each of these movements, a container truck may be partially or fully unutilised. This may disadvantage the whole freight supply chain by increasing road congestion around ports, carbon emission, transportation costs and also cause a decrease in system-wide truck capacity. Here, for the sake of brevity, it is assumed that a typical container truck has a two slot capacity for transportation purposes and that all containers are twenty-feet in length. Trucks are involved around four times in a container exporting process (Figure 53): (1) to export cargo, the shipper requires an empty container from the empty depot. An empty-truck is sent from the trucking company to the port; (2) an empty container is sent from the port to the exporter’s premises (e.g., warehouse); (3) the, previously sent, empty container carries the load and the truck comes back to the port; and (4) the truck leaves the port territory. Soon after leaving the port premises, the truck may go to another warehouse or back to the trucking company. To further limit the boundary of the simulated modelling project, it is important to note that two basic types of trucks are generally used for container transportation in the above-mentioned movements; trucks that are empty and trucks that are full. The empty trucks are smaller, they have small trailers and they can carry empties only. The trucks capable of carrying laden containers are different from those that are empty. They have bigger tires, and they can carry up to around thirty tons. Hence the classification is based on the weight that a container truck can carry and the focus of the simulation modelling is the laden container trucks only as shown in movement 3 of Figure 53.

![Figure 53. Modelling boundary of the current simulation project](image)

To specifically highlight the boundary of the simulation modelling task, the application of the simulation modelling is limited to one of the two container terminals in the case study port. The selected container terminal is the country’s largest and most advanced terminal with five post-panamax ship-to-shore cranes and hybrid straddle carriers, and 90% of the container volume of the port goes through this terminal using its own ship-to-shore cranes. The result of the analysis conducted is not meant to provide a complete measure of the number of empty trips in both terminals, but to give a specific picture of transport capacity improvement opportunity and carbon emission reduction potential from cargo transportation through a container terminal.
Another major boundary of the simulation modelling is that it does not explicitly take into account those container trucks that do not carry any container during arrival at the port. This is because incoming trucks have the flexibility to change their booking slots. As a result, for example, an export truck, which is assumed to deliver a loaded container, could carry a different type of container, such as an import pickup. By taking into account these facts and considerations, the potential advantages of the truck-sharing idea could be high.

6.4.2.2 Modelling assumptions. In order to develop simulation models, apart from setting the simulation boundary of the truck hauling process, the procedure followed here focuses on the study of the complex real-life components of a port. To simplify the model for the truck arrival process of the port being studied, the specific assumptions are: (1) a container truck has two slots in (transports two containers to the port); (2) the analysis focuses solely on the export procedure without taking the importing process into consideration; (3) in terms of the export procedure, all the containers taken into account in the model developed are twenty-feet in length and are mostly general in nature; (4) the objective of this chapter is to explore potential truck-sharing benefits, rather than taking into account details (e.g., preferences of exporters) of trucking-sharing simulation modelling; (5) while leaving the Port shortly after discharging export containers, a truck does not pick up two import containers, although this would be likely to increase the chance of real-life truck-sharing benefits; and (6) a partially utilised truck waits for a period of up to 100 hours to try to receive another container for transportation to the port of exportation.

6.4.3 Step 3: Conceptual models
Since a model is the simplification of a reality, a conceptual model should have a certain level of simplification to represent the pragmatic world (Zeigler et al., 2000). Hence to represent simplicity and abstract reality simultaneously in the same model, a conceptual model may be slightly different from the developed model on a computer (Nance, 1994). Here, the authors have attempted to explain the conceptual models in a way that is easy to understand, develop and execute using simulation software. Brief descriptions of the as-is and to-be processes are provided in the "model translation" subsection.

6.4.4 Step 4: Data collection
To enhance comprehension of the as-is process, the authors of this simulation examine multiple data sources. Three priorities are involved in the data collection phase, as shown in Figure 54.

6.4.4.1 Process flow. Process flow analysis is an illustrative demonstration of the phases involved in a process. This is necessary for the in-depth exploration of the underlying process. The analysis of the truck-related process may include the investigation of pre-arrival and post-arrival processing tasks. Pre-arrival tasks consist of current truck dispatching operations and management; these are the nerve centre of a road carrier. A description of the pre-arrival tasks and the retrieval of such data goes beyond the scope of this chapter. Conversely, post-arrival tasks include processing jobs performed at the gates of the container terminal. A semi-structured question set was designed to fulfil the objectives of exploring processing jobs; and three interviews of varying duration have been conducted with each of the respondents. These respondents were well-informed about the truck appointment system because of the nature of tasks they perform and the kind of decisions they make on any typical day. A combination of structured and unstructured questions was asked to assist in the replication of standard procedures and practices. In order to comprehend and examine the as-is process, the researcher
has analysed the interview notes and recordings of the staff members who were interviewed; not all of the interview conversations were recorded. Observation also played a major role in formulating strategies to crosscheck the data provided through the interviews with port staff. Visits to the study sites were of approximately three hours duration were particularly useful when observing tasks performed at the entry-gate and the road-office. The data collection methods and key priority areas of this chapter are shown in Figure 54.

![Figure 54. Outline of data collection methods and key priority areas of the simulation project](image)

6.4.4.2 Truck arrival pattern. Each carrier selects the type of appointment (e.g., an export box delivery) using the web portal and chooses the date and time zone on which to deliver the laden container to the port. So, to determine the arrival pattern of the trucks in the simulation and to follow the appointments system that the port authority mandates, the booking data (e.g., number of slots per hour) has been recorded using the Arena schedule editor. This schedule editor takes into account both the fixed arrival rate of trucks, and their uncertainty of arrivals with a Poisson distribution, where the mean is estimated from the given time slots. Each data point in the schedule editor specifies truck arrivals per hour over the 24 hours of each day of the week.

6.4.4.3 Process timing. Truck traffic data at the entry-gate and road-office, including; arrival time, service time, and queuing time, is essential for studying the as-is process. A more detailed description of the process timings relating to the as-is process is given in the next subsection.

6.4.5 Step 5: Model translation
The software converts the conceptual models into computerised models to perform simulation runs and to analyse findings. Simulation analysts add modules on the computer screen to design port components to resemble the as-is and the to-be process, and to show the noticeable connections between modules as well as the logical flow of information and resources. The following process descriptions present essential points and provide arguments, which have been used in the preparation the simulation models that are appropriate for model translation.
Figure 55. Graphical representation of the truck arrival process at the selected case study port
6.4.5.1 The as-is process (a non-collaborative scenario). According to the as-is process (Figure 55), container trucks in the form of entities entering the port of export, in accordance with the agreed shipping schedule, have been classified into two categories – full, and half. Taking into account the varying types of truck; these differ in the magnitude of their carrying load; the objective is to determine their utilisation scenarios in a typical day using a simulation model. In order to continue the pursuit this objective, at the start of the process, a preliminary simulation run encounters a driver, who comes to the port to attend the booked slot. Two options are available to collect the PIN (Personal Identification Number), which grants him access through the gate to the yard. To grant access, the carrier chooses to, either process information manually (using the road office) or automatically (using the website), as shown in Table XIII.

<table>
<thead>
<tr>
<th></th>
<th>Apr-10</th>
<th>May-10</th>
<th>Jun-10</th>
<th>July-10</th>
<th>Aug-10</th>
<th>Sep-10</th>
<th>Oct-10</th>
<th>Nov-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-service kiosks</td>
<td>15%</td>
<td>15%</td>
<td>14%</td>
<td>16%</td>
<td>17%</td>
<td>15%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Road office</td>
<td>85%</td>
<td>85%</td>
<td>86%</td>
<td>84%</td>
<td>83%</td>
<td>85%</td>
<td>87%</td>
<td>87%</td>
</tr>
</tbody>
</table>

Table XIII. Approximate percentage of trucks using the self-service kiosks

Source: The Port

(a) One option is for road carriers to personally execute the necessary processing online. For example, they can browse through the website, enter all the container details, obtain a truck appointment booking and pair the two together (the container details provided and the booked appointment) to receive an internet booking reference number. If a road carrier is able to perform that online task, a truck will arrive in front of the two kiosks of the port, which are just in front of the gate. The truck pulls up before one of the kiosks and the driver swipes his/her driving licence. Later, the driver; enters the internet booking reference number to obtain a gate card, goes to the gate and opens the gate. The whole process takes approximately four or five minutes, which is why the internet-based process is an attractive option (i.e., to complete as many trips as possible to earn more) for owner drivers. They work for other bigger road carriers.

(b) The second option is that a truck arrives at the port with the necessary paperwork in the possession of its driver in order for it to be manually processed into the port’s road office. In this case, the driver parks the truck in the parking area and proceeds to the road office on foot. This might take around two to three minutes. Once in the road office, he/she may be required to queue; the period of time for this is assumed to be between five and ten minutes before being able to start the processing procedure. If the information is correct (assumed to be correct in approximately 50% of all cases) and the documentation provided is complete, the processing takes, on average, between thirty seconds and two minutes. The timing generally depends upon how efficiently the customer service managers can read the documentation supplied (the road office has three customer service managers on first shift: from 0700 to 1500 hours; two customer service managers on second shift; from 1500 to 2300hrs; and two customer service managers on night shift; from 2300 hours through to 0700 hours on the following morning). This is due to the fact that the managers are required to assimilate the necessary information from the documentation that has been submitted. If the information is incorrect (greater priority is assumed for the operation of incomplete information), it might take up to five or six minutes to sort it out. Apart from manual processing by customer service managers, it also takes time (about another two to three minutes) for the driver to get back into his/her truck and then move to the gate (the movement takes two or three minutes). This all happens after processing has been completed and a gate pass has been received from one of the customer service managers. Following this, the gate card number is keyed in order to allow the opening of the gate.
Whichever of the above options (i.e., internet-based or road office processing) is followed, the gate opens immediately, within five seconds, if the PIN is correct. The open gate allows the truck driver to drive through onto one of the truck routes. Once the driver is on the truck route, he moves into an empty lane, dismounts from the truck and announces his gate pass number (e.g., 1234) and lane number (e.g., lane 5). This action dispatches the system, allowing the truck’s container to be automatically dropped off. The container truck usually leaves the port gate with an empty slot. In most cases, this process takes a total time span of two to five minutes on average, causing only minimal delay.

6.4.5.2 The to-be process (a collaborative scenario). Two different truck utilisation scenarios (fully utilised and partially unutilised) are developed, and evaluated for the as-is process. Alternatively, if an optimised truck operation scenario (the to-be process) is adopted, sometimes underutilised truck spaces can be turned into a productive resource intended to increase overall transport capacity at ports. So, a maximum truck utilisation process has been defined in the to-be process, and a simulation model has been established to facilitate the presentation of results, and to explain the accrued benefits of the process. It is intended that the to-be process is developed by the integration of the truck appointment system with the truck-sharing concept. The objective of truck-sharing is to offer a planned matching facility so that shippers and carriers are able to share any empty slots that are available on trucks. Initially, and in order to achieve that objective, every time a one container truck arrives, the to-be process checks if there is already one holding (one container on a single truck). If there is, two containers are paired and a single truck goes on to the system. If no matching is found, the truck will wait for a maximum of 100 hours for a match. If no other container arrives within that period, it goes on as a single container truck.

