Empty Container-truck Movement Problem: At Ports of Auckland

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Abstract

The sea port of any country is a very important link for the national supply chain. The importance increases significantly if the country is an island nation like Australia or New Zealand. Since the containerization of shipping ports, everything has changed, from cargo handling to cargo dropping at the customer's doorstep. The demand for containerized movement is increasing day by day because of the easy handling and security. On the other hand, the growing demand has introduced the empty container movement problem. There is a lot of literature that focuses on this problem. Interestingly, there is not sufficient literature on the empty truck movement problem which has a connection to the empty container repositioning problem to a certain extent, however the two problems are significantly different. During any import or export, trucks coming or going from the sea port are empty of containers most of the time, which creates traffic congestion, carbon emission, gate delay and most importantly, increased Vehicle Miles Travelled (VMT). There is no major review, as far as the authors know, on the empty truck movement problem. This paper will investigate some possible strategies to solve the problem for Ports of Auckland for achieving efficiency.

Key words: Empty Mileage, Ports of Auckland, Sustainability, Gate Delay, Game Theory

1 Introduction

Since 1990, the globalization of world trade has contributed extensively to the increased use of containers (Cheumo & Chen, 1998). Today, at least 60% of the world's seaborne cargo is transported in containers, and in more developed countries in particular routes this is 100% (Steenken, Voß, & Stahlbock, 2004). For some years, there has been a continuous growth of container volume which is equivalent to 6.6% worldwide and it is expected to increase at a pace of 5% up to 2015 (UNESCAP, 2006). The growth rate is significant and rational because containerization of goods offers tremendous benefits like increased security, ease of handling, reaching the doorsteps of more customers and making shipping cheaper. Currently, in a sea port, there are container terminals along with multi cargo wharves. Moreover, there is specialized equipment available to accelerate the cargo handling process in the container terminals. As a result, hinterland container transportation has increased rapidly for the last several years along with seaborne movements (Carpenter, 2006).

1.1 Research Motivation and Objectives

Containerization brings some problems like container fleet management, deciding between owning and leasing containers, empty container repositioning and container preloading preparation (Bandeira, Becker, & Borenstein, 2009). A core problem for the shipping companies is to reposition empty containers in the demanding ports (Shen & Khoong, 1995). There is substantive literature addressing this problem can be found, interested readers can be referred to (Cheumo & Chen, 1998; Choong, Cole, & Kutanoglu, 2002; Crainic, Gendreau, & Dejax, 1993; Lam, Lee, & Tang, 2007).

On the other hand, the empty movement of container-trucks increases costs in the national supply chain, creates congestion in the port's territory and consumes more diesels, which is not sustainable for the environment. In order to be competitive with other leading ports of the world, it is very important to focus on improving the efficiency level of the ports operations as there are many decentralized truck operators. But the problem is not addressed in the literature sufficiently. This paper will analyze the problem in the subsequent sections and propose appropriate strategies to deal with it.

1.2 Research Questions

This paper will analyze the empty container-truck movement problem. The goal is to investigate the collaboration opportunities among the stake holders. Thus, research questions include the problem investigation and co-operation prospects among players. Stakeholders are treated as players who play different roles in a container sea port.

1.3 Paper Outlines

Section 1 summarizes the adoption of containerization with research objectives and questions. Section 2 gives an overview of the Ports of Auckland along with describing possible threats from competition and POAL's recent adopted objectives to become more competitive nationally and internationally. Section 3 introduces a short summary of the port's regular operations. Moreover, the empty container-truck movement problem is described. Section 4 outlines possible mitigation strategies from the literature. Section 5 and 6 draws conclusions and possible future research streams consecutively.

2 Ports of Auckland

New Zealand is a trading nation where import-export represents 70% of GDP and geographically isolated where sea ports account 99% of international trades by weight (Auckland Regional Holdings). According to the Global Competitiveness Report of 2008, New Zealand ranked 24th (Nagar & Enderwick, 2010). This was possible because over the last two decades, government has transformed the country from an agrarian economy to a more industrialized economy so that New Zealand can compete globally, and per capita income has risen consecutively thereafter ("Foreign Investment Climate," 2010). Moreover, New Zealand has a total of 13 commercial ports which were corporatized in 1988, and basically owned by the local governments (*Economic infrastructure*, 1996).

