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The impact of hinterland transport on port operational performance: a Jordanian case

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THE IMPACT OF HINTERLAND TRANSPORT ON PORT OPERATIONAL PERFORMANCE

A Jordanian Case

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me. The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **The Impact of Hinterland Transport on Port Operational Performance: A Jordanian Case**

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This dissertation is a study of the impact of hinterland transport upon port operational performance. Such study is considered very useful as it adds to the literature and current research more evidence and analyses using a quantitative approach and statistical analyses; also, it explains and elaborates the importance of hinterland transportation in the general context, and particularly its impact on port operational performance. This study is motivated by the objective of identifying the relationship between port operational performance and hinterland transport through studying the impact of an organized truck system on port operational performance.

A case study approach was adopted based on NAFITH Company, which controls the flow of trucks to and from the port of Aqaba/Jordan, to examine the hinterland transport, and to be used for further tests and analysis. Using a secondary research design, quantitative methods, a time series of available data was assembled from the port and NAFITH company for a ten-year period; 2006-2015. Then, a conceptual framework was initiated and an analytical model derived from it to explain the primary assumption, which indicates that hinterland transport impacts port operational performance. The analytical model was operationalized by four hypotheses after the parameters were projected.

After examining the literature of both hinterland and port performance, the research took the trucks (truck turnaround time from the marshalling yards) as the variable that represents hinterland transport (independent variable) vis a vis four performance indicators of a dry bulk terminal (ship turnaround time, berth occupancy rate, gross berth productivity, average ship call size) that represent port performance (dependent variables). Hence, four hypotheses were formulated to explain the analytical model; for each hypothesis, the truck turnaround was the independent variable, and the four performance indicators mentioned above were the dependent variables, one variable in each hypothesis.

The hypotheses were tested by correlations, t-test, and simple regression, following that, the results were analyzed and discussed. The findings from the research concluded that there is an impact of improved (efficient) hinterland transport (truck turnaround) on port operational performance, as three hypotheses were significant. However, further research is required to examine all port terminals and determine how much hinterland transport impacts port operational performance as a whole.

Keywords: Impact, Hinterland transport, Port performance, Relationship, Model

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LIST OF ABBREVIATIONS

ABMC	Arab Bridge Maritime Company
ACT	Aqaba Container Terminal
ADC	Aqaba Development Corporation
APC	Aqaba Port Corporation
APM	A.P. Moller–Maersk Group
ASEZA	Aqaba Special Economic Zone Authority
BRIC	Brazil, Russia, India, China
ECMT	European Conference of Ministers of Transport
EDI	Electronic Data Interchange
FSRU	Floating Storage Regasification Unit
GDP	Gross Domestic Product
GPS	Global Positioning System
GRT	Gross Registered Tonnage
HM Treasury	Her Majesty's Treasury
IFC	International Finance Corporation
IMO	International Maritime Organization
ISPS Code	The International Ship and Port Facility Security Code
JGTP	Jordan Gas Transmission Pipeline
JNSL	Jordanian National Shipping Lines
JPRC	Jordan Petroleum Refinery Corporation

JOD	Jordanian Dinar
Km	Kilo meter
KPIs	key performance indicators
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LPI	The Logistics Performance Index
MARPOL	The International Convention for the Prevention of Pollution from Ships
MEA	Middle East Area
MoT	Ministry of Transport
NSW	National Single Window
NAFITH	National Freight Information and Transportation Hub
PPI	port performance indicators Unit
PPP	Private Public Partnership
RFID	Radio-Frequency Identification
RoRo	Roll-on/Roll-off Ships
SCS	Screening Center System
SOLAS	The International Convention for the Safety of Life at Sea
STCW	The International Convention on Standards of Training, Certification and Watch keeping for Seafarers
TCIMS	Truck Control Information Management System
TCS	Truck Control System

TEUs	Twenty-foot Equivalent Units
TMF	Traffic Mitigation Fee
TOS	Terminal Operation System
TRB	Transportation Research Board
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNCLOS	The United Nations Convention on the Law of the Sea

Chapter 1 Introduction

1.1. Background

Ports have been, and still are, an integral part of freight transportation as they play a major role in a country's development and prosperity. Hence, port performance and efficiency are vital for a country's economy because the world economy continues to be the driving force behind the maritime sector (Meersman et al., 2010). Importantly, moreover, most of the world trade is carried by ships, which use ports as the ultimate gateways as world seaborne trade represents about 70% of the value and 90% of the volume of world trade (UNCTAD, 2012).

The historical role of ports is as a natural site to transfer and receive goods, working with the bidirectional logistics system. They receive goods from ships, and from land through road, rail, and inland waterway transport. Hence, ports are the nodes that link maritime and hinterland transport by providing a rigorous interface. On the other hand, they play a vital function in the supply chain because of the facilitation of cargo handling, management, and exchange of related information with different suppliers (World Bank, 2007).

Ports have become increasingly dependent on inland transport to improve port performance, such as streamlining cargo transport by decreasing cargo dwell time, reducing port congestion through decreasing transport and ship turnaround time, and improving port productivity and competitiveness. Ports can achieve those improvements through efficient coordination and organization of hinterland transport. Typically, the hinterland transport includes inland trucks, railways, and inland waterway transport that transfer the cargo to and from the ports. Certainly, this maximizes the geographical outreach of the ports.

There is still quite a high number of ports underperforming, despite new development plans, and that is because of the lack of investment supporting the transport systems

(Acciaro & Mckinnon, 2013). Unfortunately, many ports still suffer from congestion because of irregular flow of hinterland transport, which undermines a port's performance and the supply chain, no matter how efficient and productive ports are.

The issue of the hinterland is challenging for ports since hinterland transport is one of the criteria that shipping lines, shippers, and logistics service providers strongly take into account when they choose a port (Wiegmans et al., 2008).

Today, ports face many issues that come along with cargo transport, such as the increasing size of ships, which imposes a higher pressure on ports as the size of container ships has reached 19,000 TEUs and is still increasing (JOC, 2014). These issues, among others, increase the need for a robust and rational hinterland transport system that easily accommodates the elevating capacity of cargo.

Therefore, hinterland transport is gaining importance as part of the port subsystem. For example, the United Nations Economic Commission for Europe (UNECE) addressed the weakest link in the global supply chain, hinterland transport and its connection with ports, as the increasing volumes of world trade have resulted in grave bottlenecks in port hinterland connections. This issue was the focus of the UNECE Piraeus in 2008, which considered the most significant problems of hinterland connections, and discussed potential solutions (Woodburn, 2010).

In a large sense, deficient hinterland transport not only increases port congestion, ship turnaround and disruption around the gates and inside the ports, but also increases the cost of transport as ships stay longer, and transport to and from the ports takes a longer time (World Bank, 2008). Consequently, all stakeholders patch up the delay by adding more charges, which eventually must be paid by customers and end users.

On that basis, any port concerned about efficiency in the port performance, customers, environment, and capacity management, needs to focus on regulating and organizing hinterland transport. As promisingly expected, after the improvement and organizing of hinterland transport, there would be some positive impacts on the ports in general.

Despite the increased interest in hinterland transport and its importance for ports and supply chain, it is surprising that few academic studies have actually been conducted to identify the impact of hinterland transport on port performance. However, the degree of this impact and the relationship remains open for further research.

This research will explore the impact of efficient hinterland transport on port operational performance. Therefore, the research takes the Jordanian port and its transport system, NAFITH-TCS (the National Freight Information and Transport Hub) as a case where the researcher will test the relationship between the port and hinterland transport system. The case is favorable for this research because hinterland transport has been improved and organized, as it will be explained further in the Jordanian port and transport chapter (chapter three).

The Jordanian port has developed considerably over the last twenty years. It imports and exports a wide variety of cargoes, dry and wet bulks, general cargo and containers. Notably, the Port of Aqaba plays a very fundamental role in the Jordanian economy as it is considered to be the only maritime gateway in Jordan and most of the country's trade is entirely dependent on the port. The Jordanian port has witnessed many stages of development and concessions, even though it suffered from inefficient inland transport.

The port suffered from irregularities and congestion because of old monopolistic, non-transparent, and unorganized transport systems that created long queues, pollution, and clogging at the gates and in the city of Aqaba. This, without a doubt, influenced the port performance and drove corruption and disruptions in the port area. Unfortunately, that was the case in Jordan before 2006.

In Jordan, the Government, the Ministry of Transport (MoT), and Aqaba Special Economic Zone Authority (ASEZA) decided to address this chronic problem. They introduced a freight transport logistics service that aims to cut down on and eradicate all kinds of disruptions and congestion in the city and to/from the port, and overall improve the logistics services. They introduced a truck control system (TCS) that facilitated the flow of trucks in and out of the city of Aqaba, and the port, through single window services, implemented by NAFITH.

According to Nathan (2010), research was conducted to assess the economic impact of NAFITH-TCS on the Jordanian port and Jordan, in general. The research found that the project saved around 8 million JOD vis a vis the previous government spending and expenses. Moreover, the research conducted system's cost-benefit analysis, aside from the improvement in the hinterland transport in Jordan; the profit of the project paid off the cost of the project five years after the implementation.

This research attempts to contribute to the knowledge of the impact of hinterland transport on port operational performance by exploring the importance of hinterland transport, specifically, land transport (trucks), to port performance and the relationship between the two. This research reviews, analyze, and examines the relationship so as to determine whether or not hinterland transport impacts port performance.

1.2. Research Questions and Objectives

The research will focus on the impact of efficient hinterland transport on port operational performance using NAFITH and Jordanian port as a case study. The case study will concentrate on the transport system in Jordan, specifically the NAFITH project, which implemented the truck control system that controls inland transport in the Jordanian city of Aqaba and to and from ports.

The focus of this research will be summarized in four objectives that are sought to be covered and thoroughly discussed herein. For the purpose of plainness and simplicity, the objectives of the research are as follow:

1. To analyze and identify the concepts of hinterland transport and port performance in a broader sense;

2. To explain and identify how efficient hinterland transport (trucks) influences ports in general;

3. To describe and identify the relationship between hinterland transport and port performance;

4. To determine the impact of NAFITH truck control system on Jordanian port operational performance.

Along with the objectives of the research, this research and the case study are simply expected to present answers to following research questions:

1. What are the concepts (descriptions) of hinterland transport and port performance?

2. How does efficient hinterland transport (trucks) influence ports in a general context?

3. What is the relationship between hinterland transport and port performance?

4. How does NAFITH truck control system influence Jordanian port operational performance?

1.3. Significance of the Study

The research will try to explain the importance of hinterland transport in general, and particularly, trucks as the inland transport system. Moreover, the research will endeavor to determine the relationship between hinterland transport and port performance by analyzing and testing the impact of organized hinterland transport, namely trucks, on port operational performance i.e. bulk terminal.

This study will contribute to the literature as it is an attempt to elaborate on and clarify the relationship between hinterland transport and port performance since there is a scarcity of literature discussing this phenomenon. So, a proposed analytical model that assumes there is a relation between port and hinterland transport will be tested to identify the presumed relationship and impacts.

1.4. Methodology

The dissertation begins with a literature review and previous studies that have explained port performance and hinterland transport in general context. Then, it links and identifies the relationship between hinterland transport and port performance.

To achieve the aspired objectives and answer the research questions, a quantitative research approach is used. Thus, the research uses the Jordanian ports and NAFITH-TCS as the case to carry out data collection for analyses and findings.

Using a secondary research design, quantitative methods, time series available data is directly collected from the port and NAFITH. As well, further data and background information are gathered through the examination, collection and study of organizational documents, reports, websites, previous research, brochures, and data from the Ministry of Transport.

The quantitative research approach aims to answer the research questions and clarify the impact of NAFITH-TCS, after the organization of inland transport, on Aqaba port performance. However, data analysis will be conducted after collecting and testing the data using regression analysis as a tool and descriptive statistics to describe the findings.

1.5. Dissertation Structure

The research, with the case study, consists of six chapters that endeavor to discuss the different aspects and relationships between hinterland transport and port performance and analyze the findings. The chapters are organized as follows:

- Chapter one presents the introduction and background of the study, objectives and research questions, the purpose and significance of the study, research methodologies, and the structure research.

- Chapter two explains, via literature review, the hinterland transport system and port performance. Further, it points out the relationship between hinterland transport and port performance and sets out the conceptual framework.

- Chapter three describes transport systems and ports in Jordan. In addition, it describes the NAFITH truck control system as the focus of the case study. The aim is to provide an overview of ports and the current transport system in general.

- Chapter four presents the research methodology, including the hypotheses and the analytical tools.

- Chapter five contains the analysis of the hypotheses and a discussion of the findings.

- Chapter six the conclusion. It provides a summary of this research, as well as the derived implications, limitations, and suggestions on further areas for research. Figure 1 in the next page shows the dissertation flow chart.