However, there are some exceptions to consider when dealing with a truck-sharing initiatives since these may also be truck-sharing constraints; thus, it may be difficult (the difficulty level varies from port to port) to measure all the aspects accurately. For this reason, with the exception of the matching process (it is assumed in the to-be process that perfect matching is possible: every truck carries two containers in each trip), the origins and destinations of full containers for exporting, concerns such as profiles, and preferences for exporters and carriers are excluded in simulation, because:

- **Firstly**, a port authority is unaware of the contents of the containers coming in to the port. The tracking of contents depends upon the information provided to them by the carriers. Although one container may weigh only two tons, carriers may not be able to carry anything else on board the truck in instances where a container needs to be carried separately because of its contents (e.g., dangerous goods).

- **Secondly**, the port has a weigh bridge that a truck driver can use when the weight of a laden container is unknown. However, drivers usually know the weight of an inbound container because they have been previously informed by the carriers, although they do not weigh the containers in the port; thus, most of the drivers use the information exporters provide them. The information provided is unable to be verified by truck-sharing users.

- **Thirdly**, the port authority does not differentiate between trucks entering to perform a single drop. Therefore, they are not aware of the types of truck coming into the port to deliver laden containers. Trucks can be 2 TEU trucks or 3 TEU trucks since some carriers have recently introduced a third trailer. The lack of important data creates difficulty in assessing the extent to which container trucks can be shared among carriers or exporters.
After arriving at the port, the rest of the procedure is executed by using the same as-is process, which uses the truck appointment system. As stated previously, in order to simplify the processes of simulated modelling, and to focus on the efficiencies to be gained by the sharing of the limited space available in container trucks, all of the described additional considerations are excluded from this particular simulation chapter. They are outside of its scope.

6.4.6 Step 6: Verification and validation

In order to fulfil the objectives of this chapter, prior to performing the what-if analysis, this step (e.g., verification and validation) is useful in ensuring that the simulation model of the as-is process is error-free and provides a valid representation of the port operations. Verification is rather like de-bugging a computer programme; two strategies are adopted to confirm such verification in this chapter. Firstly, by running the simulation at slow speed, the logic check verifies the model. Secondly, to further justify the verification of the model, simulation test-run results are analysed based on the rationale of the researcher. The study of Greasley (2004) adopted similar approaches to model verification. Conversely, model validation confirms the reasonable representation of the case study port. To ensure model validity, this chapter calculates the confidence interval of the simulation outputs at 95 percent (α=.05) confidence level and compares them to the data provided by the port. A similar practice was adopted by Shim and Kumar (2010) and Pasin et al. (2002). The results presented are based on the average results of the 30 replications; the time horizon (replication length) for each replication was 300 days.

<table>
<thead>
<tr>
<th>As-is process</th>
<th>Performance indicator (per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate throughput</td>
<td>397 containers</td>
</tr>
<tr>
<td>Number of fully utilised trucks</td>
<td>193 trucks</td>
</tr>
<tr>
<td>Number of partially empty trucks</td>
<td>11 trucks</td>
</tr>
<tr>
<td>Emissions for 397 containers:</td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>2,564,892 grams</td>
</tr>
<tr>
<td>NOx emissions</td>
<td>21,374 grams</td>
</tr>
<tr>
<td>PM₁₀ emissions</td>
<td>313 grams</td>
</tr>
</tbody>
</table>

**Table XIV. Performance of the as-is process**

<table>
<thead>
<tr>
<th>To-be process</th>
<th>Performance indicator (per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate throughput (containers)</td>
<td>397 containers</td>
</tr>
<tr>
<td>Number of fully utilised trucks</td>
<td>198 trucks</td>
</tr>
<tr>
<td>Number of partially empty trucks</td>
<td>1 truck</td>
</tr>
<tr>
<td>Emissions for 397 containers:</td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>2,502,027 grams</td>
</tr>
<tr>
<td>NOx emissions</td>
<td>20,850 grams</td>
</tr>
<tr>
<td>PM₁₀ emissions</td>
<td>305 grams</td>
</tr>
</tbody>
</table>

**Table XV. Performance of the to-be process**
6.4.7 Step 7: Interpretation

To quantify the impact of truck-sharing, two different truck utilisation scenarios are considered due to the characteristics (the extent of space utilisation) of incoming trucks to the port. The before-and-after scenarios of the as-is and to-be processes (Table XIV and XV) compare the simulation output to analyse the variables of interest: gate capacity, transport capacity, and number of empty-truck trips. The assumptions behind these calculations are discussed below.

Here CO₂ stands for carbon dioxide, NOx for Nitrogen Oxide, and PM₁₀ for Particulate Matter.

According to the current process and based on the rules of the truck appointment system that has been developed and enforced by the Port authority to make gradual allocations for incoming trucks over the course of a day, around 204 trucks (the total number of received is approximately 61,236 trucks over a 300 day period) arrive at the port each day with an export related objective. 94% of the total number of trucks is derived from fully utilised trucks, while the remainder of the percentage stems from partially utilised trucks (6%). In the present case, therefore, for every day, 193 trucks carry two containers, instead of just one (or none); and 11 trucks carry only one standard container. By combining all of the various trucks, which differ in the magnitude of the loads they are able to carry, a total of 397 containers could be transported per day. This conclusion was drawn based on the results of the simulation, and taking into account all two of the defined categories of truck utilisation rates.

In the to-be process, by consolidating underutilised trucks, carriers will be able to redirect their resources to carry same number of containers per day, and hence the volume of containers transported by fully utilised trucks in each day will increase. For example, a significant number of approximately 11 trucks, which carry only one container in the current process, depending upon on the waiting period for a container to be matched with an underutilised truck, in the to-be process, would be able to carry same number of containers to the port, resulting in a decrease of about 10 (11 – 1 trucks) partially utilised trucks per day. To sum up, the to-be process would allow same number containers to be hauled in each day by increasing all the contributions made by fully utilised trucks coming into to the port, and decreasing the number of partially utilised trucks on roadways and the amount of manpower required to update truck drivers. Therefore, it is evident from the simulation results of the to-be process, that the truck-sharing idea boosts port transport capacity by allowing increased fully utilised truck trips, and hence reducing underutilised vehicle trips around the port area to carry an equivalent number of containers.

If implemented, the truck-sharing concept could also account for a reduction in the carbon emissions released from trucks in the port surroundings, for the reason that the overall per-container emissions would be lower, particularly in comparison with the present truck hauling process. In the as-is process, a container, for example, produces about 6,460 grams of CO₂ during its transportation period. Conversely, a container in the to-be process would produce about 6,302 grams of CO₂ in the earth's atmosphere, thus the amount of emissions per container would be lower than has been previously found to be the case in the as-is process. This is due to the fact that, the most positive impact of any of these changes is the savings that would result from the reduction in the number of underutilised truck trips, and the related increase in using more utilised trucks per trip. To elaborate, the current process generates around 204 trips to carry 397 containers per day, whereas the to-be process would require approximately 199 trips to carry same number of containers per day. This justifies the added benefit of the to-be process in increasing transport capacity (less number of trucks needed to carry same number of containers).

Here, emission calculations have been performed according to the guidelines proposed in the study of Heide (2010). The study suggests that by specifically taking into account the loading capacity of a container and the weight of its trailer, the results would be: CO₂ emissions=762
gram/km, NOx emissions=6.35 gram/km, and PM$_{10}$ emissions=0.093 gram/km. Subsequently, for a container truck, the suggested computation results in, for example, total CO$_2$ emissions=762 gram/km * the average distance a truck travels for an export trip * the total number of export-trips for all container trucks per day. The basic underlying idea is to first calculate the average distance between the port and its exporting (or, importing) geographic location. This objective has been accomplished through the findings of a port-related research report conducted in 2009. So, the average distance (16.50 km) used in this chapter is the calculated mean of these “distance-related” values extracted from that report; a summary of the findings has been presented in Table XVI.

<table>
<thead>
<tr>
<th>Origin/destination groups</th>
<th>Trading percentage of total market volume</th>
<th>Driving distance to/from the port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location A</td>
<td>8%</td>
<td>07.80 km</td>
</tr>
<tr>
<td>Location B</td>
<td>9%</td>
<td>26.20 km</td>
</tr>
<tr>
<td>Location C</td>
<td>3%</td>
<td>03.10 km</td>
</tr>
<tr>
<td>Location D</td>
<td>32%</td>
<td>13.90 km</td>
</tr>
<tr>
<td>Location E</td>
<td>13%</td>
<td>19.20 km</td>
</tr>
<tr>
<td>Location F</td>
<td>2%</td>
<td>08.00 km</td>
</tr>
<tr>
<td>Location G</td>
<td>5%</td>
<td>21.30 km</td>
</tr>
<tr>
<td>Location H</td>
<td>11%</td>
<td>24.60 km</td>
</tr>
<tr>
<td>Location I</td>
<td>8%</td>
<td>15.90 km</td>
</tr>
<tr>
<td>Location J</td>
<td>9%</td>
<td>25.00 km</td>
</tr>
</tbody>
</table>

Table XVI. Container origin and destination groups for the Port
Source: The Port

6.5 Managerial implications

With an emphasis on applied planning for transport capacity improvement potential, the findings of this chapter provide insights that have managerial implications, such as:

- The model provides an example of a sustainable transportation option in which road carriers are enabled to reach their sustainability and carbon emissions reduction targets, in addition to possessing the potential for lasting benefits (e.g., from a transport cost minimisation perspective) to the supply chain. As a result, McKinnon (2000) further reassures that a small reduction in the number of empty running by trucks can be expected to have huge benefits for the environment. Therefore, these small, though vital, contributions should not be overlooked.

- Merely relying on a road carrier’s profitability by using its number of container trucks (without full utilisation) may not be sufficient to enhance its competitiveness for the future. Collaboration in the supply chain is the key to driving innovation since the findings advise transport managers that mutual cooperation could result in the more effective management of internal resources (i.e., container trucks) with the objective of reducing the number of empty running by trucks around the port territory. Such initiatives are important in the creation of a cooperative culture in freight transportation.
6.6 Findings and conclusion
As stated in the first chapter, unproductive empty-truck trips decrease transport capacity in the container distribution chain along with causing an increase in carbon emissions, traffic congestion, fuel consumption, and pollution. In exploring a solution for the empty trips problem from a supply chain perspective, where each carrier has an equal chance of receiving benefit, the third chapter explores promising solutions (e.g., the truck-sharing concept) for the reduction of empty trips. The fourth chapter selects, extends and develops the truck-sharing mechanism to overcome the limitations inherent in the literature. In order to focus on the implementation of the truck-sharing model, the fifth chapter explores the challenges to truck-sharing and effective ways of dealing with those. However, an important question that remains unanswered so far is: What are the benefits that can be gained by adopting the truck-sharing concept? To justify the value of developing such a collaboration model, this chapter, using a case study approach, develops a simulation model of the truck-sharing concept to evaluate the effects of the changes made in order to reduce the number of empty trips. In other words, in order to promote the benefits of truck-sharing, this chapter employs simulation models to provide an evaluation of the concept that truck-sharing has the potential to improve transport capacity in and around a port territory and that it is likely to lead to a reduction in emissions and the incidence of empty truck trips.