2.1 Importance of Ports of Auckland

One of New Zealand's leading ports is the Ports of Auckland, which is a critical part of the international trade. The Ports of Auckland is NZ's largest container port by volume and claims 35.7% share of the total of NZ's containerized and non-containerized cargo (Madsen, 2010b). Ports of Auckland (POAL) contributes the most in the distribution of import and export values of the country. For example, in the year of 2007, POAL handled 50% of imports and 24% of exports, and overall, POAL handled 37% of the total annual trade by value (Colegrave, Simpson, & Denne, 2008). An economic impact assessment of POAL concluded that economic activity by the port will increase to $16 billion annually which is equivalent to 36% of New Zealand's GDP ("Port Facts," 2000).

2.2 Competitive Pressure

There are some significant differences between the container ports of Australia and New Zealand. For example Australia which has five times more population than New Zealand, has only 6 container ports and the ports are far away from each other (Smith, 2010). It is interesting to note that the Australian government has invested sufficient money to improve the infrastructure of the Australian ports (Auckland Regional Holdings). On the other hand, New Zealand has 11 container ports and the ports are very close to each other (Smith, 2010). Most of the ports can't handle 11,000 plus container ships and several billion dollars are indeed needed to improve the infrastructure of the ports, but the current profit levels are not sufficient to justify the huge investment necessary to improve the infrastructure of the ports. The largest vessel that New Zealand can handle now is 4,100 TEU capacities (Auckland Regional Holdings). Shipping lines want to use bigger ships because it saves costs for the shipping lines, importers and exporters.

According to big shipping lines, if the money is not spent to improve the infrastructure of the ports, New Zealand risks becoming a spoke of the Australian hub (Smith, 2010). Moreover, at the same time, developing an efficient supporting transport infrastructure is very important to accommodate these bigger ship volumes and increased traffic flows through the whole supply chain approach (Auckland Regional Holdings). For an example, according to the same report, California upgraded its port infrastructure to support more TEUs (6,000-7,000 TEU) without updating the supporting transport infrastructure, which resulted in bottlenecks in 1990.

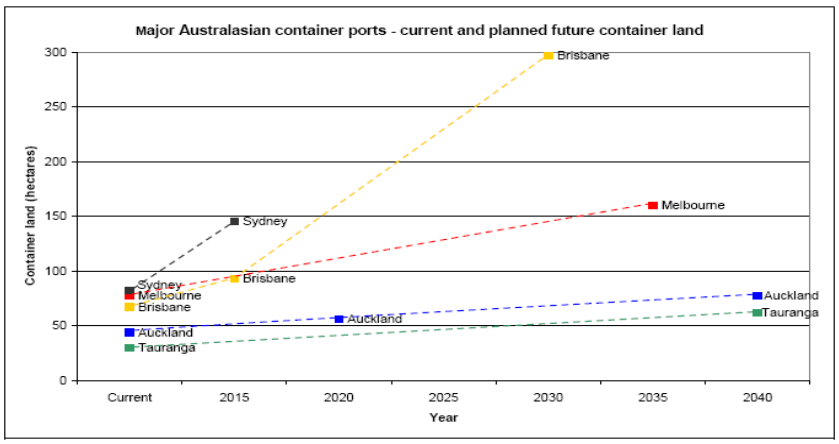

Figure 1: Major Australasian Current and Planned Future Container Land
Source: (Auckland Regional Holdings)

2.3 POAL's Objectives:

POAL's objectives can be classified in three categories, such as Improving Productivity, Reducing Unit Cost and Increasing Return on Capital Investment. Ports of Auckland is planning to improve the productivity of the port by handling more containers and eliminating container-truck queues (Jayne, 2009). This productivity improvement is very important for many reasons. One of those reasons is that North Island freight demand is expected to raise 70-75% in the next 20 years because of the increasing population growth rate which could cause systematic infrastructure failure (Madsen, 2010a).

3 Empty Container-truck Movement Problem

In a typical port, the operation of the container terminals can be seen as material flow (cargoes within containers) between two interfaces (Quayside VS Hinterland). Quayside operations are responsible for loading and unloading from ships, and hinterland operations account for loading and unloading from trucks and trains (Steenken, et al., 2004). POAL is not an exception. When a container ship arrives at the port, a berth is allocated for the ship and containers are loaded and unloaded consecutively by gantry cranes. The unloaded containers are put together in a particular place in the container terminal for transhipment in trucks or trains. Further, those are moved by straddle carriers or reach stackers to put on trucks or trains, or in empty container depots, sheds or packing centers. Rail is currently responsible for only 10% of the total landside movements of the Ports of Auckland (Ports of Auckland).