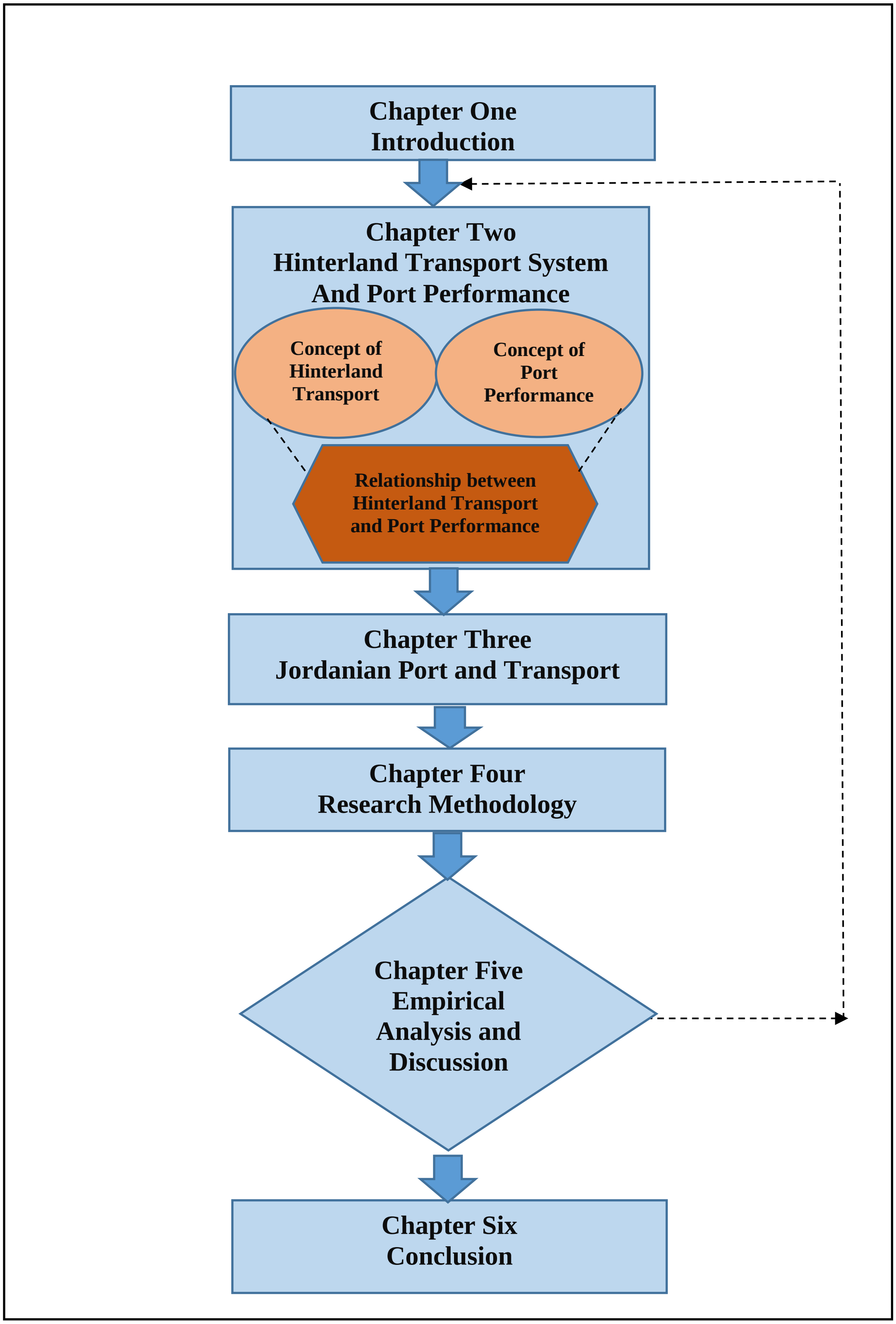

Figure 1: *Dissertation Flow Chart*

Chapter 2 Hinterland Transport System and Port Performance

2.1. Concept of Hinterland Transport system

Hinterland transport plays a very vital role in any region's market; it enables a swift movement of freight which, ultimately, improves the country's economy and the competitiveness of its ports, especially when the hinterland system is efficient. It becomes essential for national and international economic and trade growth, importantly, when it serves a wide geographical outreach. All modes of transport provide various ways of movement of cargo and freight to meet the needs of industry and transport users under a framework that engages all modes. Many writers have expounded the topic of hinterland transport; some reasoned that the liner shipping challenge has shifted from the sea to ports and then to the hinterlands (Guthed, 2005; Notteboom, 2002).

Furthermore, the hinterland forms a crucial part of port composition. Most ports, despite high engagement in deep sea or feeder services such as transshipment, do have some percentage of transit traffic gateway, i.e. the containers are unloaded from the container ship to the yard then through the gate to the hinterland via modes of transport (Acciaro & Mckinnon, 2013). In this sense, hinterland transport is a paramount component to ports. In their research, Horst and De Langen (2008) stressed the need to analyze hinterland transport systems because the hinterland transport costs are, by and large, more than the maritime costs.

Moreover, the problems of congestion, and bottlenecks, in door to door container service and handling of rails, barges, and trucks, take place in the hinterland networks. Also, the development of any container port and its expansion depends on good hinterland transport, for which sufficient provisions should be crafted for road and rail capacity to help in the functioning of the terminal with high value added services (Acciaro & Mckinnon, 2013). In general, the hinterland chain of ports is segmented into the gate process and hinterland transport process.

2.1.1. Overview of the Hinterland

A port's hinterland is defined as the inland area to which import cargo is delivered, and export cargo is collected from (Woodburn, 2010). The hinterland flows across the various transport modes, in countries, regions or across corridors. Port hinterland study started in the mid-1980s, as it discussed the optimization and coordination of the system to meet the economic development of ports (Ming-Jun & Yan-Ling, 2012). In this regard, Ming-Jun and Yan-Ling established a multi-objective programming model for a port logistics transport system and economic benefits when choosing the dynamics of hinterlands.

In fact, the literature widely discussed and analyzed the roles, specifications, and advantages of hinterland. Research on hinterlands is wide ranging, such as; (Notteboom & Rodrigue, 2005; Cullinane & Wang, 2006; Woodburn, 2006, 2007). Yang (2002), for example, blended a gravity model and a thorough evaluation model to define magnetism and the scale of service between the port and its hinterland. As well, Bai (2008) genuinely evaluated the relationship of port and hinterland, and constructed a segmentation method dependent on a force model. Fang (2004) argued about the effects of ports on adjoining principal hinterland, subsidiary hinterland, and likely hinterland as he studied the whole system of a port. Lu (2001) analyzed the development and advancement of port logistics and its hinterland.

2.1.2. Hinterland Transport Modes and Development

The intensity and intricacy of landside activities differ significantly depending on the terminal size, transport types, and infrastructure accessibility in the area, and the terminals operation technologies applied. The big terminals, noticeably, rely on a mixture of road and rail transport and also, if available, barge transport. Nevertheless, road transport continues to be one of the major hinterland transport modes given that its flexibility and possible outreach are high owing to the fact that trucks can go wherever there are roads, according to Zuidwijk and van Asperen (as cited in Acciaro & Mckinnon, 2013).

According to UNCTAD (2008), hinterland transport can be divided into four modes, herewith hinterland transport is identified as:

1. Inland waterway transport (barges)

Inland waterway transport is the transport of cargo via ships or barges or any water craft in inland canals, rivers, and lakes. between ports and harbors. While still under-utilized, it is considered the most environmentally friendly mode of transport. Inland waterway transport plays a critical role in linking cargo and passengers from remote areas to further or more developed places. It is considered a very valuable alternative in developed countries to relieve road transport congestion and reduce the environmental effects from trucks emissions; this fact helps to contribute more to the growth and development of inland waterways.

Moreover, inland waterway transport has acquired a very considerable importance because it offers cheap and reliable transport, which has attracted many container shippers who have used barge transport since the eighties (van der Horst & de Langen 2008). According to UNCTAD (2008), the European inland waterway transported around 500 million tons of goods in 2007, an increase of 4% from 2006. Moreover, goods transported in the United States, in the same year, amounted to around 800 million tons, China as well along with Yangtze River increased the traffic of inland waterway up to 1.3 billion tons.

2. Railway transport (Trains)

Railway transport is capable of carrying general cargo, containers, and dry/wet bulks, has developed significantly in recent years. The International Union of Railways (as cited in UNCTAD, 2008), reported that railway traffic witnessed improvements and advancements all around the world, especially in BRIC countries, which resulted from the development of demographical aspects and the globalization of trade.

In Europe as well, railways developed very quickly both within countries as in Germany, The Netherlands, Belgium and Sweden or across borders to serve wider hinterlands. The development continues in many countries, such as the United States, Russia, China, and Chile. By doing so, another mode of transport is given a share in the servicing of the hinterland, improving logistics and supply chain and decreasing congestion at ports.

Rail and barge are highly advocated to be utilized because they offer substantial cost and environmental advantages (van der Horst & de Langen 2008). On the other hand, this kind of development needs a proper infrastructure which requires capital intensive investment and many private and public investors and agencies to work together harmoniously. Hence, the coordination must rely on specific policy action to perform successfully (van der Horst & de Langen 2008).

Still, many countries may not move forward to invest in railways, nonetheless it is an efficient way to improve terminal integration with intermodal transport.

3. Road transport (Trucks)

Road transport is the haulage transport of goods mainly using trucks that operate on roads as its primary network. It is a more frequently used way to cover the hinterlands, carrying general cargo, containers, dry/wet bulks and dry break bulks. Many issues result from the use of road transport i.e. road congestion, pressure on infrastructure, and environmental and safety issues, especially when the whole system lacks the organized consolidation of its components and/or trans-country outreach.

Despite that, European road transport makes up 90% of inter-urban transport traffic, which means that roads are still highly used among all other modes of hinterland transport (UNCTAD ,2008). Practically, trucks dominate most of the port hinterland traffic, causing most of the congestion in and around port areas, and commonly generating most external costs (Merk & Notteboom, 2015).

So, many ports included a modal shift in their strategic plans, from trucks to rail or inland waterway transport; unfortunately, not all ports are well connected with developed rail systems or have inland waterways. Moreover, in some ports, if it is feasible to elect the use of railways, the cost may outweigh the return on such investment. Therefore, a modal shift in many ports is not applicable, but there is a wide variety of instruments that can be applied to mitigate and lessen the effect of truck usage in hinterland transport, see 2.1.4. and 2.1.5. in this chapter.

2.1.3. Measurement of Hinterland Related Performance

According to the UNECE report (Woodburn, 2010), no uniform method measures hinterland connection performance due to the data unavailability and consistency matters that make the comparison very hard. Hinterland can be regarded from a macro level, a country level, and a micro level, the county's ports and corridors. However, the World Bank and the World Economic Forum provide an international comparison between countries on the basis of logistic activities, which aims to quantify countries' logistical performance; certainly, this incorporates the hinterland links within the index.

Three significant indices can incorporate the hinterland connection performance, those indices, as stated by Woodburn (2010), are:

- **The Logistics Performance Index (LPI),** produced by the World Bank, which measures the country's logistics performance friendliness. Based on the World Bank (2007a), the LPI is composed of six core component. Importantly, they measure the perceptions of the logistics environment of trading partner countries. This incorporates customs, border procedures, transport quality, shipment arrangement, the industry of local logistics, the cost of domestic logistics, shipment tracking ability, timeliness in shipment arrival to end destination, and IT infrastructure. Moreover, the index provides information on the logistics environment in the home country of operation, and the real time-cost performance data for country of operation.
- **Trading Across Borders indices**, produced by the World Bank and focus on the specific procedures taken to export and import goods in countries.
- **The Enabling Trading Index**, produced by the World Economic Forum covers market access, border administration, communication and transport infrastructure and the business environment (World Economic Forum, 2008).

For the hinterland connection at the individual port or corridor level, there is no regular analysis. However, ports, individually, can quantify the hinterland performance concerning the connectivity to inland location through measures related to the number of inland terminals served, the frequency of service, the journey time, turnaround time, and goods that terminals or geographical areas receive. Moreover, measures regarding environmental performance are progressively more important (Woodburn, 2010).

2.1.4. Ways to Improve Hinterland Transport Performance

A wide variety of stakeholders is engaged in hinterland transport, such as private companies, shipping lines, terminal operators, freight forwarders, clearing agents, hinterland transport providers e.g. trucking, rail, and barge companies, in addition to public authorities such as customs, port authorities, inspection services, and infrastructure managers (Horst & De Langen, 2008). Horst and De Langen (2008) analyzed the coordination in hinterland transport, giving different arrangements to enhance coordination in order to improve hinterland transport where more bottlenecks exist throughout supply and logistics chain.

They stated that the development might be hampered by the lack of motivation and incentives for further cooperation, e.g. free-riding problems, information irregularity, and the requirement for contractual obligations, which stem from an imbalance between the costs and benefits and the lack of eagerness to invest. It was recapped that coordination problems are due to many reasons i.e. insufficient information exchange, difficulties in investments, new services requiring basic volumes which might be rejected if not being met, inadequate planning on empty containers, customs and inspections delay and insufficient information about customs clearance of containers.