Two possible scenarios have been developed to compare and contrast the results of truck-sharing (to-be process) with the base case (as-is process) scenario which represents a truck appointment system. Simulation results show improvement in the truck-sharing idea’s performance. For example, the to-be process aims to boost port gate-and transport-capacity and handles the increasing future truck volume effectively. The model is also able to account for the reduction in the amount of carbon emissions generated from container trucks in a port territory. The truck-sharing benefits realised in this chapter are a comparatively a small proportion of the potential total. However, the full potential benefits can only be realised by undertaking the necessary work to ensure that the relevant information is obtained. This could be achieved by including truck-traffic information concerning all the container terminals of a port and preferably those concerning other procedures, such as, import pickups, and empty container delivery. These procedures generate a considerable amount of empty truck running on regional roads. It is also possible to adopt innovative truck-sharing strategies in ports depending on their operational procedures. For example, every truck visiting the port for an export delivery, could also pickup two containers for an importer. Thus, the degree to which such collaborative practices could improve truck-sharing benefits is potentially high, than what has been found in this chapter.
Chapter 7: Findings and conclusion

The economic contribution of a port makes it an indispensable part of its supply chain. This has been widely recognised in the literature on maritime logistics. However, a capacity shortage problem is an important issue for the major ports and container terminals of the world. Among the many key problems and challenges arising, which are more evident because of capacity shortage issues, there is an increased necessity for increasing transport capacity for containerised goods. The reason is, a container transportation system is shaped by a series of capacity-influencing components. All of these components are functionally interconnected to each other. Therefore, if there is a capacity shortage in one area, it usually affects another. As a result, the transport capacity problem is one of the most significant issues to be addressed by the port community (e.g., importers, exporters, port authorities, and road carriers). Therefore, to secure sufficient transportation connection with its hinterland, a port has road, rail and barge services, although transportation using roads (truck transportation in particular) has been observed to be more popular than other methods. Truck transportation occupies the maximum market share in many congested ports of the world and near high population centres. Therefore, recognising the importance of truck transportation and the severity of capacity shortage problem in the container transportation industry, the key research question for this thesis is: How can the number of empty container truck trips to and from a port be reduced to increase the road transport capacity?

An attempt at solving this transport capacity problem by only increasing the number of container trucks is a potential solution with challenges. Such a typical solution may encourage congestion, fuel consumption and pollution. For example, trucks emit carbon dioxide, carbon monoxide, nitrogen oxide and sulphur oxide. Considering all these negative side effects of truck transportation, an important opportunity worthy of consideration is the huge number of empty truck trips that occur in a port. This option would increase the transport capacity of each truck on every trip, and would affect the transport capacity of the existing road carriers and the overall port region. This concept is feasible for the reason that if the, currently underutilised or unutilised, empty space on travelling container trucks is made available for use to carry a larger number of containers under the same conditions, those trucks would then be able to carry extra containers per trip. However, as far as the researcher is concerned, only a limited amount of literature is to be found that relates to the problem of empty truck trips. However, the existing literature does cross the boundaries of many disciplines, for example, from supply chain collaboration to coordination problems in hinterland transport networks, and to the traditional backhauling problem.

Therefore, new critical perspectives, on empty trips are deemed necessary to fill the majority of the research gap in the existing literature and to bridge the connection between theory and practice for both academics and practitioners. Accordingly, to begin to shed some light on underlying conditions that might be at play in the deployment of sharing truck capacity for freight, this thesis looks into the causes and potential solutions of empty truck trips, and the benefits and the constraints of reducing empty truck trips. From a perspective of the same principle of resource sharing, this thesis also develops a truck-sharing mechanism from the reviewed literature by which road carriers could reduce the number of empty trips for their container trucks. As a result, to bring a new perspective on precisely what important advantages the truck-sharing concept (which is already proving popular in other research fields in the form of carpooling or ride-sharing) can do to empty trips reduction within the field of maritime logistics, is an important line of research. As stated before, underutilised space on trucks encourages more emissions and traffic congestion. This is also important to justify the rationale that the truck-sharing initiative has the potential to improve transport capacity in and around a port territory by sharing existing container trucks.
However, before answering the research questions and discussing the lessons learned across chapters, the second chapter of the thesis addresses the overall port capacity problem. Thus, the question addressed in this chapter is: How can a port's capacity be improved? In answering this question, the first section of the second chapter provides an overview of the problems that arise in the management of a container terminal. To achieve the research objective, the section also presents a comprehensive coverage and review of recent papers in the OR literature. Based on that review of the literature, the section identifies some important issues concerning the urgent need for further research on the integrated approach (taking into account all the components of a seaport) using simulation procedures. In response to that call for research, the second section of the same chapter offers a conceptualisation (a port capacity management framework) based on the extensive literature review of the academic and industry-related papers concerned with the factors influencing port capacity from a holistic point of view (taking into account all the components of a seaport). Although the earlier section has examined the capacity shortage problem by reviewing the literature to suggest a framework, it did not show the managerial implications of the framework. Therefore, to guide the effect of the framework on port capacity improvement potential, the third section further explores the potential usefulness of the suggested framework from two perspectives. A micro-level view looks into a capacity management problem at a port from a single dimension, such as, yard operations, which are important in the controlling of container inflows and outflows as terminal space is limited. However, all components need to work together to ensure the appropriate performance of a port as all elements are functionally interconnected, and a capacity shortage in one dimension affects the service quality of the others.

Therefore, the macro perspective suggested here considers all connected dimensions of a port.

The contribution of Chapter 2. To date, as far as the researcher is aware, few studies have been published that review the factors affecting port capacity; the researcher has found only two studies that attempt to review part of the literature. The studies found exclude certain important factors affecting rail, truck, and dry port capacities, and finally the system-wide performance of the overall port capacity issues. To fill this gap, this chapter offers a system dynamics framework based on the review of the studies concerned with the factors influencing port capacity from a holistic point of view (taking into account all capacity-influencing components of a port). Thus, this chapter takes a wider look at port capacity management. In brief, the chapter is significant as there is limited literature on the subject concerning factors affecting capacity; studies carried out so far on capacity improvement mechanisms are constrained principally by the lack of an integrated point of view. It is also interesting to note that academic research that addresses ports operations from a system dynamics perspective is still scarce in contrast to the typical discrete event-driven simulation approaches. This is another major contribution of this chapter.

The importance of Chapter 2. Due to the evolving capacity shortage, port authorities are seeking opportunities that may lead to the resolution of the problem. The proposed capacity management framework inherits the potential for use at ports in capacity-management-related problem solving. The framework will be of importance in assisting managers in identifying capacity expansion opportunities (including, but not limited to, the issue of transport capacity shortage). The suggestions should be applicable to most ports, given the customisation of the framework to accommodate differences that are inevitable from port to port.
7.1 The research answers
To reduce the number of empty trips made by trucks, four supporting research questions have been formulated, in addition to the provision of the research methods for this investigation. In other words, in order to provide an answer to the main research question, in this thesis, the results of the four chapters provide answers to the questions that motivated the research as follows:

7.1.1 Chapter 3: What are the different mechanisms available in different disciplines and domains for reducing empty truck trips?

This chapter has been able to cover an extensive review of the academic and industry-related papers concerned with the empty trips problem from a holistic point of view (taking into account all road carriers in the container transportation industry). The potential solution concepts highlighted in this chapter are from many interdisciplinary fields, including, but not restricted to, passenger and freight transportation. These potential solutions can be considered as alternative freight transportation options for container road carriers in order to meet the increasing demands of future transport capacity. In other words, the findings of this research have implications for port authorities and transport managers for the reduction in the number of empty trips made by container trucks at times of high pressure, when alternative solutions may be sought that can be explored, tested, and finally, adopted. The explored solutions are collaboration in hinterland transport chains, the backhaul problem, Chassis Exchange Terminal (CET) concept, the street-turn strategy, the dry port, Collaborative Logistics Network (CLN), the shared-transportation concept, Collaborative Transportation Management (CTM), and code-sharing agreements.

7.1.1.1 The contribution of this chapter. The number of studies focusing on trucks at container terminals is limited. Among these limited truck-related studies, to date, as far as this researcher is aware, there have been no major reviews offering assistance to port authorities in their decision-making processes that concern the issue of empty truck trips; this is despite the fact that a number of reviews have previously been published. Although such reviews have effectively summarised the literature on port operations, a research gap still exists in regard to synthesising the literature relating to the issue of empty truck trips. Thus, it is this gap that provides, with the use of literature reviews and synthesis techniques, the basis for the adaptation of interesting theories from other disciplines to logistics research. This current chapter bridges the outlined research gap.

7.1.1.2 Relationship to the main research question. A non-structural mechanism (e.g., without much risk, investment or effort) to increase road-side transport capacity would be to lessen the number of empty truck trips in order to transfer an increasing number of containers using the same number of trucks. Therefore, with the aim of increasing container transport capacity, a synthesis of literature from differing, but complementary, research areas should result in the identification of a set of concepts that can provide useful insight; this, in turn, could lead to the full utilisation of otherwise underutilised trucks. For example, one interesting concept explored from the literature is the idea of truck-sharing (the shared-transportation concept), which can be used to reduce the number of empty truck trips, and thus, to improve container transport capacity around port gates.
7.1.2 Chapter 4: Is it possible to introduce a dynamic truck-sharing facility for a computer-based matching system to reduce empty truck trips?

This chapter explores a dynamic truck-sharing facility for a computer-based matching system to assign probable containers to available empty slots of a container truck. In other words, the proposed model reengineers the truck appointment system. The objective is to reduce the number of empty-truck trips to increase container transport capacity around seaport gates. Thus, the dynamic truck-sharing system will offer a systematic matching facility. For example, if some exporters have similar departure and destination locations, they could share container trucks. Container trucks can be shared as long as empty slots are available. Therefore, a dynamic truck-sharing system may provide a unique benefit, such as maximising total transport capacity (and minimising total miles travelled). Total transport capacity represents the total number of containers of the port that the combined services of all trucks can transport to facilitate containerised cargo exportation and importation. To achieve the research objective, this chapter evaluates the results from an investigation of the truck appointment system using a case study approach. The data collection phase involved primary and secondary sources (e.g., available data on port operations).

7.1.2.1 The contribution of this chapter. The contribution of this chapter is both theoretical and practical. To the researcher’s knowledge, previous research, from a perspective that considers all truck companies covering the empty-truck hauling problem in the maritime logistics domain in order to provide a promising solution, is scarce. In other words, the empty trips problem has not been addressed much in previous studies from a perspective where all road carriers have an equal chance to contribute to optimise the entire supply chain in contrast with the typical one-company-based optimisation techniques. So, the collaborative solution applied in this chapter uses the truck-sharing concept to cover that gap. For example, the suggested truck-sharing model can account for all road carriers to assign probable export containers to available empty slots of a container truck. This truck-sharing concept (the shared-transportation concept) is becoming popular in other areas (e.g., car-sharing) as well. This has been extended to maritime logistics area in this chapter.

7.1.2.2 Relationship to the main research question. Due to increases in container-freight traffic, the leading ports and terminals of the world are experiencing a transport capacity shortage that results in traffic congestion. In practice, the research findings of this chapter are useful as the proposed truck-sharing model can be introduced to enhance capacity in the transport chain of the port territory. For example, importers and exporters should be able to take advantage of the available empty slots of container trucks. Hence, the proper utilisation of all available slot capacity should result in an increased number of containers being transported using the same number of trucks. So, the suggested model should increase the road-side transport capacity of the port.
7.1.3 Chapter 5: What are the truck-sharing challenges in achieving a higher level of collaboration among carriers to gain optimal container-truck utilisation and how to best overcome those challenges?