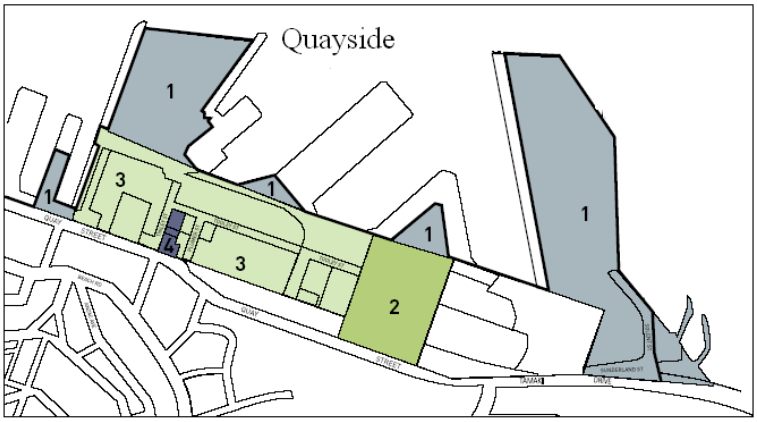

Figure 2: POAL's Current Layout
Source: (Ports of Auckland, 2008)

In an ideal import scenario, a completely empty truck comes to POAL. Afterwards it loads a laden container (cargo within) on it and goes to importer's premises or warehouse. Subsequently the importer unloads the cargo from the container and the container becomes empty. The empty container goes back to the shipping terminal on the truck. Sometimes, it brings back one empty container if it is needed by an exporter or if the same importer wants to export something. The steps are shown in detail in follwing.

On the other hand, in a typical export scenario, a completely empty truck comes to the Ports of Auckland. Afterwards, it loads an empty container which is demanded by the exporter for export. Then the truck goes back to the exporter's premises or warehouse. There the exporter loads the container with cargo. The container becomes a laden container. Thereafter, the truck attaches the laden container to its chassis and comes back to the Ports of Auckland. The steps are shown in the following figure 3. In both import and export scenarios, the question is, how to reduce the empty truck movements.

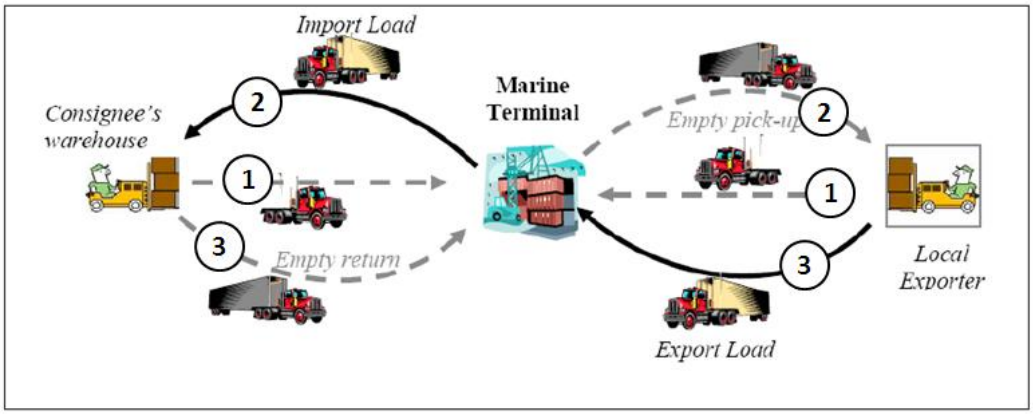

Figure 3: Illustration of Empty Truck Trips (Import and Export Scenario)
Source: (Theofanis & Boile, 2007)

At present, there are almost 250 trucking companies delivering and collecting containers from POAL (Dawson). The trucks operate for 24 hours per day and 7 days per week within the port territory. Per week in Ports of Auckland, almost 12% trucks operate on Monday, 14% on Tuesday, 2% on Sunday and 18% on each rest of the days of the week (Ports of Auckland, 2008). Moreover, research also found that most of the trucking companies attempt to deliver and collect containers in the morning (Ports of Auckland, 2008), refers to the following figure 4. This tendency of the trucking companies creates gate delay and traffic congestion in the area of the port during peak times. To alleviate the problem, POAL introduced Vehicle Booking System (VBS) to evenly distribute the road volumes (Ports of Auckland, 2008).