Furthermore, four major mechanism frameworks were set up to boost coordination, which are, the initiation of incentives i.e. penalty system, different prices, and rewards, generation of inter-firm alliance, and organization scope change and design of collective actions by port authorities and transport firms. Besides, they arranged and classified one of the techniques mentioned above to each coordination problem in the port of Rotterdam, which witnessed improvement and addressed some problems in the hinterland transport.

2.1.5. Optimization of Trucks Flow

A great deal of research has discussed and examined solutions to make hinterland transport more efficient. Regarding trucks, Wada and Tsuchida (2013), on one hand, reported that Nagoya port in Japan developed a trailer document Screening Center System (SCS) in 2011 to verify whether the trailers have the appropriate documents to enter the terminal. They found that approximately 13 % of trailers had incomplete documents. Hence, by eliminating such trailers, congestion in front of the terminal gates could be relieved.

On the other hand, Motono et al., (2014) conducted a survey at Chennai port in India, which observed heavy trailer congestion. They revealed that only half of import container trailer drivers carried the proper documents, which was believed to be one of the main reasons for ports gate congestion.

Another example comes from the Transportation Research Board (TRB) (2011), which pointed out that the improper documents carried by trailer drivers were one of the causes of congestion at the gates of ports. According to Merk & Notteboom (2015), ports have applied multiple strategies to streamline the flow of trucks, and decrease congestion and other implications of high dependence on truck systems. The strategies are as follows:

1. **Port gate strategy**

In many ports and ports cities, the port gate strategy was launched to reduce idle trucks in ports and mitigate the traffic so as to reduce urban congestion and environmental impacts. The major policy instruments in this regard are terminal appointment system, extended gate hours, and virtual container yard system.

- **Truck appointment system**

The main aim of the appointment system is to decrease congestion on the roads to terminals or at terminals by granting special treatment to trucks that schedule themselves in the appointment system. The feature of this system is that terminals allocate time for trucks to come to ports, which enables them to spread truck flow more uniformly throughout the day.

The system here is not compulsory most of the time, but sometimes it is imposed by terminal laws, such as the case of the state of California, which imposed the appointment system in the Port of Oakland, Los Angeles and Long Beach. Accordingly, truckers incur a penalty of 250 USD for a truck that idles for more than half an hour. The system typically utilizes the internet where an application is submitted providing information to gain clearance before the truck’s call at the port.

These applications have developed the flow of trucks, increased terminal throughput and improved productivity for trucking companies and terminals. In addition, truck turnaround time was reduced by 30% on average, as in the case of Georgia Ports Authority, according to US EPA (as cited in Merk & Notteboom, 2015).

- **Incentives for off-peak traffic**

Extended gate-hours endeavor to rearrange the arrival times of trucks to port terminals during the day by offering incentives to motivate the use of off-peak hours that aim to decrease congestion at the terminals and on the city roads. An example of a very popular extended gate time is the PierPASS program, which was employed in Los Angeles and Long Beach ports. It had a Traffic Mitigation Fee (TMF) for truck operation during peak hours paid by the cargo owners; on the other hand, the system exempted trucks calling at off-peak hours.

However, there are drawbacks to this program including long queues just before the off-peak time starts.

- **Extended gates and dry ports**

The extended gates approach is a relocation of part of the port to be closer to the hinterland, by transferring the cargo handling, customs, and other formal procedures to an inland port. This ultimately reduces port terminal and gate congestion. Many ports have developed this concept, such as the case of Antwerp port, which created a network of inland extended gates. Some ports created dry ports by merging the inland terminals and the distribution centers to facilitate hinterland transport systems.

2. Dedicated freight routes

The idea of dedicated freight route lanes and corridors was created in many countries to facilitate and expedite uninterrupted freight transport, thus permitting a very limited mixture with the transport of urban passengers.

3. Potential automated hinterland transport technology

Automated transport is still in the immaturity phase, except for some internal transport at factories or container yards. Notwithstanding, the application of automated freight transport is very seldom. The interest of automation is on the rise; there are many benefits of automation, such as lower labor cost, all day operations and higher reliability (Visser, Konings, Pielage, & Wiegmans, n.d.). In the same paper Visser et al. discussed the most considerable automated transport technology for hinterland i.e. container transport over a radius of 50 to 150 km. Those types of automated transports are;

- Automated trucks and multi-trailer systems;
- Automated trains;
- Automated barge handling systems;
- Automated capsule/alternative rail systems;

The automation requires a highly organized infrastructure, which is an extra cost that needs to be taken into account. Then again, the cost and performance in the above mentioned study showed positive results after labor cost cuts and 24-hour operability.

In light of that, Lloydslist (2016), in a description of truck transport outside the port of Los Angeles and Long Beach, stated that truck turn time or truck queue time is an indication of the quality of the service provided by ports. In summary, efficient inland transport would, of course, reduce congestion at port gates and truck turnaround and waiting time in queues would decrease. In the view of the author, the regulation and optimization of truck performance involves three sides; infrastructure expansion, management and processing, and the political and governmental side.

2.2 Concept of Port Performance

Ports are essentially the interface that provides services to ships, inland transport and cargoes that enter the port from seaside for transshipment or transit to the hinterlands outreach, and from the landside heading to the forelands. Given that around 80% of global trade by volume, and more than 70% of its value is transported by sea and handled at ports (UNCTAD, 2015), efficiency in port performance is highly required. For many developing countries the case here is even more important due to the dependence on ports, which handle most of the imports and exports of those countries.

With the limited number of ports, it is fundamental to have efficient ports that avoid congestion, streamline international trade, and thus improve a country's economy and living standards, and port competitiveness (Chin and Tongzon, 1998). Ports may offer splendid services for ships calling at their berths, which satisfy the carriers. On the other hand, ports may not offer satisfactory services for cargo interests; for example, poor inland transport might, or cargoes might not be serviced very well i.e. less added value or poor services.

Ultimately, this situation is the cause behind the fact that some customers become unsatisfied with what they call poor performance. Port performance, or efficiency, is considered a form of output relative to input which quantifies various aspects of port operation (Song & Cullinane, 1999). On the other hand, measurement of such performance has become of high importance, owing to the wishes of all stakeholders to deal with an efficient port with very good quality performance.

According to Song (2012), measuring performance is always sought for many reasons namely;

1) To monitor activity;
2) To compare present with past performance;
3) To compare present with target performance;
4) To compare with competitors' performance;
5) To adjust targets;
6) To promote the business;
7) To check port's efficiency, productivity, and effectiveness.

In essence, performance measurement enables the use of data to improve port operation and develop future undertakings to remain competitive in a very competitive maritime field. All measures of port performance are interrelated; thus it is not possible to measure any one on its own to rate performance. Performance comparison among different ports is not similar. It is a very insubstantial issue as there are great differences in the geographical locations of ports, and this sometimes influences their technical structures (Suykens, 1983).

Ports are different in size, number and size of ships calling the port, as well as the variability of goods passing through; hence, considerable intricacy is entailed in benchmarking performance measurement. The lesson here is that port performance is not measured from one side or a single value i.e. seaside. It is a set of complex activities and inclusive measures that encompass multi-faceted factors in the port. Ports, in fact, entail a composite group of activities with many diverse input and output sources that make comparisons between two ports very difficult (Valentine and Gray, 2002).

In fact, a meaningful evaluation of port performance, according to De Monie (1987), needs to take into account the following factors:

1) Ship stay duration in the port (ship turnaround);
2) Cargo handling quality;
3) Service quality of inland transport trucks during time at the port, truck turnaround time.

The concept of port performance has grown rapidly and has started to be used widely. Monitoring port performance has become a more challenging and difficult task than it used to be (Park and De Langen, 2004). Nevertheless, performance contains overall productivity, efficiency, effectiveness and economy of the port as it is always used jointly with port efficiency and effectiveness. Truly, we need to understand all port performance measures and identify them to set forth the required actions. To do so, most ports use port performance indicators and key performance indicators (KPIs).

The port operational performance indicators are used to measure and assess the relationship between supply and demand for a country's port services. Thus, the port performance indicators can be quantified, and they can also be improved if targets are established for key performance indicators. The issue of performance measurement and monitoring is very significant for future development and management of application of new plans, such as set up of new transportations network (World Bank, 2007b).

2.2.1 Traditional Port Performance Indicators (PPIs)

As suggested by UNCTAD (1976), port performance indicators are classified into financial indicators and operational indicators as shown in Table 1 and Table 2. This is still a valid way of configuring port performances, but it is considered a traditional way that brings about productivity and effectiveness as measures of port performance.

Table 1: *Financial Indicators*

Financial indicators	Units
Tonnage worked	Tons
Berth occupancy revenue per ton of cargo	Monetary units/ton
Cargo handling revenue per ton of cargo	Monetary units/ton
Labor expenditure	Monetary units/ton
Capital equipment expenditure per ton of cargo	Monetary units/ton
Contribution per ton of cargo	Monetary units/ton
Total contribution	Monetary units/ton

Source: (UNCTAD, 1976)

Table 2*: Operational Indicators*

Operational indicators	Units
Arrival date	Ships/day
Waiting time	Hours/ship
Service time	Hours/ship
Turnaround time	Hours/ship
Tonnage per ship	Ton/ship
Fraction of time berthed ships worked	-
Number of gangs employed per ship per shift	Gangs
Tons per ship-hour in port	Ton/hour
Tons per ship hour at berth	Ton/hour
Tons per gang hours	Ton/hour-hour
Fraction of time gangs idle	-

Source: (UNCTAD, 1976)

The performance indicators suggested by UNCTAD represent the traditional PPIs that entail measures of productivity and effectiveness and have been used as a reference in much of the literature. However, the recent PPIs can replicate the current status and the related needs of ports, such as new PPIs for additional logistics services have been adopted and developed too (Tsamboulas, Moraiti, & Lekka, 2012). New indicators suggest that the measurement of port performance and efficiency, should not only be restricted to quantitative indicators but could also comprise qualitative measurements (Antão, Soares and Gerretsen, 2005).

2.2.2. Container Terminals PPIs

Ports are focusing on quantifying and improving container terminal performance indicators because of the rapid growth in container trade. Besides, there is fierce competition from inter-ports in the surrounding regions to attract more customers and set an example of a paramount performance that makes all customers more satisfied. Hassan and et al. (1993), proposed that interrelated port operations are divided into four classes, namely ship operations, cargo handling, warehousing, and inland transport.

In the same way, Koh and Ng (1994) divided operational activities in container terminals into the following aspects;

1) Berth operation: The key element here is the time a ship spends in the berth which is widely known as ship turnaround time. At arrival, ships are allocated with a specific berth, cranes and other quay services to load and unload cargo.
2) Ship operation: In this activity, the cargo is loaded and unloaded to/from the ship using an arranged numbers of quay gantry cranes; in this respect, a good plan to achieve high throughput, i.e. in TEUs (Twenty Foot Container Equivalent Unit), must be conducted to optimize the output per hour.
3) Yard operation: This is considered the busiest among all other activities where containers are stowed, shuffled, shifted, handled from hauling transport, and/or moved to another terminal yard.
4) Gate operation: It deals with entry and exit of import and export cargoes to/from the yard or the quay through modes of transport viz. railways and trucks. Generally, this kind of transport is mastered by freight forwarders.
5) Scheduling: This is a very important function, it makes certain that assorted resource pools, e.g. gantry cranes, yard cranes, prime movers, and any other handling equipment, are scheduled and utilized efficiently taking into account constrictions and different demands on them.

Moreover, with respect to the aforementioned activities, more comprehensively and inclusively, as shown in Table 3, Thomas and Monie (2000) categorized performance measures into four groups, which are;

- Production measures: That is, the traffic measures, identified in "*Measuring Container Terminal*" (2012) as, “the quantity of cargo passing through a terminal in unit time, and/or throughput measures, which signifies the effort involved in moving that cargo, in terms of container movements per unit of time.”
- Productivity measures: “The ratio of output to input, in general terms, productivity is expressed in terms of the quantity of production (items, tones, units etc.) achieved per unit of resource (per person, per square meter, per item of equipment) in unit time (day, week, month etc.)” ("*Measuring Container Terminal,*" 2012). This measure is very important for the ports and/or terminal operator due to the fact that it involves the cost of the terminal operation.
- Utilization measures: They are measures of how intensively the production resources are used, and are generally calculated as a ratio, expressed as a percentage, between the actual use of a resource and the maximum possible use of that resource over a particular time period ("*Measuring Container Terminal,*" 2012).
- Service measures: They indicate the quality of service to the terminal’s customers, such as ship operators, shippers and receivers of cargo, and transport operators. They signify the satisfaction to those customers with the services offered. The operators of terminals must be concerned not only with trade, traffic, and efficiency, but also with the degree to which the terminal meets customer’s requirements for a reliable, regular and rapid service ("*Measuring Container Terminal,*" 2012).