The objectives of this chapter are to explore the application of truck-sharing challenges and a successful way to deal with them to help practitioners gain knowledge of shared-transportation. This is facilitated by: (1) understanding the industry trends (opportunities and threats) affecting the trucking industry; (2) considering collaborative arrangements between road carriers and non-controllable constraints in maximising truck utilisation to include more collaboration and effort towards truck-sharing success; and (3) exploring the roles of some important truck-sharing constraints that can be changed, treated, or modified for better truck-sharing results. The research findings are interesting. For example, in a truck-sharing initiative, technical issues (e.g. carrying capacity) arise, some of which involve the container truck and some involving constraints that cannot be controlled, such as driving restrictions, seaport operating hours, and the presence of the large number of container categories pertaining to the industry. Therefore, a significant amount of “structural empty running” may always prevail. It should also be noted that some, seemingly vital, constraints can actually be changed, treated, or modified for better truck-sharing outcomes, such as building a foundation of trust and establishing coordination among road carriers. Based on the idea of real-life obstacles to container truck-sharing initiatives, and integrated with earlier research, this research was conducted through the interviewing of road carriers since truck-sharing success requires supply chain collaboration among those road carriers.

7.1.3.1 The contribution of this chapter. To date, as far as the researcher is aware, only a few studies reviewing the factors hindering truck-sharing engagements have been published and only three studies were found that attempt to explore the challenges from the perspective of general trucks (as opposed to container trucks). Hence, although container trucks have fundamental operational similarities with the general-purpose trucks that transport non-containerised loads, several other variables (e.g., physical characteristics of container trucks) have to be taken into consideration in order to explore the constraints associated with containerised transportation. Thus, the literature appears to have ignored the factors affecting the hauling of container trucks in maritime logistics. This chapter fills that research gap by examining the truck-sharing constraints of container trucks.

7.1.3.2 Relationship to the main research question. A probable solution to the problem of increasing hinterland transport capacity is to make appropriate use of the huge number of idle truck slots that exist; this could be achieved by encouraging the acceptance of the challenges of truck-sharing realistically and suggesting an approach to handling them. To broaden its appeal, truck-sharing initiatives must be able to overcome challenges by combining theoretical insight with an understanding of the practical aspects of such an endeavour. Therefore, the findings lead to a collaboration framework that will advise managers on how to establish collaborative arrangements with the objective of reducing the number of empty truck trips, and improving transport capacity.
7.1.4 Chapter 6: How will the case study port's transport capacity be affected by different scenarios?

To justify the value of developing a collaboration model for shared-transportation (the truck-sharing concept), using a case study approach (the data for this chapter is provided by a port, and simulation results are validated by integrating real-life data from the port as well), this chapter develops a simulation model. The developed simulation model represents the truck-sharing idea to evaluate the effects of the changes made in order to reduce the number of empty trips. Two simulation models have been developed to compare and contrast truck-sharing (to-be process) results with the base case (as-is process) simulation model, which represents the truck appointment system. Simulation results show improvement in the truck-sharing model’s performance. For example, the to-be process boosts port gate-and transport-capacity and handles the increasing future truck volume effectively. The model can also account for the reduction in the amount of carbon emissions generated from container trucks in the port territory. A new contribution in the literature comes from the analysis of simulated results for the truck-sharing concept, which addresses the empty trips problem to cover that gap in the studies.

7.1.4.1 The contribution of this chapter. The truck-sharing concept has been considered here as a potential mechanism for future improvement in container transport capacity. As far as this researcher is aware, the use by the road carriers of the truck-sharing concept, has never been simulated under the conditions assumed (a collaborative scenario as opposed to a non-collaborative scenario) in this chapter. In support of this researcher’s assertion, researcher, Huang et al. (2008:247) further confirmed, “Little work has been done in container terminal capacity analysis using simulation”. This implies that the application of simulation modelling in port capacity management demands further research in order to drive further productivity gain at container terminals. This chapter fills that research gap, and contributes to the existing literature of port capacity management.

7.1.4.2 Relationship to the main research question. With an emphasis on applied planning for transport capacity improvement potential, the findings of this chapter provide insights that have real-life applications. The findings are also relevant to practitioners in the industry, such as the model can be used for transport capacity planning by a port authority, because the simulation model is developed based on specific parameters. These important parameters can be used to solve, to a certain extent, the transport capacity shortage problem by using the underutilised capacity of road carriers. Some of the parameters of the simulated truck-sharing model are, for example gate throughput of export containers for delivery, number of empty truck trips appearing at the port and their capacity utilisation. Each of these parameters is significant for consideration in order to justify the competences that are vital for evaluation of port-related policies (e.g., transport capacity planning). Hence this chapter will assist port managers with replies to questions, such as “What impact will truck-sharing have on transport capacity expansion?”
7.2 Managerial implications of this thesis
The concept highlighted in this thesis is the applications of a truck-sharing idea, which can be considered as an alternative and viable sustainable transportation option for container carriers. The objective is to meet increased demands of future transport capacity, as well as the demands from the market for efficient transport solutions for all stakeholders. Therefore, in order to deal with increased demands for transport capacity, and to improve efficiency in freight transportation and also to reduce system-wide cost by introducing more efficient transport management and information exchange between parties, transport collaboration between carriers and shippers (exporters and importers) can be productive. In summary, all these preliminary discussions (e.g., truck-sharing causes, benefits, and constraints) accentuate the utility of shared-transportation concept (a collaborative transport setting) over the conventional freight transportation (a non-collaborative transport setting) in maritime logistics and supply chain management.

7.3 Conceptual implications of this thesis
It is important to address all of these socio-economic issues (e.g., vehicle miles travelled, traffic congestion and environmental pollution) in order to make a specific and pragmatic contribution to the supply chain domain. Hence, to further innovatively contribute in this supply chain field by introducing progressive ideas, and to assist academics in the adoption of the truck-sharing concept in order to reduce the chances of incurring empty trips by container trucks, this research aims to analyse the pros and cons of sharing a container truck. This approach has been further refined by identifying its (the truck-sharing concept) most important characteristics, such as the constraints of the concept. In view of that, this is expected for transport and logistics researchers at this point to borrow ideas (i.e., the findings of this thesis) from other disciplines. Already logistics has borrowed many theories from other disciplines, including, but not limited to, accounting, management, computing, economics, marketing, mathematics, philosophy, political science, psychology and social science (Stock, 1997); and shaped the important decisions of business researchers. Researchers in the field of business administration need theoretical support for more potential practical applications. Suggesting a similar concern as a requirement for this developing logistics field, many years ago Stock (1990:5) stated, “…many of the business and non-business disciplines have much to offer logistics in terms of concepts, principles, methodologies and approaches that could be applied to various logistics issues, problems and opportunities.”

7.4 Future research needs of this thesis
To make further contributions to this emerging research domain of maritime logistics in terms of reducing the number of empty trips made by trucks, it is imperative to look more into potential truck-sharing possibilities. For example, to know more about the technical possibilities of truck-sharing (a further assessment of the enablers and disablers), and how carriers and shippers plan to address them in a collaborative view. Efforts should be made to gain further clarity to determine the nature of the difficulties that carriers and shippers experience in the sharing of containerised freight transportation. Through further investigation, it would also be important to note the differences between the maritime and non-maritime industry, and to take into consideration the features of the maritime industry. For instance, the configuration of a type of truck may vary from industry to industry. Apart from these implications for future research, following the development of this thesis, further opportunities exist to test the implementation of the truck-sharing idea and to contribute to the scant work that has been done on issue of empty miles. For example:
(a) From a micro-level perspective, practical issues (e.g., carrying capacity of trucks) may be involved with a truck-sharing initiative in addition to other constraints that cannot be controlled, such as, the restricted driving hours of container trucks and the limited import-export operating hours of the port. Hence future research may include computer-based simulation tests to assess the success of the truck-sharing idea with the inclusion of these important truck-sharing constraints.

(b) Apart from addressing these constraints in a future research, in order to adopt a new approach to identifying research directions, it is important to note that the port authority is looking for options to increase container transport capacity without contributing to congestion at peak times on the roads surrounding the port. Therefore, one option would be to use the periods available outside peak handling hours and days. For that reason, according to a study conducted by the case study port, current container transport volume can be increased beyond the current level by utilising out-of-peak hours (3 pm to 11 pm) and weekends (especially Sunday).

(c) Another opportunity which has been considered to be a worthwhile idea by the port authority, is to encourage road carriers to enhance utilisation of trucks servicing the port. For instance, at present, only 25-30% of container trucks arriving and leaving the case study port carry containers in both ways (i.e., full capacity utilisation during both picking up and dropping off) on the same trip. Such a lower utilisation of truck capacity indicates that 70-75% of the truck trips could carry full loads to and from the port. Higher utilisation may lead to more transport capacity in the port region since import and export volumes are almost balanced, and most trucks are capable of carrying two containers during both export drop-offs and import pick-ups.

(d) The simulation model developed in Chapter 6 is employed to perform only export functions (in an organised truck-sharing initiative) in accordance with the export procedure of the case study port. This leaves further room for future research. Therefore, future simulation models can be developed to further explore and incorporate all import data and process of a terminal.

(e) The conceptualisation (a System Dynamics framework) of factors affecting port capacity presented in Chapter 2 offers further research opportunities in terms of handling port capacity shortage issues from an integrated point of view. Such a holistic approach takes into account all components of a seaport in order to increase overall capacity. Therefore, this is an opportunity to work toward developing a System Dynamics model based on real-life data of a port company.

7.5 Limitations of this thesis
A qualitative study is used to critically explore the steps necessary for developing a truck-sharing mechanism from a supply chain perspective in order to minimise the number of empty-truck trips in the case being studied in Chapter 4. Due to the qualitative nature of this research, the adopted methodology provides deep insights in regard to the participants. Although the research results are not directly generalizable to other settings, the work encourages further quantitative study in the field. Therefore, Feng and Manuel (2008) have suggested continue working with both types of research methodology (qualitative and quantitative) in order to maximize the advantages of each of the methodologies (e.g., generalizability of the research results, and deep insights of the participants). The same problem with issues of generalizability is also applicable to Chapter 5 that adopted a qualitative research approach. In explaining the limitation of the single case study approach, it is also argued in the literature, that a single case study can be sufficient to understand a phenomenon if multiple data sources are used (in fact, this is the approach followed in Chapter 4) (Yin, 2003). The overall limitations of a case study-based research have also been described by Chakravorty (2009). For example, the results of a case study can be biased, due to the fact that the respondents, from where the results are drawn, are exposed to the perceptions of the researcher.
Appendix A:
Mechanism(s) and constraints of reducing empty truck trips

1.1 Mechanism(s) to reduce empty truck trips
In order to achieve the objective of improving competitive advantage on the level of difficulty of the competition and its resulting impact on the overall company objectives, and to achieve greater efficiency in a time of economic and financial pressure, supply chain collaboration can be a crucial part of any finely-tuned business strategy, ultimately improving the productivity and profitability of any transport business and its supply chain as a whole. As a rule, supply chain collaboration is defined in the supply chain management literature as an approach of working together on a project undertaken by two or more parties (e.g., carriers) that want to achieve one or more mutual benefits (e.g., empty miles reduction in transportation) that cannot be accomplished in a working-alone environment, or in situations of isolation (Simatupang and Sridharan, 2005). Accordingly, to encourage joint efforts and networking between trading partners in the supply chain, several descriptors are used throughout the literature to denote the meaning of working together, such as “cooperation”, “coordination”, “collaboration” and “partnership”, all signifying similar concepts, although there are slight differences between each descriptor (Yu et al., 2001, Corsten and Felde, 2005). To further present the benefits and advantages of collaborative efforts to be made in achieving sustainable benefits, two concepts that are likely to be particularly useful to transport decision makers in making joint transport plans with other trading partners and the execution of those plans, are the concepts of the, Collaborative Logistics Network (CLN) and shared-transportation. These two potential collaboration mechanisms to reduce empty truck trips have been described in the following.