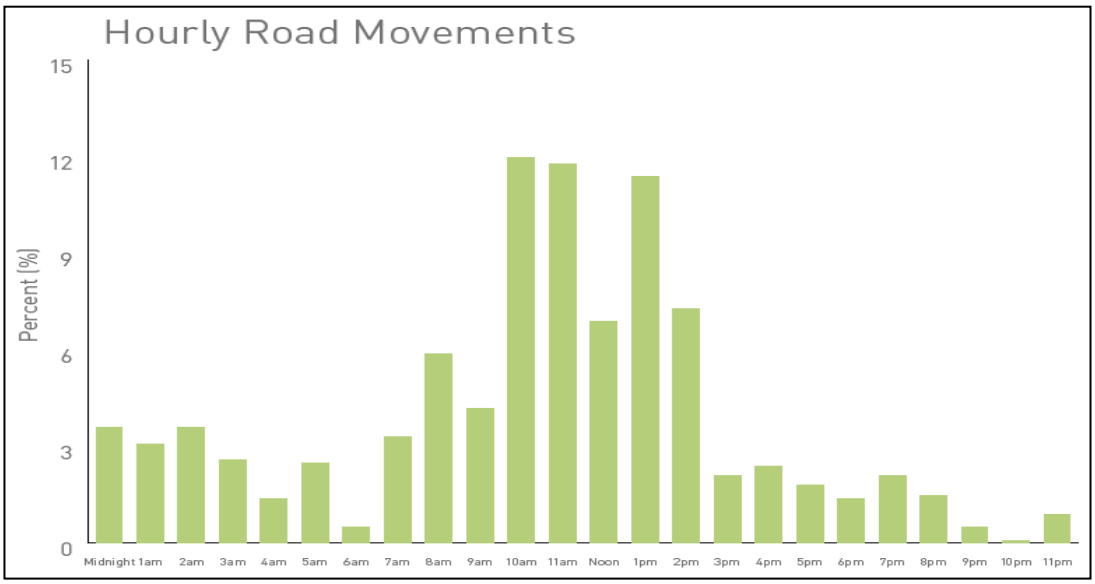

Figure 4: Hourly Road Movements of Trucks in Ports of Auckland
Source: (Ports of Auckland, 2008)

4 Collaboration is the Key

In any sea port, there are many stakeholders involved and they influence each other. Typically, the stakeholders are container owners (ocean carriers and leasing companies), ocean carriers (deep sea carriers and short sea carriers), stevedoring companies, container depot operators, consignees (may be an importer or a third party like a freight forwarder and consolidator), exporters, the marshalling company or the port authority. The success of the national supply chain depends on the collaboration of all the parties to remove inefficiency from the supply chain ("Port energy savings repay significant capital outlay," 2009). Collaboration will reduce the duplication of processes, cut inventories, avoid half-full vehicles and empty containers on back turns ("Collaboration key for success," 2008). Moreover, according to the same source, New Zealand has an added advantage that it has many smaller companies where it is possible for cross-functional co-operation, but at the same time it is important to avoid potential conflicts for mutual goals or domination by one. In the following, some of the strategies are mentioned that will help to mitigate the empty container-truck movement problem to a certain extent, but it requires a sufficient amount of collaboration to bring success. Game theory can be adapted to outline the collaboration scenarios which can be performed as the following.

Use of game theory to understand supply chain conflicts and cooperation is recently studied by researchers (*Handbook of quantitative supply chain analysis : modeling in the e-business era*, 2004; *Research methodologies in supply chain management*, 2005; Thun, 2005). It may be planned to build on this literature to model cooperation, collaboration and competition regarding the container truck movement. Assuming the players' behaviours depend only on the current state, a common assumption in operational settings, consider a repeated game by the players. In such a game, each state implies resultant players' actions in a that period, which then take the system to a new state and the players choose their actions based on the new state, and so forth. However, the resultant state is not certain and thus uncertainty enters the model. So an appropriate stochastic game formulation might be attempted. The mathematical analysis of that game may be made using existing literature or by developing new results specific to the situation as needed. Therefore the research consists of identifying and abstracting the real conflict situation into a suitable stochastic game and studying the game for equilibrium strategies for the different players. So, there will be a framework to compare the benefits of cooperation to the value creation. In addition it may have insight from game theory regarding how to share the additional value created among the players in a coalition.

4.1 Virtual Container Yard:

Virtual Container Yard (VCY) is an internet based system to collect information about an empty container interchange possibility between an importer and an exporter. This is also called street-turns (Deidda, Di Francesco, Olivo, & Zuddas, 2008) (Jula, Chassiakos, & Ioannou, 2006). This is one of the most effective methods of reducing empty container repositioning problem. Moreover, the same method can be used to reduce the unproductive empty container-truck movement problem. In this process, an importer will not return an empty container to the Auckland Port. Without returning, the empty container will be given to another nearby exporter to export cargo (Theofanis & Boile, 2007) as shown in the figure 5. This way, it will save couple of empty container-truck movements to and from the Ports of Auckland.