Table 3*: Port Performance Measures*

Category	**Relevant measures**	**Reflection**
Production measures (traffic throughput per unit of time**)**	Ship throughput	Containers loaded on or discharged from the ship in a given time period (a shift, day, month or year).
	Quay transfer throughput	Tons or containers moved between quay & storage area

	Container yard throughput	Movements sum in the storage areas
	Receipt/delivery throughput	Outbound & inbound containers
Productivity Measures **(**ratio of the output to the input**)**	Ship productivity	Container handling rate of a ship's call to the time taken to service the vessel
	Crane productivity	Calculated per crane in gross and net values
	Quay productivity	Relation between production and quay resources in unit time/ by working on length of the quay or per meter of the quay
	Terminal area productivity	Ratio between terminal production and total terminal area for a given unit time.
	Equipment productivity	Number of container's moves per working hour for an individual machine or for the stock of a particular type of machine
	Labor productivity	Productivity of man-hour over a measured period
	Cost effectiveness	Cost of handling terminal container traffic or throughput over a specified period, month/year
Utilization Measures (how intensively the production resources are used)	Quay utilization	Amount of time that the berth was occupied out of total time available
	Storage utilization	Comparison of storage slots occupied out of the total number of available slots according to the yard's design capacity
	Gate utilization	Smooth and rapid processing of incoming and outgoing inland trucks at the gate
	Equipment utilization	Proportion of time it was effectively deployed over a specified period
Services Measures **(**reliability, regularity,	Ship turnaround time[1]	Total time, spent by the vessel in port, in a given call. The sum of

[1] One of the most significant indicators of service to ship operators is ship turnaround time. Ideally, ship turnaround should be only marginally longer than ship's time at berth and thus waiting time in particular should be as near to zero as possible (Esmer, 2008).

and quickness of services)		waiting time, plus berthing time, plus service time i.e. ship's time at berth, plus sailing delay
	Operational dwell time	Total days outbound containers delivered to the terminal before agreed time; and total days inbound containers remained in the container yard after being ready for collection
	Road vehicle turnaround time	Time required to load a container from the terminal or discharge one
	Rail service measures	Not useful for service performance

Resource: (Thomas & Monie, 2000)

2.2.3. Common Port Operating and Financial Measures

According to the World Bank's (2007b) Port Reform Toolkit, port regulation module, module 6, the common indicators of port operation and financial performance were outlined in one set. However, very frequently, separate values for indicators need to be specified to be consistent with different major categories of port traffic and vessel types i.e. containers, breakbulk, dry and liquid bulk. Those indicators facilitate the overview of performance for different categories. Table 4 explains those indicators and the calculation method as well.

Table 4: *Common Performance Indicators*

Operating Measures	
Average ship turnaround time	Total hours vessels stay in port (buoy-to-buoy time) divided by total number of vessels
Average ship waiting (idle) time (for berth)	Total hours of vessels waiting for berth divided by total number of vessels berthed
Average vessel time at berth	Total hours alongside berths divided by total number of vessels berthed
Average waiting rate (%)	Total hours vessels wait for a berth (buoy-to berth time) divided by total time at berth
Gross berth productivity	Number of container moves or tons of cargo (for breakbulk and bulk cargoes) divided by the vessel's total time at berth measured from first line to last line
Berth occupancy rate (%)	Total time of vessels at berth divided by total berth hours available
Berth utilization rate (%)	Total time that ships actually work divided by total time of ships alongside (time that the berth is occupied)

Working time over time at berth	Total time of vessels being serviced at berth divided by total hours at berth. Reasons for non-working time may include labor disagreements and work rules, rain, strikes, equipment failure, port operating schedules, and holidays
Cargo dwell time	Cargo tons times days in port from time of unloading until the cargo exits the port, divided by cargo tons
Ship productivity indicator	Total number of moves (for containers) or tons handled (for breakbulk and bulk cargoes) divided by total hours in port
Tons per gang-hour	Total tonnage handled divided by total number of gang-hours worked
TEUs per crane-hour	Total number of TEUs handled divided by total number of crane-hours worked
Average Tons per ship-day (hour)	Total tonnage of cargo handled divided by total number of vessel days in port
Average vessel call size	The average in tons
Financial Measures	
Operating surplus per ton handled	Net operating income from port operations divided by total tonnage of cargo handled
Charge per TEU	Total charges for container handling divided by total TEUs handled
Collected charges per billed charges	Total collected charges as a percent of accounts billed (with 30-day lag)

Resource: (World Bank, 2007b)

The input data is usually readily obtainable from operational reports produced by the operators of terminal or ports. Alternatively, the berth occupancy indicators are calculated independently for container, general cargo, and bulk ships. With regard to vessel waiting time, for example, the input data are also usually obtainable from port, customarily the harbormaster's office, or the operational reports of the terminal operator (World Bank, 2007b).

The ship waiting time indicator is calculated as the average waiting hours per ship, by type of commodity; also, average waiting time is often compared to average time at berth to produce the ship waiting rate. In this sense, berth occupancy, berth utilization and waiting time are clear indicators of under-capacity, which in turn may indicate, not only congestion in the port and underperformance, but also the absence of considerable competition (World Bank, 2007b).

2.2.4. PPIs for Logistics Products

In their analytical study to find new port performance indicators (PPIs) for port logistics, De Langen, Nijdam, and Horst (2007), identified a number of important new PPIs. Most important, is the connectivity index, which can be used to quantify how well a port is connected to overseas destinations asserting that such an index is used in airports, but this index does not yet exist for seaports. Hence, a realistic approach is needed to develop such index that encompasses both hinterland and foreland accessibility by calculating the quality of connections, with respect to frequency and transit time, to a large number of ports and terminals.

Moreover, the analysis above provided another new PPIs for port logistics e.g. the percentage of goods to which value is added in the port region, the average throughput per square meter, value added per square meter, consumer benefits from low transport costs, and the price of warehouse space. Despite the fact that not many ports gather PPIs for their logistic performance i.e. logistics products, ports are able to distinguish their part in the logistics chain. For example, ports such as Rotterdam and Antwerp assemble data on warehouses and other logistics services in the port.

2.2.5. Port Performance and Hinterland Transport

In the usual course of events, data for major port operations has been rather easy to obtain as most ports supervise the common features of their operations. Port operators are motivated to make available relevant statistics because it is important for port competition, cargo carriers, and terminal service providers. In Canada, the government has developed a transport fluidity index. It is composed of performance indicators that highlight port performance and hinterland intermodal services (OECD/ITF, 2016). The fluidity index was effectively employed to encourage and develop transport services through Canada's gateway ports, competing with US port routes, to industrial centers in the US.

The focus was on port operation metrics, such as ship turnaround time, ship turn around per container, number of vessel calls, vessel size distribution, port productivity indicators and cargo dwell time, see Table 5. The indicators differentiated between operation types, i.e. bulk vs. liner services. Moreover, the Canadian government worked with trucking companies and operators to utilize the GPS data to discover bottlenecks leading to or at the port.

Table 5: *Indicators of Port Efficiency Chosen for Transport Canada's Fluidity Index*

Intermodal indicators (containers)	**Units**
Vessel turnaround time	Hours
Vessel turnaround time per TEU	Seconds/ TEU
Average vessel call size	TEU
Berth utilization	TEU/ m. of workable berth
Import container dwell time	Days
Dwell target - % under 72 hours	%
Vessel on-time performance	%
Gross port productivity	TEU/ hectare
Gross crane productivity	TEU/ gantry crane
Container throughput	TEU/month
Bulk indicators	**Units**
Vessel turnaround time	Hours
Average vessel call size	Tones
Berth occupancy rate	Percent
Gross berth productivity	Tones/ hour

Resource: (OECD/ITF, 2016)

All in all, the overview of port performance indicators showed that quite a large number of PPIs are being used. However, different ports use different PPIs; it is the port that defines the performance indicators to improve the port among other competing ports and to develop the port's trade for more profitability and efficiency (Esmer, 2008). This means that there is no uniform scheme for indicator calculations. Beyond doubt, this seaport practice is the foremost weakness of existing PPIs measurement.

2.3. Relationship Between Hinterland Transport System and Port performance

After a review of both the academic literature and the current policies and frameworks, it is very clear that port hinterland transport has become important as it concerns all supply and logistics chain policy makers. On that basis, it is likely that decision makers in the logistics and supply chain consider the characteristics of the whole chain instead of focusing on specific legs (Woodburn, 2010).

Hinterland connections increasingly turn out to be the weakest link in the chain; therefore, there is a substantial risk that ports will bear a loss of traffic if their hinterland connections are inefficient or incur high costs (Woodburn, 2010). This Means that the hinterland transport system is one of the factors that influences port performance, as it largely boosts port efficiency and productivity. The better-organized the transport, the better and more promising port performance will be.

If the hinterland transport is poor or inefficiently organized, no matter how good the port assets are, it still undermines port performance as outlined earlier. For example, shippers and shipping lines will reconsider trading via that port. With the development of the logistics chain and the transport of the hinterland, according to Heaver (as cited in Acciaro & Mckinnon, 2013), shipping lines may change ports of calls and commit to other terminals just to have a secure capacity and maintain flexibility. Given that, these inefficient terminals lose their competitiveness and their customers because of longer ship turnaround time, which normally results in higher cost of inventory and negative ramification in the entire supply and logistics chain.

Also, hinterland transport is one of the most important pillars of the logistics structure. By and large, transport from and to ports is considered vital for shippers, carriers, consignors, and consignees. They all seek routes with lower cost, ports offering efficient hinterland connectivity throughout reliable modes of transport, and with shorter ship waiting time at ports (Robinson, 2002). The efficiency of hinterland transport is what keeps the port rigorous; indeed, it is one of the important issues in port performance.

Horst and De Langen (2008) emphasized that and stated, "Ports and their hinterland transport systems can only attract and manage additional container volumes if the hinterland transport network is organized efficiently and effectively." In other words, once the terminal throughput/tonnage increases due to efficient hinterland transport (containers traffic), port operational performance improves; thus, it is a sign of a relationship between hinterland transport and port performance.

In light of this, hinterland transport is an important part of ports. That is, the maintenance and creation of efficient, effective, and stable transport prospects for port customers in the supply chain is a very important strategic goal for all ports. As a consequence, the loss of port market share in spatial hinterlands leads to less cost efficient containers flows and might weaken transport quality and stability (Jensen & Bergqvist, 2013). Moreover, regarding the competitiveness of a seaport, it depends, as well, on the extent to which the cargo handled in the port can reach its hinterland destination (Merk & Notteboom, 2015). As such, the vital role of hinterland connections is known as one of the most fundamental issues in port competitiveness and development all around the world.

Unfortunately, the connections of port hinterlands have not followed the same pace of economies of scale in ship size and the related surfacing of hub and spokes ports (Merk & Notteboom, 2015). Therefore, this has clearly aggravated the bottlenecks in hinterland connectivity and created more congestion and disruption in port performance.

2.3.1. Hinterland and Ports as Logistics Chain

Over the last few decades, there has been a very quick growth in world throughput as a result of liberalization of international trade, globalization, industrialization, and the expansion of the geographical dispersion of products (OECD/ITF, 2009). Consequently, extensive pressure was placed on many port aspects like the hinterland transport connections, which increased the consequent economic, social, and sustainable issues, and more importantly, the cost and expense issues, i.e. increased supply chain costs, which stem from inefficient hinterland transport connections (Woodburn, 2010).

The transport system is important for shaping and deciding the costs in trade, an ECMT[2] and HM Treasury[3] study (as cited in Woodburn, 2010) stated that the cost of transport is directly affected by the performance of the transport system and logistics costs. Besides, the transport cost is still considered a barrier to the global trade.

In such a globalized world, efficient transport systems, inland or maritime, become an urgent requirement for the global supply chain. The development of global logistics chains has had a major impact on the function of ports along with hinterland connections (OECD/ITF, 2009). The concept of port hinterland related issues i.e. supply and logistics chain and the economic context was thoroughly covered and discussed in the literature (OECD/ITF, 2008; de Langen, 2008; Notteboom, 2008; Zhang, 2008). De Langen (2008), for example, emphasized that the cost of the transport chain, specifically door-to-door services, is higher than the maritime transport and ports charges together. As well,

[2] ECMT: European Conference of Ministers of Transport.
[3] HM Treasury: Her Majesty's Treasury (HM Treasury), a British governmental department.

Notteboom (2008) reasoned that carriers are aware of the growing importance of inland transport quality as it connects their customers and affects door-to-door service and the whole logistics chain.

Therefore, shipping lines have attained or improved cooperation and arrangement with terminal operators to be involved in the inland, rail and inland waterway transport operations serving port hinterlands. Moreover, the literature discussed the logistics chain and its contents, in general, giving a wider look at the inland transport system, hinterland transport, and how it affects the port and its logistics. Most agreed that a port's success, progress, and competitive strength do not exclusively depend on its developed infrastructure, high productivity and performance per se, but also on other dynamic factors such as its hinterland connections.