1.1.1 Collaborative Logistics Network (CLN)
The application of collaborative logistics is made possible by the use of the internet. The internet has made possible the creation of a new mechanism for doing business today, and thereby has positioned itself as an essential necessity in producing efficiency in the supply chain (Lin et al., 2002); this is due to the fact that the internet offers advantages in overcoming some of the obstacles in traditional marketplaces. For example, internet-based online markets lower the transaction cost and ease the negotiation process (Nandiraju and Regan, 2008). Firstly, online markets can lower the transaction cost for the shipper since the employment of staff dedicated to contractual negotiations and contract formulation, can be avoided. Savings in transaction cost can be obtained in other forms as well, such as lowering the cost of searching and marketing (Lin et al., 2002). Therefore, all saved transaction cost in many forms allows the shipper to lower the cost of freight bills. Secondly, similarly, online markets, with the click of a button, can ease the negotiation process since the parties concerned have access to a more extensive marketplace with competitive pricing. All these potential benefits help to achieve higher efficiency performance for both the shipper and the carrier; the achievement of efficiency of operation is important to them (Ergun et al., 2007a, Asawasakulsorn, 2009). For shippers, the impetus is fuelled by: (1) the necessity to send smaller quantities of product in order to reduce inventory volume while fulfilling customer's need within a shorter time frame; for carriers, the impetus is created by: (2) the fact that existing profit margins are low, driver turnover is high, and recruitment is difficult due to shortages, fuel costs are rising and incomes remain the same or even decrease, whilst insurance costs are increasing (Ergun et al., 2007a, Ergun et al., 2007b). These are all compelling reasons that together (Figure 1) are sufficient to encourage the adoption of collaboration in transportation in order to achieve efficiency (Mason et al., 2007, Asawasakulsorn, 2009).
**Figure 1.** Key cost reduction pressures leading to increased transport collaboration

**Electronic marketplaces**
An internet-based platform to facilitate interaction between buyers and sellers

**Electronic Logistics Marketplaces (ELMs)**
An internet-based platform to facilitate interaction between buyers and sellers of logistics services

**Electronic Transportation Marketplaces (ELNs)**
An internet-based platform to facilitate interaction between buyers and sellers of transportation services, such as Collaborative Logistics Networks (CLNs)

**Figure 2.** Interrelationships between internet-based marketplaces
Following on from the relative importance of collaboration, transport collaboration is facilitated by internet-based Electronic Transportation Marketplaces (ETMs) (Alt and Klein, 1998, Goldsby and Eckert, 2003). ETMs are in fact internet-based platforms to facilitate interaction between buyers (e.g., shippers) and sellers of transport services (e.g., carriers) (Lin et al., 2002). The Collaborative Logistics Network is a type of ETM and ETMs are a class of Electronic Logistics Marketplaces (ELMs), which are also internet-based platforms that have been created to ease interaction between the buyers and sellers of logistics services (Yu and Liu, 2008). ELMs are widely available in a variety of industries and, in the logistics field, vary in function from transportation and warehousing to manufacturing; a few examples of ELMs are available, such as; the Descartes Systems Group, Manhattan Associates, the National Transportation Exchange, Nistevo and Transplace (Kale et al., 2007). ELMs are a category in the electronic marketplace. An electronic marketplace is an intermediary platform for the establishment of links between buyers and sellers in the conducting of transactions (Choudhury et al., 1998). To evaluate the association and boundary between each category in the marketplace, see Figure 2.

1.1.1.1 Rationale of CLNs. The reduction of system-wide cost in a typical supply chain is important to all the involved parties since no one person or company controls the cost, although such cost is faced by all participants in a supply chain (Ergun et al., 2007a). Generally, a reduction in system-wide cost is difficult to achieve for a single company. A typical example is asset repositioning cost. A carrier needs to reposition its empty trucks to execute new shipment orders received from shippers. The flow of asset repositioning generates empty miles, and the unproductive empty miles have a cost, which adds to the pressure to achieve efficiency for the carrier. Therefore, the cost is transferred to the shipper for the carrier in the form of increased freight bills, and the shipper pays more than usual to cover it. Eventually the cost is transferred from the shipper to the final customer, who then indirectly pays for the asset repositioning cost in the form of increased price of the final product. To reduce such wasted empty miles, shippers and carriers can work together towards collaboration, such collaboration could lead to finding the best ways of filling an empty truck. Following that appealing collaboration formula in order to avoid the empty running of trucks, there are already a few examples of operational collaborative logistics networks that are available in the business community, such as; Nistevo (www.nistevo.com), Transplace (www.transplace.com), and One Network Enterprise (www.onenetwork.com). All of these third-party centralised facilities offer collaborative mechanisms to members to allow for interaction with each other in order to increase truck utilisation and reduce the cost of system-wide logistics in the supply chain (Sarraj et al., 2012).

1.1.1.2 Importance of CLNs. Many examples of the empty trips problem are available to emphasise the importance of transport marketplaces to the business community. For example: (1) in the USA, for large carriers, 17% of truck trips remain empty; and for small carriers, the figure is 22% (ATA, 2005); (2) In Thailand, in the year, 2006, 6,90,000 trucks made 71.74 million trips, and on 46% of those trips, the trucks were empty (Peetijade and Bangviwat, 2012); (3) All trucks that used the road were 30% empty, according to the National Statistics of the US (Carmel, 2007); (4) In Ireland 37% of trucks were reported as running empty trips (Eurostat, 2007); (5) In the UK food supply chain, 48% of the truck space remained empty on trips and only 52% of the space was occupied by cargo (Department for Transport, 2006); and (6) In the EU countries, around 25% of the trucks ran empty (Eurostat, 2007).
1.1.1.3 Benefits of CLNs. To indicate the benefits of a collaborative logistics network, when applied to a supply chain setting, the study by Mavrommati and Migdalas (2002:350) described its importance and significance, “These networks enable organisations to share capacity, automate interaction with carriers and streamline their supply chain processes, while enabling carriers to optimise their capacity and improve driven retention.” For example, after joining up in collaboration with one of the members of the Nistevo’s network, the two members are enjoying a repeatable 2500-mile continuous move route to reach US cities (including many stages, distribution centres, production facilities, and retail outlets) (Ergun et al., 2007a). The new combined route has resulted in a 19% saving for both shippers. In addition and similarly to these benefits for the shippers, the carrier made a higher profit, associated with lower driver turnover, following a regular driving schedule (Lynch, 2001a). More information of benefits and savings by using CLNs can be found in the studies of Golicic and Davis (2003) and Strozniak (2001). Analogous to these results, success stories (for an example, see Strozniak, 2003) have been reported in order to prove the usefulness of the business models inspired by CLNs; however, these are often in the form of trade press reports that show the published outcomes of a number of supply chain members participating in transport collaboration.

1.1.1.4 How do CLNs work? A CLN can be a special category in an exchange market, which, in brief, is the combination of the auction market and spot market, but to a higher extent, since it also facilities in ensuring execution of the transaction between shippers and carriers in an innovative way. It does more than the matching of capacity with loads (for information on exchange market, see Song and Regan, 2001). Here, in the case of a CLN, a shipper looks for similarities in the frequently used transport lanes of other shippers. The aim is to explore the synergy between a shipper’s own lanes and the lanes of many other shippers; this is done by extensively studying shippers’ transport profiles and selecting potential collaboration partners. The transport profiles help to determine repeatable continuous move routes (multiple loads to create a continuous route for a truck without repositioning it anywhere in between the routes of given source and destination); the combined transport profiles are of importance when requesting lower prices from carriers in order to stay competitive in the business (Kuyzu, 2007). The carriers also tend to accept lower prices in the case of dedicated continuous move routes in order to reduce asset repositioning cost and driver turnover.

Here, the challenge is to discover similar routes from a given set of routes; the optimisation problem is known as the Lane Covering Problem (LCP). The objective of an LCP is to determine an optimal set of continuous move routes to optimise the freight transport within the network (Sarraj et al., 2012). However, this is a challenging task if the size of the network of the collaborative logistics grows. The size of the network increases and becomes complex if the number of added participants and their submitted number of lanes increase (Erhun and Keskinocak, 2011). According to the same study, the complexity of the optimisation problem also depends upon: (1) when time-windows are given as constraints; and (2) when rules (e.g., maximum driving hours for a driver per week) are also given as constraints. Although complexity arises with an increase of members and their lanes, it also provides further efficiency in matching lanes by servicing a diverse base of shippers (Chan, 2006).
Figure 3. Potential empty trips of a general truck
Source: Adapted from McKinnon and Ge (2006)

Figure 4. Potential empty trips of a container truck
1.1.1.5 Characteristics of a container truck for load-matching. The similarities and differences between a general freight truck (non-maritime industries) and a container truck (maritime industries) have been documented, and thus confirmed, by the Chapter 5.

- **Similarities.** Both industries are characterised by: poor communication and coordination among the various groups of stakeholders that have an interest in the freight distribution process, high fixed cost for carriers’ operating activities, stochastic market demand and, most importantly, the limited number of slots which generate cost if they remain empty.

- **Differences.** A general truck may remain empty, in the case of the backhauling process. On the other hand, a container truck may remain empty in cases of both backhauling and fronthauling; this is due to the complexity associated with the deployment of a container for a particular task (e.g., empty container pickup or drop-off, and laden container pick-up or delivery). All of these attributes are shown in Figure 3 and 4, respectively. For more information, see McKinnon and Ge (2006), and Chapter 5.

Building on the ideas and conceptual arguments of Kuyzu (2007), and based on the context of the previously given example of the two shippers that joined the Nistevo’s network and enjoyed a repeating 2500-mile continuous move route for general freight movement by trucks, the benefits of a CLN can be further elaborated as shown in Figure 5. Here it is evident that when both the shippers combine their freight transport route to allow a driver to go beyond the common freight route, they will be able to save significantly more money by avoiding the empty running of a vehicle by adopting a continuous move route from origin to destination and, if necessary, back again. Similarly, using the same theoretical rationale for containerised freight transportation, the application of a CLN can be extended by container trucks, such as in scenario 1, scenario 2, scenario 3 and scenario 4.

**Figure 5.** Continuous move route for a general truck to reduce system-wide cost

Source: Adapted from Kuyzu (2007)
**Figure 6.** Scenario 1 (export: empty pickup):
Continuous move route for a container truck to expand expansion

**Figure 7.** Scenario 2 (export: full drop off):
Continuous move route for a container truck to expand capacity
• **Scenario 1 (export: empty pickup).** As shown in Figure 6, taking an export job as the example, it can be shown that the first part, which is the collection of an empty container from the port that usually creates a completely empty run, for a heavy truck, when arriving at the port, can be avoided if the container truck drops off an importer’s empty container to the port while then picking up an exporter’s empty container from the port. The truck described here is able to pick up or drop off empty containers only, but not full containers.