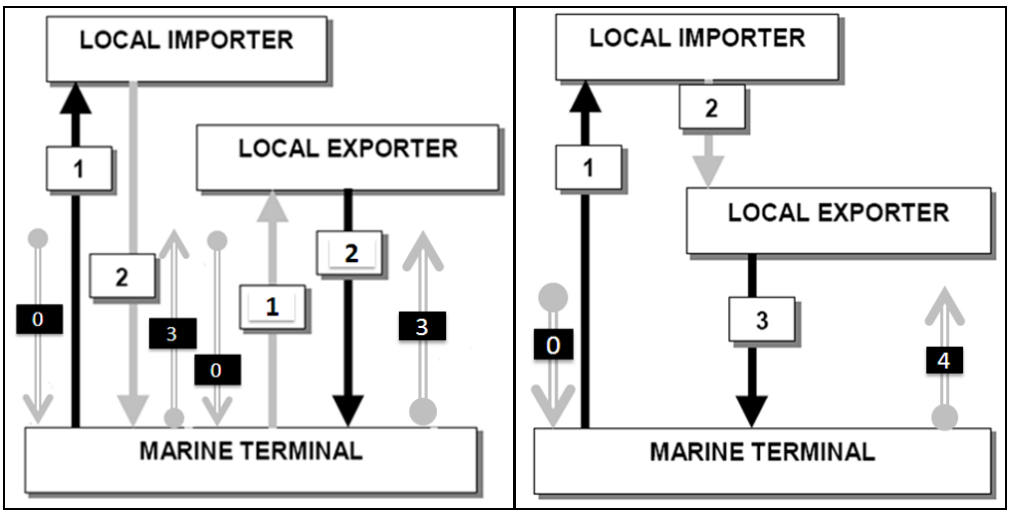

Figure 5: Left (Without Streen-turn), Right (With Street-turn)
Source: (The Tioga Group, 2002)

From the above figure it is evident that, in an import scenario, an empty truck (without any container) comes to the Ports of Auckland (step 0), grabs a loaded container and goes back to the importer's premises (step 1), the importer unloads cargo from the container and the truck with empty container returns to the Ports of Auckland (step 2), and the empty truck (without any container) returns from the port for another assignment. In this whole process, step 0 and step 3, are the unproductive empty truck trips. On the other hand, in an export scenario, step 0 and step 3 are also the empty truck trips. It is found in the research that only 25-30% of trucks servicing the Port of Auckland carry containers in and out in the same trip (Ports of Auckland, 2008). But with street-turn strategy, at least half of the unproductive truck trips can be reduced. It is quite possible for Ports of Auckland to adopt this strategy as imports and exports are almost equally balanced and most trucks are capable of bearing two TEU in each direction which will maximize the truck utilization rate significantly. At this moment, Ports of Auckland is working with a web-based platform, called VBS (Vehicle Booking System) that may help in the future to make this happen (Ports of Auckland, 2008).

4.2 Off-dock Empty Container Depot:

Usually, empty container depots are located within the port's premises because shipping lines like to see the empties there and find it more convenient to send those boxes in the places where shippers want it for exporting. But replacing the depots in other places will give significant benefits to the port authority in terms of traffic congestion, gate delay and reducing empty truck movements. According to the industry experts, off-dock empty container depot can be used as neutral point for interchange purpose in the street-turn strategy (The Tioga Group, 2002). According to this report, it can be used for other purposes as well. But clearly it will reduce empty container-truck movements in the container terminals because empties can be put in this neutral point instead of the container terminal, from where exporters will take the boxes during exporting needs. At present, there is an empty container depot located within the Ports of Auckland (United Containers Limited).

5 Conclusion

The successful implementation of concepts those are presented here, depends on the close participation of stakeholders (Theofanis & Boile, 2007). This is why it is very important to understand the needs of each player and respond positively to those expectations in order to come up with a widely accepted system. There are lots of barriers of successful collaboration with many players. But careful investigation and avoidance of conflicting objectives will bring success at the end. This current paper has performed two objectives. Firstly, the paper reports the work that is in progress relating to the empty container-truck movement problem using game theoretical approach, and secondly, presents the research problem for possible solutions.

6 Future Research Streams

In the future research, the Ports of Auckland will be used as a case to collect input for modelling and the trucking companies working with them could provide an understanding of the existing collaborations. So qualitative data from interviews with executives from relevant organizations will be collected and analysed as part of the research. In addition it is planned to do a simulation study to see whether the insight from the game model still holds, as the abstracted model may have omitted some details from the real situation.

Apart from that, it might be interesting to model the impediments of successful collaboration in the context of the Ports of Auckland. Moreover, location planning of off-dock empty container depot can be practical. The issue is not covered sufficiently in the literature. System thinking approach to understand the problem may be appealing.

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