It is crucial to have an effective and active hinterland transport system that is highly integrated with the logistics and supply chain. This certainly improves the fundamental performance of the port. In their research about port supply chain integration, Song and Panayides (2008) defined important parameters that enhance port integration and thus port performance and competitiveness such as, inter alia, the relationship with inland transport operators.

In view of the fact that container ports are considered as a main link in the global logistics chain, as asserted in Horst & De Langen (2008), the competition between ports has shifted to competition between transport chains, i.e. logistics and supply chain. Consequently, ports are keen to develop the quality of their hinterland transport system.

Recently, for example, hinterland access has been seen as a crucial success feature for ports in Europe (De Langen, 2004). Considering that port terminals stand in an essential position in the supply chain, an increase in productivity and reliability at terminals demands more tracking, vast container visibility, and more emphasis on environmental issues and regulation compliance (Notteboom 2008). This demand could be achieved and facilitated through an efficient hinterland transport system where information is shared, and movement of goods and containers is easily tracked from and to destinations.

2.3.2. Hinterland Transport and Port Performance

The port congestion issue is one of the most important factors that influence port performance, which could be aligned with performances of port subsystems, inter alia, the hinterland transport system. Port congestion, however, is either at the seaside or the landside. With regard to seaside congestion, berth occupancy and ships waiting for berth are the two measures that interpret one phenomenon i.e. port congestion (World Bank, 2007b).

On the other hand, ship waiting time[4] is in a direct relationship with berth occupancy. That is, when berth occupancy is low, there are customarily no, or nominal ships waiting. Conversely, at a particular occupancy level, ship waiting time begins to escalate very quickly; subsequently, a small increase in the level of berth occupancy brings about congestion and long ship waiting times.

A question arises here as to the relationship between hinterland transport (trucks) and the congestion that stems from the seaside i.e. does inland transport (trucks) impact the congestion factors mentioned above? In fact, the answer depends on whether the trucks are really engaged more in the quay operations, such as in the case of bulk terminals. Even if they are not directly involved in the quay operations, they still have an impact therein, but to a lesser extent.

That is, if trucks come to port on time, cargo is loaded and unloaded either from or to the ships at the quay, and from or to the storage and stacking yards. As such, more space is created, enabling the port to receive more ships and to work the ships more quickly. That, indeed, enhances and betters the berth occupancy and waiting rates because ships do not wait longer outside the port due to inland transports issues. With that, moreover, ship turnaround time becomes even less. Hence, these congestion indicators of port performance, at the seaside, would capture the performance of hinterland transport.

On the other hand, landside congestion usually occurs at the gates of the terminals or ports, and truck transport is considered the catalyst factor. Therefore, if transport is organized, it plays a vital role in the holistic port performance theme, or, if not efficiently organized, it

[4] The accepted standard would be a waiting rate that does not go beyond 5% for a full container vessel, 10% for a general cargo/breakbulk vessel, and 10–20% for a bulk vessel (World Bank, 2007b)

causes more congestion and clogging. In this essence, this argument is augmented according to the conclusion of Zhao and Goodchild (as cited in Acciaro & Mckinnon, 2013), that the organization of inland transport, especially trucks, would enhance the efficiency of ports operation.

Additionally, since the inclusive efficiency of a terminal is dependent on the efficiency of its subsystems, terminals are particularly wary of delays at gates because any delay means congestion and eventually challenges the port performance.

To benchmark and improve the hinterland transport performance, as in the truck case, truck turnaround time from the marshalling yards outside the port must be observed to see where the problems are for further improvement. As well, the truck waiting time at the gate, which shows how long it takes until the truck is let in through the gate, must be examined because it impacts the whole truck turnaround time. It could be concluded here that the truck turnaround time is one of the most important inland transport performance indicators. Because, within it, it incorporates most of the congestion problems and improvement factors i.e. if the truck turnaround time is high, that means trucks are always late and take a longer time in the port to arrive at the quay, as well, they cause problems in the port such as congestion either at the gate or inside the terminal.

To sum up, as reviewed in the literature, if we want to look in-depth at the relationship between hinterland transport (trucks) and port performance, we select the port performance indicators that would include the congestion factor within them, including the berth occupancy and ship waiting rate, and ship turnaround time. On the other hand, regarding the hinterland transport reaction with port performance, truck turnaround time is the indicator that, generally, involves the truck performance and is considered a robust factor reacting with port performance. It shows if there is congestion due to trucks idling at ports or if the movement is regulated and streamlined.

2.4. Conceptual Framework

It is very apparent that authorities and governments that control ports need to attempt their best practices in order to improve and boost the hinterland transport connections. The proper scheme of hinterland transport is believed to have an effect on port performance, port competitiveness, the flow of trade, and the country's economy.

In consequence, transport and logistics experts considered this by including hinterland connections as a vital part of the supply and logistics chain. Unquestionably, hinterland transport is a crucial issue in port access. It attracts more customers, shippers and shipping lines, and facilitates further container traffic if the hinterland network is managed and controlled efficiently and effectively.

Conversely, there is a considerable risk that ports will suffer a loss of traffic if their hinterland transport connections are inefficient or costly. So, to avoid problematic issues that undermine port performance and ultimately the whole logistics chain, such as, seaside and gate congestion, superior plans and better coordination must be put into action to have efficient hinterland transport.

In essence, hinterland transport plays a very central role in port performance; this role is critical and undeniable as hinterland transport is one of the important port services (supply). In other words, it is one of the port subsystems that contribute to port performance measurement.

Notably, within this chapter, the literature, both about the importance of hinterland transport and about the supply and logistics chain, reflects the importance of the hinterland transport connection system to the ports. However, there does not appear to be a consensus in the literature as a straightforward or a metric alignment (quantification figures) of the relationship between hinterland transport and port performance. Hence, the researcher's intention is to examine a port performance where hinterland transport was, over a long-term period, improved and properly organized. In this case, it is truck transport. The aim is to find the relationship, the impact, between hinterland transport and port operational performance.

To test the assumption, which is proposed by the researcher, that efficient hinterland transport has an impact on port operational performance, it was necessary to select a port terminal which had improved its hinterland transport and was believed to have become more efficient than before. Accordingly, the researcher chose a dry bulk terminal that is dependent on hinterland transport i.e. trucks, to further test this assumption.

However, as explained in the previous literature review (UNCTAD, 1976; World Bank, 2007b; OECD/ITF, 2016), bulk terminal performance and efficiency can, most of the time, be examined by four port performance indicators, i.e. ship turnaround time, berth occupancy rate, gross berth productivity, average ship call size. Those indicators as well reflect the performance in relation with intermodal transport as in the case of the Canadian fluidity index (OECD/ITF, 2016). Moreover, some of these indicators, as explained earlier, include the congestion factor that occurs at the seaside, which is believed to be influenced by many factors, among others, the disruption resulting from inefficient hinterland transport (trucks). Those indicators are; ship turnaround time, and berth occupancy rate.

With regard to the other two indicators, one would represent the berth productivity i.e. gross berth productivity, which in the case of the dry bulk terminal would improve if the truck flow is efficient and fast. The last indicator is the average ship call size, which, in the long run, would reflect the tendency of shipping lines to call at ports with bigger ships if the port is performing very well, especially once a port has very efficient hinterland transport. Regarding the hinterland transport (the trucks), its performance can mainly be explained, as indicated earlier in this chapter, by the literature on hinterland transport, by truck turnaround from the marshalling yard (outside the port where dispatch of truck start and leave the city) and the truck waiting time before the gate i.e. how long trucks wait before they enter the gate.

The researcher's conceptual framework assumes that hinterland transport influences port operational performance. That is, once the transport improves, the port performance would, gradually with time, witness improvement. Figure 2 shows the conceptual framework of the hinterland transport relationship with the bulk dry terminal operational performance. It summarizes the conceptual framework that was explained above and illustrates the proposed relationships, either direct or partial relationship.

In brief, to explain the impact of hinterland transport, namely the trucks, on port operational performance, we need to test the impact of the two truck performance indicators vis a vis the four bulk terminal performance indicators. Hence, an analytical model is required to test this assumption, which would include the four explained variables of port performance and the two explanatory variables of hinterland transport performance. See chapter four.

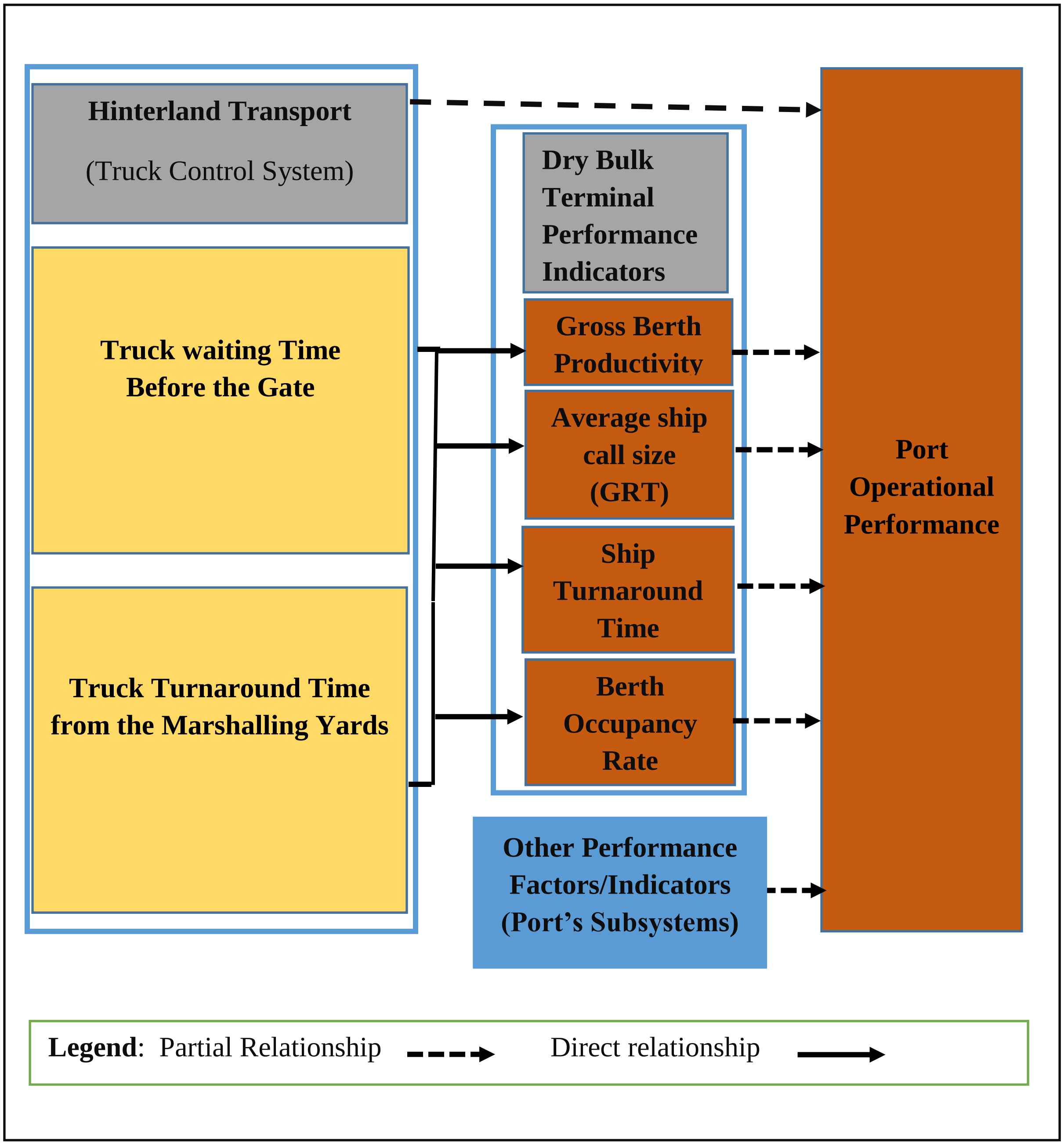

Figure 2: *Conceptual Framework*

2.5. Summary

This chapter has examined in details the literature regarding the concept of hinterland transport and port performance, and provided an answer to the first two research questions. The improvement of hinterland transport efficiency, with time, could illustrate the relationship with port performance. Meaning that once the hinterland transport works efficiently it facilitates and improves port operations, which could be clear through improved port performance.

The literature did not test the relationship between hinterland transport and port performance, but it showed the importance of hinterland transport for ports as part of the port subsystems. Moreover, this chapter aligned the relationship between hinterland transport and port performance, and introduced a conceptual framework that explained the relationship between hinterland transport and port performance, which will be operationalized by analytical model in chapter four to explain this assumption.