• **Scenario 2 (export: full drop off).** As shown in Figure 7, taking an export job as an example, it can be shown that the second part (of an export process), which is the delivery of a full container at the port that usually creates a completely empty run for a heavy truck, particularly when returning from the port, can be avoided if the container truck can pick up a full container for an importer from the port while dropping off a full container from an exporter to the same port. The truck described here can pick up or drop off both full and empty containers because of the structural configuration of the truck.

• **Scenario 3 (import: full pick up).** As shown in Figure 8, taking an import job as an example, it can be shown that the first part, which is the collection of a full container from the port, which creates a completely empty run and, in particular, for heavy trucks, when arriving at the port, can be avoided if the container truck is able to drop off a full container from an exporter to the port while picking up a full container for an importer from the same port.

![Diagram](image)

**Figure 8.** Scenario 3 (import: full pick up):
Continuous move route for a container truck to expand capacity

• **Scenario 4 (import: empty drop off).** As shown in Figure 9, taking an import job as an example, it can be shown that the second part (of an import process), which is the delivery of an empty container to the port that usually creates a completely empty run for a heavy truck
particularly, when returning from the port, can be avoided if the container truck is able to pick up an empty container for an exporter from the port while dropping off an empty container from an importer to the same port.

**Figure 9.** Scenario 4 (import: empty drop off):
Continuous move route for a container truck to expand capacity

1.1.2 The shared-transportation concept
The concept of shared-transportation is becoming popular in different types of passenger transportation systems, especially in carpooling (CP) to remove inefficiency (as described by the study of Kleiner et al., 2011) from contemporary transportation models and to develop a transportation demand management strategy (Morency, 2007). The idea behind the concept of carpooling or ride-sharing (another term frequently used for carpooling) is the low occupancy rate of vehicles (for more information on low occupancy rate of vehicles, see EEA, 2005). The low occupancy rate (for an example, a car carries on an average 1.6 passengers, and this means that 75% of emissions are caused by carrying empty seats according to a study by Jeanes, 2010), which is evident in many passenger vehicles, whose empty space could be used more efficiently, the ride-sharing services provided by many organisations accumulate passengers based on the similarity of travelling routes (itinerary—a planned route) and their schedules (timetables). The name ride-sharing implies, as defined by Zhao and Dessouky (2008:135) “...the consolidation of many passenger trips onto a single vehicle (ride sharing).”

Many benefits are associated with the establishment and regular operation of a transportation-sharing service like carpooling. For example, the study by Manzini and Pareschi (2012:85) explores and describes the benefits of carpooling as “…a special typology of the basic strategy of sharing vehicles to directly reduce the use of private cars, the requirement of parking space, and indirectly contribute to reduce vehicle externalities including emissions of greenhouse gases, crash costs, roadway congestion, space consumption, etc.” Accordingly, the enormous potential benefits that can be obtained from greater adoption of carpooling are confirmed by observations in many
studies, such as reducing traffic on the road (Fu et al., 2008, Yan and Chen, 2011, Talele et al., 2012, Wang and Chen, 2012), transportation cost (Ferrari et al., 2003, Kamar and Horvitz, 2009, Manzini and Pareschi, 2012) and emissions (Kamar and Horvitz, 2009, Yan and Chen, 2011, Manzini and Pareschi, 2012, Wang and Chen, 2012) reduction. In order for a carpooling transportation service to achieve these important objectives, there are two ways to operate the business: Daily Car Pooling Problem (DCPP) or Long-term Car Pooling Problem (LCPP). For more information on key differences between DCPP and LCPP, see Wolfler Calvo et al. (2004).

Carpooling is mostly a collaboration problem as the concept is based on the sharing of a critical resource (e.g., a car) (Kamar and Horvitz, 2009). To facilitate collaboration with other passengers, many carpooling organisations have developed websites to assist in obtaining and sharing information on travel routes, departure/arrival times and departure/arrival locations (Yan and Chen, 2011). Some carpooling services can be found at Nuride, Zimride and Craigslist; other sophisticated examples of similar services are evident at iCarpool and CarpoolWorld, which offer passengers an online matching facility (Kamar and Horvitz, 2009). To offer efficient carpooling services to its customers, some leading web-based organisations use optimisation algorithms. However, only a few studies (for few of the optimisation studies, see Ferrari et al., 2003, Calvo and Colomi, 2007, Kamar and Horvitz, 2009) have addressed the application of optimisation algorithms to the carpooling problem (Ferrari et al., 2003, Yan and Chen, 2011).

1.1.2.1 Potential application of shared-transportation in containerised transportation. It has been already evident, that the empty trips problem is not limited to freight transportation (for more information on the empty trips problem in freight transportation, see McKinnon, 1996, McKinnon, 2000, McKinnon and Ge, 2006, McKinnon, 2007, McKinnon et al., 2010), but has prolonged exposure and is visible in passenger transportation (for more information on the empty trips problem in passenger transportation, see Kamar and Horvitz, 2009, Yan and Chen, 2011, Manzini and Pareschi, 2012, Wang and Chen, 2012). In fact, taking both of them (i.e., passenger and freight transportation) as two different but homogeneous groups, it might be sufficient to draw attention to the existence of the similarities between them (rather than the differences), such as high fixed costs of operation and a lower proportion of variable costs, and a limited number of slots which generate a cost if they remain empty throughout the day. It is also worth noting that the empty trips problem has been addressed in the passenger transportation domain using the shared-transportation concept to improve the low occupancy rate of vehicles. However, as a matter of fact, as far as the researcher is concerned, the existing literature on this topic in freight transportation (especially containerised freight transportation) is limited. A few studies have made similar findings. For more information, see Chapter 3.

According to the procedure described in those few studies (Figure 10), a dynamic truck-sharing system stores information of the users (e.g., exporters, importers and carriers) in a database. The stored information can range from user information (e.g., profile and preferences) to trip information (e.g., origins and destinations of the truck trips). The preferences of both carriers and their customers are important. This is not considered an exception to the collection policy of the sharing system, since it is possible that a carrier may have preferences for maximum deviation from the expected route to pick up or drop off an empty or full container. In another example, an assigned driver of the carrier may have preferences for the number of stoppages the driver is ready to incur during the trip. Apart from this stored information, a user of the system can also advertise to share a trip or delete a previously created trip invitation.

154
Once the required information is stored electronically in a central database, a query is performed against the database to explore potential matches to fill the advertised jobs. The query takes into account the pre-established parameters set by the users and thus ensures consistency throughout the matching process. These pre-established parameters could be, for example: (1) both the users of the freight service are moving to the same or a similar destination, although they may have originated from different (but closer) geographical locations; (2) each trip leg of the truck towards the port must follow the appointments as set out in the appointment system (for more information on truck appointment systems, see Zhao and Goodchild, 2013, Asperen et al., 2013); (3) to be economically profitable, the assignment of the container is within an acceptable (i.e., economically profitable) radius for a freight trip by the truck driver; (4) to encourage participation, the truck-sharing assignment should be profitable for all parties, from the exporter or importer to the carrier; (5) and finally, to benefit from the truck-sharing task, the diverse characteristics of both the truck and containerised freight should match each other for a successful sharing. Once all conditions are fulfilled, the system selects the candidates.

Figure 10. The truck-sharing model for matching loads with truck capacity
The short-listed candidates are further evaluated using “Dijkstra’s algorithm” to select the potential user (exporter or importer), based on the shortest distance to the truck’s location till a final candidate is found. For more information on Dijkstra’s algorithm, see Sghaier et al. (2010). Once the decision on the offer of a freight service is made, the system communicates the information to the selected customer. The system also informs the selected customer the calculated savings (e.g., economical profit and carbon emissions reduction) that can be achieved from this truck-sharing event. The truck-sharing system may use the email to communicate information to the final user. Then again, the carrier receives a map and trip information from the system, with the contact information of the customer (exporter or importer). Based on the information provided, the truck driver picks up the container at the agreed time and location. After receiving the service, the customer is able to provide feedback about the service and rate the service provider.

1.1.3 Evidence of load-matching concepts from the maritime literature
The approach discussed and elaborated on previously has only been referred to in a small number of studies in this maritime research area, and has sometimes, been termed as a “double-move”. For example, in Guan and Liu (2009). Another similar strategy to that which this current study identifies as a double move (note that the implementation of this collaboration-driven strategy requires increased communications between carriers and shippers in addressing the empty truck trips problem), has subsequently been suggested to address the common and difficult problem of empty container repositioning by various studies, such as those of Deidda et al. (2008) and Jula et al. (2006). Therefore, the mechanism to completely solve or minimise the empty container repositioning problem is also similar to that of the empty truck trips problem, namely the synchronisation of effort and collaboration among the supply chain members to work together towards a mutually beneficial goal and an acceptable optimum solution. In brief, the potential solution of the empty container repositioning problem can be described as the reduction of empty container repositioning cost by container sharing (Kopfer and Sterzik, 2012). The urge to “solve the problem” is commendable because, as in the empty truck repositioning problem, the empty container repositioning problem also generates huge cost in the form of, for example, inland transport charges (Karmelić et al., 2012). Therefore, to minimise the transport cost, a strategy has been suggested and termed “street-turn strategy” (Deidda et al., 2008). According to this innovative strategy (Figure 11), an importer receives a laden (e.g., full) container from the port; after unloading of the cargo from the container, the importer gives the empty container to an exporter instead of returning it to the port; and the exporter can uses the container for an export move. The success of this strategy can be gauged by the recent study of Wolff et al. (2012:22), “In recent years the share of street turns increased due to the fact that better capacity utilisation was described by the shipping lines too and information exchange on that issue has improved as well.” However, in summary, by comparing both of those strategies (“double-move strategy” versus “street-turn strategy”) it is evident how identical they really are in terms of, especially, the requirements of enable carriers to search for shipping loads for the trucks.
1.1.4 Evidence of load-matching services in practice
Each of these container transportation strategies (i.e., double-move strategy for reducing empty trucks, and street-turn strategy for repositioning empty containers) may have sufficient merit in terms of reducing transportation cost and its impact on the supply chain. However, the double move strategy, which has similarity to the basic principle of a collaborative logistics network and thus ensures continuous fully loaded tours for a truck, is not still commonly accepted by many carriers in the transportation industry as a potential tool (for clarification, see the Ports of Auckland case study). There may be various factors (e.g., lack of trust among partners, see Sahay, 2003) that require coordination to realise its full potential and further expand the benefits to small and medium-sized carriers and shippers. On the other hand, in the case of empty container repositioning problem, which is also based on the logic of reducing system-wide transportation cost, some web-based collaboration tools are getting attention and acceptance among the port community. For a further description of these internet-based tools, see Theofanis and Boile (2007). Two of such web-based services that are being used by port stakeholders to a certain extent have been described below briefly.

1.1.4.1 eModal (www.emodal.com). This web-based platform provides management facilities for intermodal customers, such as truck registries, appointments, dispatching, chassis rental billing, depot management and equipment registry, among others. The platform is also planning to provide data sharing capabilities to benefit the whole supply chain.