For a comprehensive overview of both ports and transport in Jordan, the next chapter will explain the Jordanian transport system, Jordanian ports, and the NAFITH truck control system as the case used in this research.

Chapter 3 Transport Systems and Ports in Jordan

3.1. Jordanian Transport

The strategic location of Jordan, see Figure 3, enables the transport sector to offer service nationally and cross-border. The transport mainly serves KSA, Europe, Iraq, Egypt, the Red Sea and the Mediterranean Sea. The transport sectors in Jordan contribute around 12% to the GDP. However, the transport demand growth is expected to increase annually by five to six percent, which is faster than GDP growth (Mot, 2014a).

Aside from the economic benefits to the country that result from the transport sector, it is also very important and relevant for the development of the Middle East Region. Jordan started, as the first country in the Middle East, a process of liberalization of the transport sector with the purpose of raising the performance, efficiency and enhancing competitiveness.

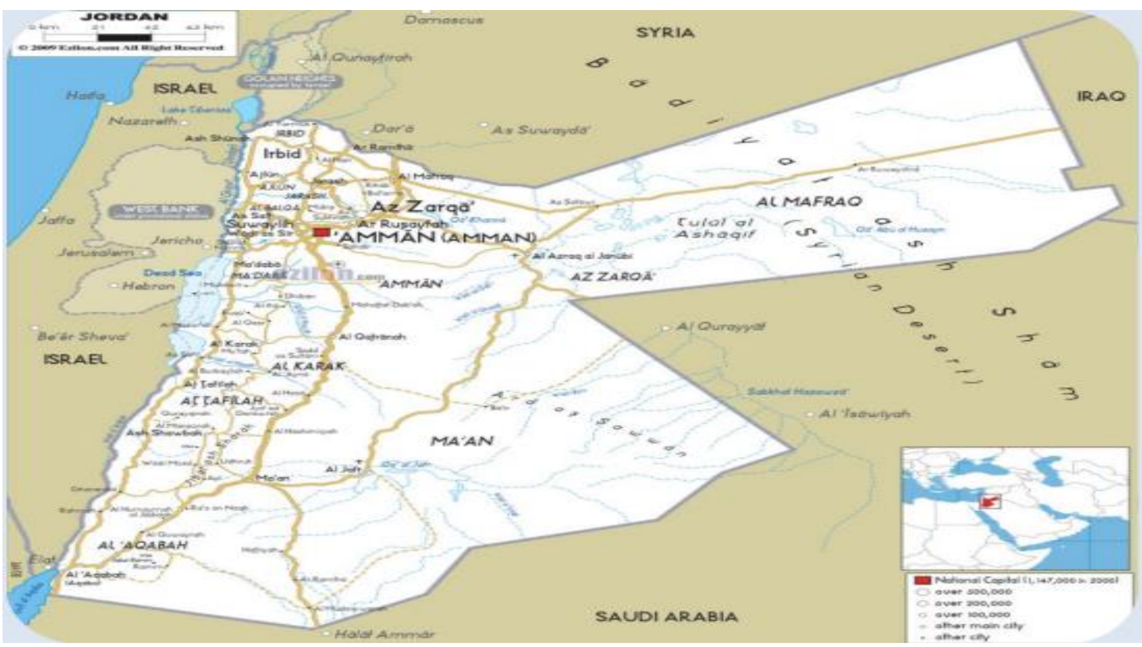

***Figure 3**: Jordanian Transport Map*
Source: (MoT, 2014b)

3.1.1. Land Transport and Network

Jordan's road network is around 7,900 km, 7,430 km of which is paved national roads, up to 70% of which have a good profile and alignments (Mot, 2014b). Jordan invested heavily in its road transport network and has improved urban mobility by creating around 1700 km of highway that stretches from north to south, including the desert highway that connects Amman to Aqaba city, and from West to East, connecting Zarqa city to the Iraqi and Saudi borders.

On the other hand, Jordan was one of the first countries in the Middle East to liberalize the transport sector for many reasons, mainly to increase the sector's competitiveness, efficiency, and performance. Correspondingly, the number of privately owned vehicles increased by approximately 7% per annum. In 2013, the number of cars was around 1,200,000. (Mot, 2014b)

3.1.1.1 Trucks[5]

Jordan recently deregulated all freight transport services and put into action a framework that coordinates the movement of trucks from and to the major trade city, Aqaba, which has the port gateway. The system that was created by MoT required all truck owners and operators to register with a trucking company, which eradicated the cartel system that prevailed in the past. Therefore, freight agents would negotiate the service required and the cost with the company of their choice. After that, MoT and ASEZA imposed a regulation on trucks under the truck control system (TCS) which stipulated that trucks entering the Aqaba zone should have a permit so as to control the flow of truck transport.

By this system, which has over 220 companies with around 16,000 trucks, only trucks that have been contracted are permitted to enter the zone for either loading or discharge of cargo, then leave the zone to their final destination. The system was advanced by the addition of marshaling yards, checkpoints, exit points, and terminals.

In parallel with that, NAFITH was assigned to design and develop an information system to control the flow of trucks. In 2006, NAFITH started working and took control of the

[5] All information regarding trucks has been gathered from MoT statistics.

whole TCS to ensure that trucks and trucking companies complied with the system, and for further coordination and cross country integration.

3.1.1.2 Rail Transport

The total existing railway network length in operation is 620 km, composed of narrow gauge track (1050 mm gauge) (MoT, 2014a). There are two railway companies in Jordan:

- **Jordan Hedjaz Railway** has 217km plus 111km of abandoned lines. The railway provides one train service between Amman and Damascus, the capital of Syria, upon request of tourists and school trips.
- **Aqaba Railway Corporation** is composed of 293km of rails that transport the Phosphate from mines to Aqaba Ports. The Railway also transports all products of Phosphate, Phosphoric Acid and Sulfur, from El-Shidiya mines that produces around ten million tons each year. On the other hand, Aqaba Railway Corporation was privatized to support the investment needs of the railways and customers' requirements.

Additionally, there are different plans for future development of Jordanian Railways that aim to connect the Jordanian cities Irbid, Mafraq, Zarqa, and Aqaba to each other and to bordering countries i.e. Syria[6], Saudi Arabia, and Iraq. Figure 4 shows a map of Jordanian Railways of Hijaz, Aqaba line, Phosphates Mines, and the new project.

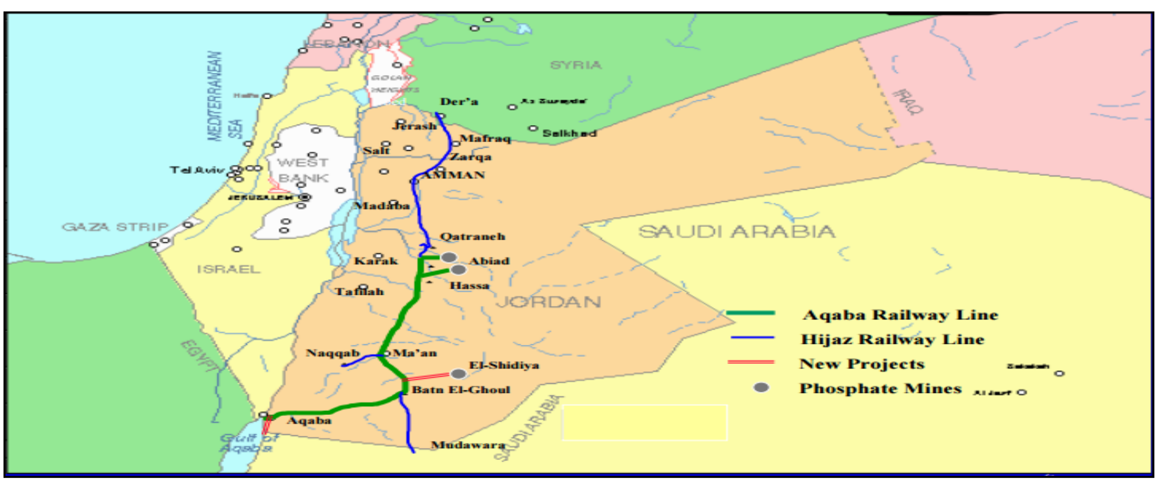

***Figure 4**: Railways Map*
Source: (MoT, 2014b)

[6] The Hidjazi railway already connects Jordan with Syria.

3.1.2. Air Transport

Jordan is currently equipped with three airports namely Queen Alia International Airport, by far the largest in Jordan, Amman Civil Airport, and King Hussain International Airport (Aqaba)[7]. All airports are controlled, operated and managed by the Civil Aviation Regulatory Commission; the Royal Jordanian Airlines are the national air carrier. Queen Alia Airport has witnessed many developments over the last few years which have increased the capacity of the airport to meet expected passenger and cargo traffic growth.

Other plans are being implemented to expand and enhance services in the other airports, especially Aqaba airport, which is to be utilized to service the sea ports in Aqaba. The primary international airport, Queen Alia, handles approximately 90% of the domestic and international traffic and 93,000 tons of freight yearly ("Economic Benefits from Air Transport in Jordan," 2010). Besides, around seven million passengers fly through Jordanian airports and 102,367 tons of freight were transported in 2013 (MoT, 2013).

3.1.3. Maritime Transport

The Jordanian Maritime Commission[8], under the umbrella of MoT, works as the national authority that controls and supervises maritime transport modes in Jordan. The commission's mission, inter alia, is to supervise and continuously develop the maritime sector according to the international organizational standards. In addition, Jordan has ratified around 27 international instruments that belong to the IMO or UN. In essence, Jordan is a signatory to the most important conventions, codes, and protocols such as SOLAS, UNCLOS, STCW, MARPOL and ISPS code.

The Jordanian maritime fleet is increasing, and currently has 24 vessels above 500 GRT that can conduct international voyages (JMC, 2014). The maritime transport sector is represented by different associations, i.e. Shipping Agent Association[9], Forwarders Association, Jordanian National Shipping Lines (JNSL), Jordanian International Chartering Company[10], Arab Bridge Maritime Company (ABMC), and other privately

[7] This airport helps the seaport in terms of cargo transfer because it is very close.
[8] Previously known as Jordanian Maritime Authority JMA, which was changed in 2014 to JMC
[9] This Commission involves shipping and freight forwarding agents.
[10] It provides chartering and brokering services to Jordanian ship-owners.

owned companies, all of which engage in facilitating maritime transport and activities in Jordan and worldwide.

The JNSL manages the Jordanian fleet as it owns, operates, and manages numerous different vessels, and works with and offers services nationally and internationally to ship-owners. Furthermore, the ABMC is a joint venture project between Jordan, Egypt, and Iraq to facilitate shipping and logistics services and passenger ferry transport through the Aqaba/Nuweiba Line. It owns a seven vessels fleet of ferries and ROROs. The ABMC generates a very significant traffic flow to Jordan by transporting about 300 thousand tons of cargo and up to one million passengers annually (ABMC, 2016)

3.2. Ports in Jordan

The Jordanian port is in the city of Aqaba which is a 375 km^2 city in the southern part of Jordan and on the very top north part of the Red Sea. Aqaba port was established in 1952 as the primary maritime gate in Jordan; it is located in a very strategic area which forms a corridor at the conjunction of three continents, Asia, Africa, Europe, and four countries, Jordan, Saudi Arabia, Egypt territorial water, and Israel, with a coast line of 26 km surrounded by a series of mountains.

The port handles around 75% of Jordanian imports and exports of cargo. In 2015, the port handled 18,39 million tons of cargo, both domestic, and transit for neighboring countries i.e. Saudi Arabia, Israel, Iraq, and Syria. Moreover, the port is located in a very competitive environment among the countries mentioned above; therefore, the port requires a very rigid approach to surviving the market forces. Hence, it has witnessed many developments over the last couple of decades, the most recent being the new general port, located south of Aqaba, which put the master plans into action.

The port is managed by Aqaba Port Corporation (APC), an independent financial structure, which is under the umbrella of the Ministry of Transport. However, for the sake of development and application of the port master plan, which was launched in 2001 by the Aqaba Special Economic Zone Authority (ASEZA), ASEZA handed over the development of ports to its right arm in this matter, Aqaba Development Corporation (ADC) in 2004.

Ever since, ADC has been working on the development of the ports and diligently enabling the application of the plan. Figure 5 shows a map of Jordan; Figure 6 shows a map of Aqaba Port; and Figure 7 shows the Aqaba ports which are: Northern port (main port), Middle port (container and passenger terminal), Southern port (industrial and new general cargo port).