1.1.4.2 SynchroNet (www.synchronetmarine.com). This web-based communication platform, which is basically dedicated for the empty container repositioning problem at a regional level, provides real-time container information to reduce one-way shipments and to increase asset utilisation. The service covers more than eighty eight countries.
1.1.5 Barriers of offering load-matching services

These (e.g., eModal and SynchroNet) described internet-based technologies in the maritime industry provide interesting results and collaboration mechanisms among the key stakeholders, although they do not offer load-matching services in the form of a collaborative logistics network or shared-transportation yet. This important “service gap” implies that further opportunities to increase cooperation among carriers and shippers may exist; and added efficiencies may be potentially realised and increased transport capacity can be achieved by reducing the number of empty trips made by container trucks using the proposed concepts in the literature. It is also important to take into consideration the inherent barriers of implementation and management of a web-based mechanism similar to those. Even though various studies suggested many identified barriers, it is difficult to find one single approach to manage all barriers or to find an optimal sequence of activities necessary for successful functional outcomes. Some of the major barriers are: (1) it is difficult to convince companies to share information (Strozniak, 2001); (2) the whole procedure must allow flexibility along with keeping the present relationship intact with other companies (Lynch, 2001a); (3) the success also depends on their (shippers and carriers) intention to invest in the technology and commitment in the efforts to reduce empty running to a minimum for the transport industry (Lin et al., 2002); and (4) it is also vital to follow the 7 laws of collaboration, written by C. J. Langley, Jr. and M. Hammer (www.Nistevo.com) (Mavrommati and Migdalas, 2002). Apart from these few studies, an interesting study was conducted by Asawasakulsorn (2009). The study was carried out to explore collaboration issues, especially in terms of transport collaboration, to describe partner selection criteria during the formation stage of transport collaboration, based on the rationale that it is important to select suitable partners.

![Diagram](image)

**Figure 12.** Leading research streams on truck-sharing constraints
1.2 Constraints of reducing empty truck trips

Despite the importance of efficient space management of freight trucks, there is limited literature reporting on the truck-sharing constraints of the empty trips problem to be found in a range of research domains pertaining to freight transportation. In fact, the literature can be divided into two streams of thought, depending on the prevalence of types of vehicles referred to in research papers, as shown in Figure 12. However, the majority of the results from the limited literature relate mainly to general vehicles (e.g., freight truck transportation) for the retail industry, as opposed to the maritime industry and giving only generalised descriptions related to that cluster of companies; for a list of references to the research on general vehicle-sharing constraints, see McKinnon (1996), McKinnon and Ge (2006), McKinnon (2007) and McKinnon et al. (2010).

![Fig 13](image)

**Figure 13.** Major truck-sharing constraints for general trucks

Source: Adapted from McKinnon (1996)

1.2.1 General freight truck transportation

For a summary report of the referred studies (all of these studies reported similar findings concerning the list of truck-sharing constraints) that are particularly related to general freight trucks, the study by McKinnon (1996) can be taken as an example that explores the factors constraining the return loading of vehicles. As shown in Figure 13, the factors are logically grouped in eight categories, showing the percentage for each category which was received from the participating firms. Firstly, carriers give more importance to the outbound transportation of
finished goods than to the inbound back-loading of supplies; this is necessary in order to maintain a reputation for delivering on time. Secondly, carriers miss many back-loading opportunities because of the non-alignment of inward and outward trips. Thirdly, the mismatch between transport vehicles and consolidated products is a clear example of missed back-loading opportunities. Fourth, the mandatory task of collecting handling equipment can limit a carrier’s opportunities for creating profitable back-loading events. Fifth, the uncertainties of operations that may occur at a supplier's premises may cause back-loading operations to be difficult for carriers. Sixth, inappropriateness between the transport capacity of vehicles and transport demands is another limiting factor to satisfactory back-loading practices. Seventh, the distance between delivery and collection points, coupled with poor timing, together act as a limiting factor to successful back-loading operations. Finally, the scheduling software used may not allow diversions from the distribution route for the collection of supplies for back-loading.

**Figure 14.** Standard classification of truck-sharing constraints for container trucks
1.2.2 Containerised freight truck transportation
Chapter 5 aims to contribute to closing the existing research gap in the limited literature in regard to container truck-sharing constraints, provides a list of the constraints and classifies them into three major groups (Figure 14) based on similarities or patterns in the nature of the constraints (i.e., an assessment of the degree of manageability or controllability of a constraint from a decision-maker's perspective). The groups are formed in such a way as to ensure a well-defined boundary between the diverse constraints, and the constraints within a group will altogether or individually, either influence and facilitate, or not facilitate in any way the development or deployment of shared-transportation for a reduction in the number of empty trips. For example, endogenous constraints are among the included variables, which may have the highest impact on reducing empty trips, and at the same time, decision-makers (e.g., carriers or the port authority) are likely to manage and monitor any aspect of those constraints in the pursuit of goals (e.g., mutual cost reduction, transport capacity expansion, carbon emissions reduction). The excluded constraints are partially related to the promotion of, or increase in, truck-sharing perspectives. The remainder of the constraints which may be difficult to manage or control from a decision-maker’s perspective, are classified and treated as exogenous variables. The study further classifies the truck-sharing constraints with respect to the key aspects of similarity, which comes from a sense of relatedness or homogeneity among the constraints. For example, the intense business competition between carriers prohibits their collaboration. This factor falls under the category of “carriers”. Expressed in this way, in total, four categories of factors are explored and discussed. For more discussion of the constraints and their effect on empty trips, see Chapter 5.
Appendix B:
A review of Operations Research (OR) at ports: An update

<table>
<thead>
<tr>
<th>Literature Survey On Operation Research Methods on Container Terminal Operations (From 2000 to 2010 in Peer Reviewed Journals)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Berth Allocation Problem</strong></td>
</tr>
<tr>
<td><strong>Quay Crane Allocation Problem / Quay Crane Scheduling Problem</strong></td>
</tr>
<tr>
<td>Storage Space Allocation Problem</td>
</tr>
</tbody>
</table>
| Integrated Approach (Analytical) | (Kozan, 2000) (Murty et al., 2005) (Vis et al., 2005)
Vidovic and Kim, 2006) (Corry and Kozan, 2006) (Alessandri et al., 2007) (Chen et al., 2007) (Imai et al., 2008a) |
|----------------------------------|-------------------------------------------------------------------------------------------------------------|
| Integrated Approach (Simulation) | (Liu et al., 2004) (Veenstra and Lang, 2004) (Parola and Sciomachen, 2005) (Bielli et al., 2006)
Ng and Wong, 2006) (Ottjes et al., 2006) (Duinkerken et al., 2006)
(Soriguera et al., 2006a) (Soriguera et al., 2006b)
(Tu and Chang, 2006) (Vis and van Anholt, 2010)
(Legato et al., 2010) (Petering, 2010) |
Appendix C:
A review of factors affecting port capacity

<table>
<thead>
<tr>
<th>A Review of Factors Affecting Seaport Capacity (Variables Identification)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crane</strong></td>
</tr>
<tr>
<td>Variation in Crane Characteristics, Work and Safety Rules, Crane Driver Skill and Training, Supports for Breaks, Crane and Spreader Breakdown, Unavailability of Freights to Load, Delivery from Yard in Wrong Order</td>
</tr>
<tr>
<td><strong>Gate</strong></td>
</tr>
<tr>
<td>Modal Mix, Vessel Schedule, Vessel Capacity, Custom Regulations, Vehicle Safe Requirement, Vehicle Inspection Requirements, Vehicle Repair Requirements, Presence of Proper Paperwork, Communication Skill of Gate Employees and Drivers, Level of Automation, Off-dock Facilities</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Berth Operations</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind, Wave, Swell, Fog, Bad Visibility, Storm, Night Time Restrictions for Some Ships</td>
<td>Approach Channel, Seasonal Variations (Due to Weather Conditions or Due to Supply and Demand), Tidal Harbours (for Deep Draft Vessel), Physical Limitations on Turning Circles around the Berth, Industrial Labour Problems, Remote Port Location, Rail Line Capacity, Optimal Maintenance</td>
</tr>
<tr>
<td>Yard</td>
<td>Crane</td>
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</tr>
<tr>
<td>Area, Shape, Layout, Yard Handling Methodology, Box Size Mix, Dwell Time</td>
<td>Crane Characteristics, Level of Skill, Training Availability of Cargo Breakdowns, Breaks in Yard Support, Vessel Characteristics</td>
</tr>
</tbody>
</table>

**Berth**

Vessel Scheduling, Berth Length, Number of Cranes

**Labour**


**Others**

Number of Container to be Grounded or Stacked, Operational Delay, How Much Weighting, Inspection, Documentation checks are Expedited, Extent of Berth Utilisation, General Tempo of Ops

((Dowd and Leschine, 1990))

<table>
<thead>
<tr>
<th>Physical Factors</th>
<th>Institutional Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of Cranes, Insufficient Land, Odd-shaped Container Yards, Inadequate Berthage, Inadequate Gate Facilities, Difficult Road Access</td>
<td>Union Work Rules, Import/Export Mix, Container Availability, Stow of Arriving Vessels, Customs Regulations, Intermodal Train Scheduling, Safety Rules</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Determinants of Efficiency</th>
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</thead>
<tbody>
<tr>
<td>Container Mix, Work Practices (Interrupt the Stevedoring Operations due to Meal Breaks, Equipment Breakdown, Ship Problems, Weather), Number of Cranes Used, Crane Worked Hours Per Day, Type of Crane, Age of Crane, Crane Related Work Practices, Terminal Layout for Crane Effectiveness, Management for Crane Effectiveness, Vessel Size, Lack of Balance between Various Subsystems, Motivation and Quality of Container Terminal Personnel, Stowage Distribution Pattern over the Bays of the Vessel, Stowage Position in the Bays, Lashing Systems Utilised for on-deck Containers, One-way or Two-way Handling, Allocation of Handling Equipment on Terminal</td>
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<tr>
<th>Uncontrollable Factors</th>
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<td>Level of Economic Activity, Geographical Location, Frequency of Ship Calls</td>
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<th>Controllable Factors</th>
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<tr>
<td>Terminal Efficiency, Port Infrastructure</td>
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</tbody>
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### Endogenous Factors

Production Volume, Number of Workers, Actual Capital, Technological Level, Management Quality

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<tbody>
<tr>
<td><strong>Controllable</strong></td>
<td><strong>Uncontrollable (Ship Related)</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Ashar, 1997)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roadway Factors</strong></td>
<td><strong>Roadway Others</strong></td>
</tr>
<tr>
<td>Number of Lanes, Lane Width, Shoulder Width and Lateral Clearance, Design Speed, Horizontal and Vertical Alignment, Availability of Exclusive Turn Lanes at Intersections</td>
<td><strong>Traffic Conditions:</strong> Vehicle Type, Directional Distribution, Lane Distribution; <strong>Control Conditions:</strong> Type of Control in Use, Signal Phasing, Allocation of Green Time, Cycle Length and Relationship with Adjacent Control Measures</td>
</tr>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Physical Characteristics