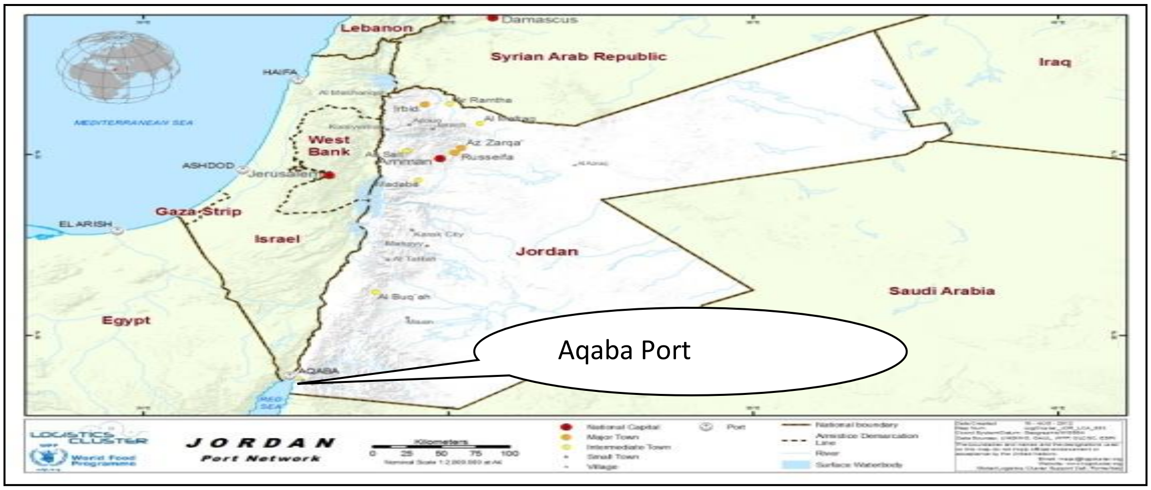

Figure 5: *Jordan Map*
Source: (ADC, 2015)

Figure 6: *Aqaba Map*
Source: (ADC, 2015)

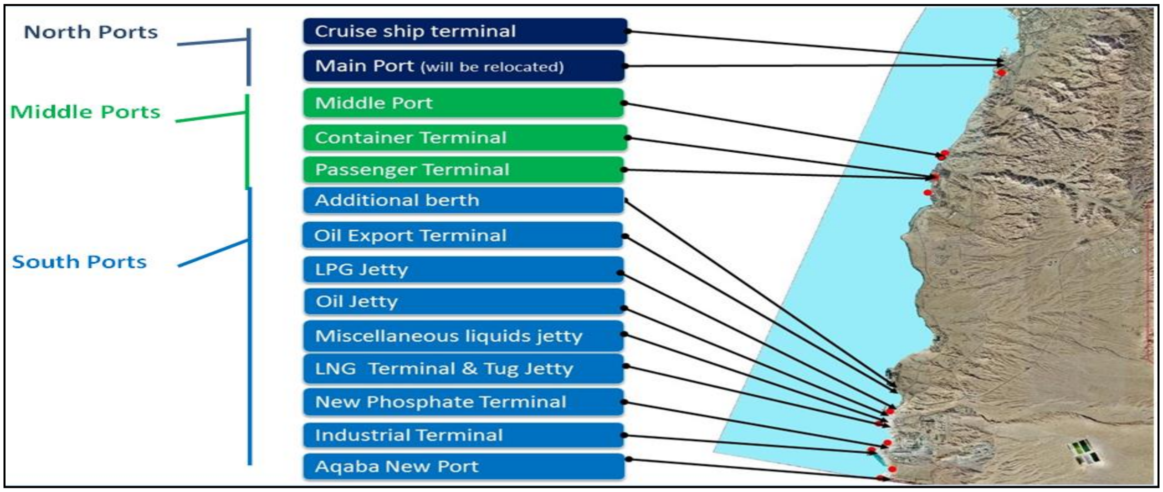

Figure 7: *Aqaba Ports Map*
Source: (ADC, 2015)

3.2.1. Port Functions and Facilities

As the sole and major port in Jordan, Aqaba port handles all kinds of cargoes, dry/break, and wet bulks as import and export e.g. general cargo, minerals, oil, and agricultural and manufactured goods. The port is considered a treasured asset to Jordan, specifically as a gateway that facilitates the country's trade, and one of the main resources of the country's economy.

3.2.3. Port Cargo Handling Equipments

The main (North) port, except for the container terminal, have various cargo handling equipment as shown in Table 6, which contains the type of equipment used in the main port, the quantity of equipment and the handling capacity in tonnage.

Table 6: *Port Equipments*

Equipment	Capacity in Ton	Number
Mobile Crane	100	2
Crane	90-120	2
Crane	45-70	5
Crane	2-40	32
Reach Stacker	45	1
Top Lift Handler	45	1
Fork Lift	25	1
Fork Lift	10-15	10
Fork Lift	5-7	17
Fork Lift	3-4	55
Towing Tractor	Various	15

Trailers	Various	80
Tug Master	Various	31
Tank	Various	1
Truck	Various	2
Heavy Lift Spreader	100	2
Heavy Lift Spreader	220	1
Container Spreader	40	2
Vacuum	40-60	12
Grab	4 M3	4
Grab	6 M3	7
Grab	24 M3	3
Wood Clam cell	15 M3	1
Bulldozer	0.75-1.3 M3	3
Barges	450 Ton	4
Barges	350 M3	3
Barges	100 M3	2
Barges	300 M3	3
Hopper	50 M^3	15

Resource: (APC Statistics, 2016)

3.2.4. Main Port Storage Facilities

The Ports have a wide variety of storage for all kinds of goods, exported and imported. Table 7 shows the available storage, the quantity of storage and the area occupied in square meters.

Table 7: *Storage Facilities*

Items	Area / M2	Number
Transit Sheds	33.537	5
Covered Sheds Storage	28.035	8
Open Storage Area	243.667	23
Phosphate Storage	410.500	6
Grain Silos	150.000	1
Petrol Refinery Storage	83,100	
Cooling Storage	500 TONS	1

Resource: (APC Statistics, 2016)

3.2.5. Main Port Berthing Facilities

The main port consists of 12 berths that are able to handle general cargo, grains, Phosphate and delicate traffic. The 2001 port master plan for the ports included the relocation of the main port to the southern area by building a new port. The new port, which is under construction at the moment, will be more efficient and will increase the operational capabilities, and maximize handling and storage abilities.

The Southern new port will handle general cargo, grain, and RoRos, while the phosphate will be handled through the newly constructed Phosphate terminal. However, the current North port, the main port, will be developed into a shore developed area where the city will have different kinds of resorts and coast facilities. Thus, the effect on the environment will be less on the dense city of Aqaba. The current berthing facilities are as shown in Table 8, and Figure 8 shows the main port view.

Table 8: *Main Port (North Port) Berthing Facilities*

Berth Name & Number.	Displacement of Ships (Tons)	Max Ship's Length (Meter)	Max Ship's Draft (Meter)	Length of Berth (Meter)
NO. 1 (G.C.) [11]	70,000	250	11.5	160
NO. 2 (G.C.)	45,000	250	10.5	180
NO. 3-7 (G.C.) each	53,000	250	11.5-13	180
NO. 8-10 (Lighters)	500-5,000	40-110	1.5- 6	150-210
Phosphate "A"	25000-30000	200	11	210
Phosphate "B"	125,000	250	15	180

Resource: (APC Statistics, 2016)

Figure 8: *The Main (North) Port of Aqaba*
Source: (ADC, 2015)

[11] GC: General Cargo

3.2.6. Middle Port Berthing Facilities

The Middle port is situated north of Aqaba Container Terminal, around 15km to the south of the Aqaba city center. The existing port is composed of one floating berth, another dolphin type berth, and RoRo and passenger ship berths. The port is due to be developed by three or four environmentally friendly berths with required facilities. Nevertheless, the berthing facilities and specifications are shown in Table 9.

Table 9: *Middle Port Berthing Facilities*

Berth Name & Number.	Displacement of Ships (Tons)	Max Ship's Length (Meter)	Max Ship's Draft (Meter)	Length of Berth (Meter)
Mo'ta North	15,000	120	9	35
Mo'ta West	53,000	200	20	150
Mo'ta South	15,000	150	10	35
Almushtarak	100,000	250	11	120
Ro - Ro	35,000	180	15	40
North Passenger	15,000	32.5	7.5	32.5
South Passenger	19,000	33	7.5	32.5

Resource:(APC Statistics, 2016)

Figure 9 shows the passenger and ferry terminal in the Middle port area with capacity of four Cruise ships per day at 2000 passengers per Cruise.

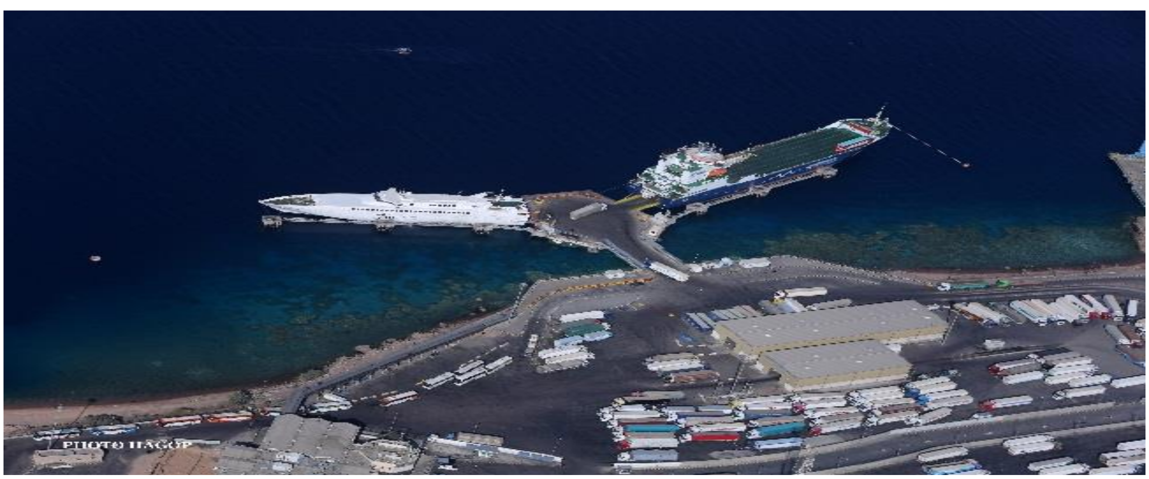

Figure 9: *Passenger and Ferry Terminal*
Source:(ADC, 2015)

3.2.7. Southern Port (Industrial Port) Berthing Facilities[12]

The Industrial Port is located in the southern area of Aqaba just north of the new port. It has different kinds of berths and facilities, and is considered the main artery that feeds Jordan with different kinds of fuel, and gas, in addition to exporting the local primary mineral product (Phosphates). Table 10 shows the Southern Port (the Industrial Port) berthing facilities.

Table 10: *South Port Berthing Facilities*

Berth Name & Number.	Displacement of Ships (Tons)	Max Ship's Length (M)	Max Ship's Draft (M)	Length of Berth (M)
Oil Jetty	406,000	370	25	140
4 Tug Jetty	5,000	120	4.5-9.5	92
LNG	205000 M^3	330	15	312
LPG	30,000	160	15	180
Fertilizer 2	500	40	1.7	40
A) Industrial Seaward	70,000	230	22	200
B) Industrial Landward	40,000	190	11.5	190
Phosphate New	100,000	250	18	190

Resource: (APC Statistics, 2016)

- **Liquefied Petroleum Gas Terminal (LPG)**

The berth, as shown in Figure 10, after renovations can receive LPG vessels that range from 5,000 DWT to 20,000 DWT with a capacity of 4 million tons per year.

Figure 10: *LPG Terminal*
Source: (ADC, 2015)

[12] The information about the development of the industrial port and the new general port is from Aqaba Development Corporation (ADC) (ADC, 2015).

- **Liquefied Natural Gas Terminal (LNG)**

Jordan has relied profoundly on the import of natural gas from Egypt since 2005 via the Jordan Gas Transmission Pipeline (JGTP) for generating electricity. Over the last few years, the Egyptian gas supply has been harshly disrupted through frequent attacks on the pipeline in the Sinai. Accordingly, the government started outsourcing natural gas through vessels which imported LNG that is received and treated through a permanent berthing unit, namely the Floating Storage Regasification Unit (FSRU), then eventually transferred by JGTP to the power generation stations. Figure 11 shows the LNG terminal.

Figure 11: *LNG Terminal*
Source: (ADC, 2015)

- **Oil Terminal**

The oil terminal handles crude oil and refined products which are either stored in the port's storage or transported via tanker truck to the oil refinery north of Jordan. Figure 12 shows the oil terminal.

Figure 12: *Oil Terminal*
Source:(ADC, 2015)

3.2.8. Aqaba Container Terminal (ACT)

In 2009, Aqaba Development Corporation (ADC) entered into a partnership agreement with the global terminal operator, AP Mueller, for a concession period. The partnership was shaped with an investment of around JD 220 Million (ADC, 2015).

The ACT has a number of berths and land handling equipment, which are; three gantry cranes (40-45 tons), 2 mobile harbor cranes, yard cranes, 376 reefer points, container yard with a capacity of (500,000 m^2) and different container handling equipment. Table 11 shows the terminal berthing facilities and capacity.