<table>
<thead>
<tr>
<th>Nautical Access</th>
<th>Land Access</th>
<th>Port-related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredging Backlog and other Factors Narrowing the Access Time-slot</td>
<td>Ill-maintained Pavements, Restricted Access to Land-transportation Network</td>
<td>Lack of Berths, Lack of Storage Areas, Insufficient Rooms for Modern Ships to Shore Operations</td>
</tr>
</tbody>
</table>

### Organisational Characteristics

<table>
<thead>
<tr>
<th>Handling Capacity</th>
<th>Procedure</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuitable and Ill-maintained Handling Equipment, Poorly Trained Work Force, Not Enough Crane Drivers, Poorly Managed (Unsuitable, Congested) Storage Areas</td>
<td>Lengthy Customs and other Administrative Procedures and Controls, Corruption</td>
<td>Non-productive Methods, Ill Prepared Calls, Too Restricted Working-time, Unwillingness of Port Operators to Work at Night, Commercial Operations Interfering with Ship-to-shore Operations, Excessive Dwelling Time of Cargo for Commercial Motives, Documentation Delays</td>
</tr>
</tbody>
</table>

### Port Infrastructure

<table>
<thead>
<tr>
<th>Labour</th>
<th>Waterways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Space, Gate Capacity, Congestion, Berth Space, Available Land, Terminal Operator Capacity, Port Equipment</td>
<td>Longshore Cost, Longshore Efficiency, Longshore Capacity, Other Port Labour Costs, Other Port Labour Efficiency, Other Port Labour Capacity</td>
</tr>
</tbody>
</table>

### Truck and Rail

<table>
<thead>
<tr>
<th>Technology</th>
<th>Government and Community</th>
</tr>
</thead>
</table>
### Internal Port Capacity Factors
- Capital Facilities, Equipment, Waterways, Labour, Technology, Efficiency

### External Port Capacity Factors
- Railroad Capacity and Efficiency, Truck Capacity and Efficiency, Steamship Line Efficiency, Road Congestion, Shipper Efficiency, OTI Efficiency

### Other Capacity Influences
- Security Regulations, Terrorism Activity, Military Deployment, Labour Strikes, Weather

<table>
<thead>
<tr>
<th>Port Infrastructure</th>
<th>Labour</th>
<th>Waterways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Space, Berth Space, Land for Port Expansion, Gate Capacity, Port Equipment, Terminal Operator Capacity</td>
<td>Longshore Labour Efficiency, Longshore Labour Costs, Longshore Labour Capacity, Other Port Labour Efficiency, Other Port Labour Capacity, Other Port Labour Costs</td>
<td>Channel Depth, Channel Width, Tug and Tow, Barge, Pilotage, Bridge Clearance, Channel Congestion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Truck and Rail</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Road Capacity, Rail (Local Capacity), Local Dray Capacity, Rail (On-dock Capacity)</td>
<td>Gate Systems, Scheduling, Container Tracking, Data Exchange with Partners</td>
</tr>
</tbody>
</table>

### Structural
- Dredging Works, Removal of Obstacles, Application of Locks, More Cranes, Additional Road and Rail Connections, Land Reclamation

### Non-structural

<table>
<thead>
<tr>
<th>Supply-MGT Measure</th>
<th>Demand-MGT Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange of Information, Loading/Unloading without Berth Interference, Improved Berth Capacity, Better Terminal Design, Improved Yard Capacity, Improved Gate Capacity, Improved Port-land Interface, Spreading of Activities to other Regions, Reallocation of Activities, Privatisation, Private Funding of Investment</td>
<td>Congestion Pricing, Peak Pricing, Demurrage Charges, Redirection of Cargo Flows, Slot Auctioning</td>
</tr>
</tbody>
</table>

(Dekker, 2005)
<table>
<thead>
<tr>
<th>(Bichou, 2006)</th>
<th><strong>Quay Site</strong></th>
<th><strong>Yard Site</strong></th>
<th><strong>Gate Site</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quay Cranes and Rely Vehicles</td>
<td>Yard Cranes, Rely Vehicles and Storage Facilities</td>
<td>Gate Equipment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Zavada et al., 2006)</th>
<th><strong>Container Yard</strong></th>
<th><strong>Berth</strong></th>
<th><strong>Crane</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Area, Shape, Layout, Handling Technology, Dwell Time</td>
<td>Vessel Scheduling Berth Length Number of Cranes</td>
<td>Crane Characteristics Availability of Cargo Vessel Characteristics Level of Operator Skill</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Henesey, 2006)</th>
<th><strong>Gate</strong></th>
<th><strong>Labour</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours of Operation Number of Lanes Degree of Automation Availability of Data</td>
<td>Work &amp; Safety Rules Workforce Motivation, Training, Skill Vessel Characteristics</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Le-Griffin and Murphy, 2006)</th>
<th><strong>Berth</strong></th>
<th><strong>Physical Expansion</strong></th>
<th><strong>Non-physical Expansion</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Berth Length, Number of Berths, Productivity Improvement By New Tech and New Machinery, Berth Operating Time (24 Hours, 7 Days)</td>
<td>Purchase New Equipment, Purchase Additional Equipment, Hiring More Labours, Development of Land, Purchase of Land</td>
<td>Improve Efficiency in Allocation of Resources, Improve Policies, Improve Management Decisions</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Internal Factors</strong></th>
<th><strong>External Factors</strong></th>
<th><strong>Others</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Configuration and Layout, Capital Investment, Labour Productivity</td>
<td>Trade Volume, Shipping Pattern, Ratio of Import VS Export Containers, Size and Type of Ships Visiting Terminal, Landside Capacity of Rail and Highway System</td>
<td>Origination-destination Type Ports: Terminal Gate, Interchange Slots, Marshalling Yards; Load-centre Type Ports: Water-side Operations of Berth and Quayside Container Cranes; Container Dwell Time, Hours of Gate Operations, Existence of Inland Container Yard</td>
</tr>
<tr>
<td>Efficiency Factors</td>
<td>Efficiency Factors</td>
<td>Efficiency Factors</td>
</tr>
<tr>
<td>-------------------</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Container Yard</th>
<th>Crane</th>
<th>Gate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area, Shape, Layout, Yard Handling Methodology</td>
<td>Crane Characteristics, Level of Skill, Availability of Cargo, Breakdowns, Breaks in Yard Support, Vessel Characteristics</td>
<td>Hours of Operation, Number of Lanes, Degree of Automation, Availability of Data</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Berth</th>
<th>Labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Scheduling, Berth Length, Number of Cranes</td>
<td>Gang Size, Work and Safety Rules, Work Force Skill, Vessel Characteristics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Berth</th>
<th>Crane</th>
<th>Yard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel Scheduling, Berth Length, Number of Cranes</td>
<td>Crane Characteristics, Cargo Availability, Vessel Characteristics, Operator’s Skill Level</td>
<td>Area, Shape, Layout, Handling Technology, Dwell Time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gate</th>
<th>Labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours of Operation, Number of Lanes, Degree of Automation, Availability of Data</td>
<td>Work and Safety Rules, Workforce Motivation, Workforce Training, Workforce Skill, Vessel Characteristics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal Factors</th>
<th>External Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal Configuration and Layout, Capital Invested, Development Strategy, Labour Productivity</td>
<td>Trade Volume, Shipping Lines Calling, Ratio of Import and Export Containers, Size and Types of Ships, Landside Capacity</td>
</tr>
<tr>
<td>(NANA, 2008)</td>
<td><strong>Storage Capacity Factors</strong></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Annual Cargo Flow Passing through Quay, Area of the Storage Zone, Cargo Dwell Time, Nature of the Handling Equipment (Super Stacker, Gantry Crane etc), Human Factor</td>
<td>Number of Quay, Quay Characteristics, Number of Crane, Hours Worked Per Day, Cargo Handling Rate, Administrative Transit Procedure, Communication Tool among Port Actors (Integration Level of the Port Community System)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Le-Griffin, 2008)</th>
<th><strong>Internal Factors</strong></th>
<th><strong>Others</strong></th>
<th><strong>Others</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use, Capital Invested, Labour Productivity</td>
<td>Expanding Hours of Operation, Decreasing Dwell Time, Better Utilisation of Terminal Land By Increasing Stacking Density</td>
<td>Increasing Utilisation of On-dock Rail, “Fluid” Movements of Containers By Short-haul Rail Operations, Inland Container Yards, Using Technology to Control Labour Expenses</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>External Factors</strong></th>
<th><strong>Railway Capacity Factors</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade Volume, Shipping Pattern, Ratio, Size &amp; Type of Ships, Landside Capacity</td>
<td><strong>Infrastructure Parameters</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Traffic Parameters</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Operating Parameters</strong></td>
</tr>
<tr>
<td>Block and Signalling System, Single Track/Double Track, Track Structure, Speed Limits, Length of the Subdivision</td>
<td>New or Existing Line, Train Mix, Regular Timetables, Traffic Peaking Factors, Priority</td>
</tr>
<tr>
<td>Yard Capacity</td>
<td>Other Factors</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Dwell Time, Twenty Foot Ground Slots (TGS), Peaking Factor, Surge Factor, Optimum Stacking Height, Maximum Stacking Height, Storage Capacity (TEU)</td>
<td>Capacity of the Subsystems within the Terminal, Equipment, Processes, Better Flow of Information / Data Integrity Among Different Stakeholders, Labour / Unions</td>
</tr>
<tr>
<td><strong>Yard</strong></td>
<td></td>
</tr>
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</tbody>
</table>

(Acosta, 2009)
Appendix D:
Examples of interview questions

- How do you receive orders from the customers?
- How do the truckers receive the information?
- Can you please tell me about the dispatching software used by the truck companies, are there any other types of dispatching software used?
- How do you prioritise the customers? Which customers are given the greatest priority?
- Do you collaborate with other trucking companies? Can you please provide some examples?
- There are other trucking companies that collaborate with each other. Do you have any examples?
- Are there any opportunities for collaboration with other truck companies? Generally speaking, is it possible for trucking companies to collaborate?
- Can you give some examples of truck-sharing that relate to slot-sharing instances in which truck drivers share the same slot?
- How do you measure truck driver performance?
- Do you exchange VBS bookings with other companies?
- You have GPS on your trucks, does this provide you information concerning the time wasted by trucks due to the inefficiency of the system?
- Can you please tell me something about competition in the container market?
- Do you go to any other truck companies? Is there any collaboration on driver exchange?
- Do you share any information with other trucking companies?
- Do you think that there is trust between truck companies?
- Based on your experience, do you think is there anything companies can do to assist in collaboration, such as have trust in one another?
- Do you think that opportunities exist for trucking companies to collaborate with each other?
- Do you know of any instances of the ways in which trucking companies do actually collaborate with each other, such as information sharing, slot-sharing, or how to trust each other? Do you have personal experience of this? What would you personally suggest?
- Load sharing, can you elaborate a little more on this topic, please?
- Can you tell me something about competition in the container market?
- What is the level of competition? How do companies survive it?
- And what kind of strategies do companies adopt in order to survive?
Appendix E:
A summary of demographic data of the respondents

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>35 years (on an average)</td>
</tr>
<tr>
<td>Length of professional experience</td>
<td>15 years (on an average)</td>
</tr>
<tr>
<td>Education (minimum)</td>
<td>Diploma</td>
</tr>
<tr>
<td>Education (maximum)</td>
<td>Graduate</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
</tr>
</tbody>
</table>

*Table I.* A summary of demographic data of the respondents
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176


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226