ACT also has wide operations and coordination with diverse stakeholders such as shipping agents, shipping lines, port authority, customs, clearance and security agencies. The current terminal capacity is 2.4 million TEUs, which reached 760 thousand TEUs and 440 calling ships in 2015 (ACT, 2016). Figure 13 shows ACT.

Table 11: *ACT Berthing Facilities and Capacity*

Berth Name & Number.	Displacement of Ships (Tons)	Max Ship's Length (M)	Max Ship's Draft (M)	Length of Berth (M)
No. 1	84,000	240	15	180
No. 2	84,000	240	15	180
No. 3	84,000	240	15	180

Source: (ACT, 2016)

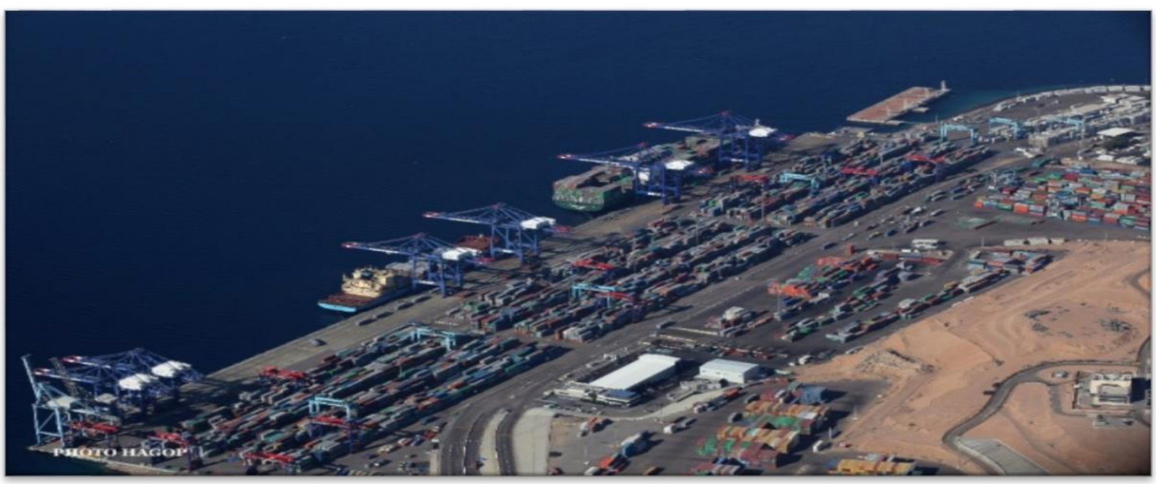

Figure 13*: Aqaba Container Terminal*
Source: (ADC, 2015)

3.3. NAFITH Project as a Case

The study of NAFITH has been retrieved from the company website, company reports and archived data, and NATHAN research, which was performed to study the economic impact of NAFITH truck control system in Jordan. NAFITH (National Freight Information, and Transportation Hub) is a freight transportation logistics service that facilitates cargo transport countrywide, and through transport corridors across the borders.

NAFITH is an International Finance Corporation (IFC) investment which is part of the World Bank group; it expanded in the Middle East Area (MEA) region, such as Jordan. In Jordan, the NAFITH project is a concession from the Jordanian government to the private sector for the organization of truck transport, and the development and operation of the National Single Window (NSW) system. Of course, there is a revenue share model with the government as the concession is meant to be until 2018 unless otherwise indicated. Rather, the project is a Public Private Partnership (PPP) with NAFITH Logistics, operated as a privately-funded, publicly-chartered utility, and financially supported by users and beneficiaries.

The NAFITH project utilizes various types of infrastructure and technology, i.e. Radio Frequency Identification (RFID), eGates, pedestals, kiosks, handheld terminals, weigh-in-motion bridges, terminal operation system integration (TOS), automated AM radio, and mobile texting. As such, while the system supervises capacity management at port terminals and routes, and moves trucks to and from marshaling yards, it collects, corroborates and reveals information to several private and governmental sector databases to reduce waiting time and to swiftly move trucks to/from Aqaba city and the port.

3.3.1. NAFITH Operational Objectives

1. The system utilizes the national single window application that:
    - Connects the hinterland to ports system;
    - Introduces capacity management;
    - synchronizes logistics on a national level;
    - Facilitate gate automation and port portals;
    - Facilitates Port Community System (PCS);

- Integrates with the Hinterland stakeholders;
- Applies the appointment system for truck operation;
- Establishes customs eGate based on RFID.

2. Fourth Party Logistics for grains supply chain for the ministry of trade, and for crude oil delivery for Jordan Petroleum Refinery Corporation (JPRC).
3. The application of RFID technology in local and national logistics transport, which is utilized by people, gates, and yards.
4. National transport databank for MoT.
5. Capacity management and resource utilization planning with predictive models and exceptional handling[13].

3.3.2. NAFITH National Single Window

The system employs different kinds of technologies and offers many services which integrate all users together through a NSW technique. Table 12 shows the whole network of trade which is mastered by the system through the NSW, and comprises customers and users, services provided, technologies adopted, and the system integration scope.

Table 12: *NAFITH NSW Network*

Customers & Users	-Ministry of Transport (MoT) sea/land ports and port terminals -Transport companies -Shipping lines -Shippers/ importers/ exporters clearing agent/ freight forwarders -Major contracts -Trucks and drivers -Trucking Companies -Rail operators -Customs -Insurance -Banks
Services	-Truck monitoring / GPS -Localized Services -Truck availability -Truck status and tracking -Fleet Management -Freight Market -Container Hull -Insurance -Demurrage Management

[13] Some product handled very exceptionally, given a priority, due to the value of time to transport, as in the case of perishables items.

	-Electronic WAYBILL -Cargo insurance -Cargo status tracking -Stakeholders clearing house -General notifications -Reporting
Technologies	-Web portal channel -Smart mobile channel -SMS channel -Document management -Workflow management -Electronic Data Interchange (EDI) -Geographic Information System (GIS) & maps -Reporting Engines -Data management -Data warehousing -E-Payment -RFID
Integrations scope	-Port/hub operators -Ports authorities -Weighbridges -Driver/vehicle license -EDI Networks -Chambers of Industry & Commerce -Insurance Companies -Ad hoc GPS Devices -RFID Networks -Rail Operators -Global System for Mobile Communications (GSM) -Tolls -Banks and ePayment Networks

Resource: (NAFITH, 2014)

3.3.3. Overview of NAFITH Truck Control System (TCS)

The NAFITH system was implemented in November 2005, with more than 300 clearing agents, connecting the national fleet that uses the TCS. The national fleet is currently about 16000 trucks, run by 220 trucking companies, and a regional fleet that consists of 10000 trucks, with up to 15000 drivers until 2015 (MoT, 2014a).

The system allows 3500 trucks a day to enter the city of Aqaba, which ultimately services all ports i.e. the main port that has general cargo and bulks, the industrial port that runs the oil and potash trade, and the container port. The system creates more than 35000 daily events. Moreover, until late 2015, seven million ePermits were issued. It operates twenty-four hours all year round i.e. 99.9% uptime. The truck registration system and capacity management implementation aims to have the "right truck, with right driver, at the right place, at the right time for the right cargo".

The Truck Control Information Management System (TCIMS) platform utilizes information technology to organize TCS processes ranging from validation and acceptance of permit requests to overseeing the physical movement of the trucks. It was designed to manage truck movement and coordinate this activity between freight/clearing agents, trucking companies, and truck drivers.

3.3.4. NAFITH-TCS Layout

The TCS layout is described as follows:

- The TCS divides the Aqaba Economic Zone into five entry and exit points. Figure 14 shows the entry and exit points which are operated by NAFITH operators in all locations.
- TCS controls four marshaling yards that link 39 destinations all around Jordan i.e. ports locations and hinterland destinations. Figure 15 shows the marshaling yards.
- TCS develops entry rules and procedures i.e. truck permits and appointments.
- TCS incorporates all existing infrastructure at terminals and other destinations into TCS through NSW.

The TCS utilizes various technologies in a framework that regulates and produces the required documents regarding truck flow. Figure 16 shows a truck driver identification card issued by NAFITH. Figure 17 shows a truck with the NAFITH logo, which uses RFID, GPS, and barcode, entering one of the gates where screen base entry is implemented. Last but not least, Figure 18 shows a map of Aqaba with the marshaling yards, and trucks routes and destinations.

Figure 14: *Gates Entry/Exit to/from the City of Aqaba*
Resource: (NAFITH, 2015)

Figure 15: *Marshalling Yards*
Resource: (NAFITH, 2015)

Figure 16: *NAFITH Truck Drivers' ID*
Resource: (NAFITH, 2015)

Figure 17*: Truck with NAFITH Logo and RFID*
Resource: (NAFITH, 2015)

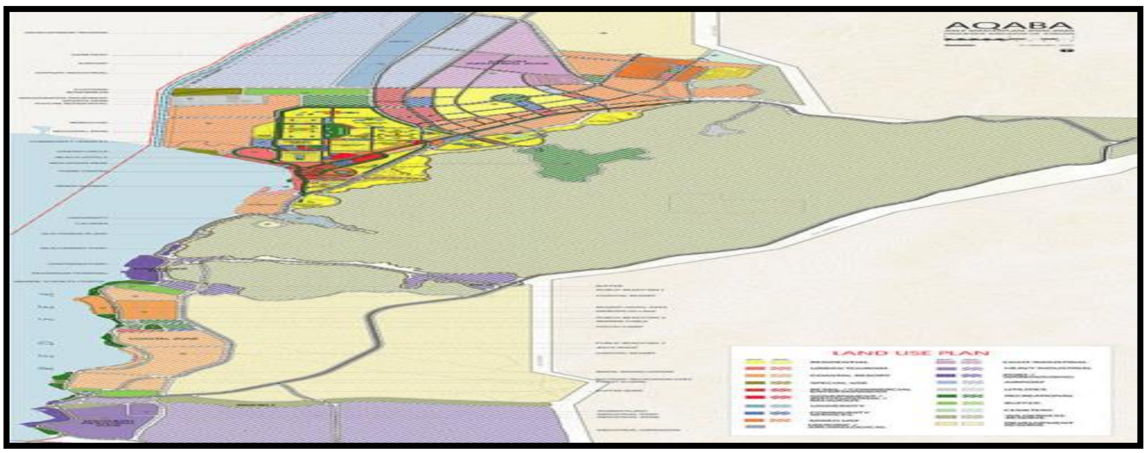

Figure 18: *Aqaba Special Economic Zone Map*
Resource: (NAFITH, 2015)

3.3.5. TCS Permit Details

To operate a truck via the system, each trucking company needs to acquire a unique permit that consists of data about the truck, driver information, authorized operation, and other relevant details. Figure 19 shows the truck permit which has a barcode where data on the truck and the purpose of the trip is coded.


Page 1 of 1
سلطة منطقة العقبة الاقتصادية الخاصة
مشروع تنظيم دخول وخروج الشاحنات
200900211443
2009-05-03 22:45:08.0
trucknationality
190
9651020561
064460600
47
715807
6036121

Figure 19: *TCS Permit*
Resource (NAFITH, 2015)

3.3.6. RFID Technology and eWaybill

RFID technology is a mechanism set up to identify and verify truck credentials as an electronic identification. This reduces the average processing time at the gates, as well as the operational and running costs, and enhances the quality of collected data as it minimizes the human factor. Moreover, it keeps employees away from heavily polluted areas. The RFID are anti-tamper, and have been granted two eSeal patents.

RFID is utilized by customers, ports, port authorities, shipping lines, auto weighing stations, projects, customs, and eGate. Similarly, the system has been producing electronic waybills (eWaybill) since 2011, issuing up to 800 eWaybills a day. This has added more visibility to the system and enhanced the work of all concerned parties such as shippers, clearing agents, trucking companies and consignees

3.3.7. TCS Work Flow and Integration within the Hinterland

NAFITH, between 2013 and 2014 began adding stakeholders to the system, including shipping lines that seek control of demurrage, freight forwarder services, banks for payment clearing, and insurance companies for cargo and container hull insurance, which can be conducted via click-insurance-method in the web-based system. The integration of data among all users makes the flow of information very simple and streamlined.

The system offers and exchanges its services online through banking, so traders get their fees transferred to their banks, or they can draw them from the ATM directly. The problem in Jordan is that people are either under-banked, they do not want to use or do not know how to use banking services, or unbanked, they do not have bank accounts.

Everything in the system is captured into events in the supply chain. It depends on the previous events. For example, trucks cannot come to the port and pick up the cargo unless the customs releases it again to the port, and then, the port, after receiving the dues and charges, issues the cargo release. This is known as capacity management.

Figure 20 shows the workflow map, where the flow of information and work order among the concerned parties is illustrated in sequence. Importantly, the system tracks capacity utilization by tracking all permits on all the roads and at each location within the system. Further, other stakeholders count on the permit for the sake of their own gate events and further coordination.

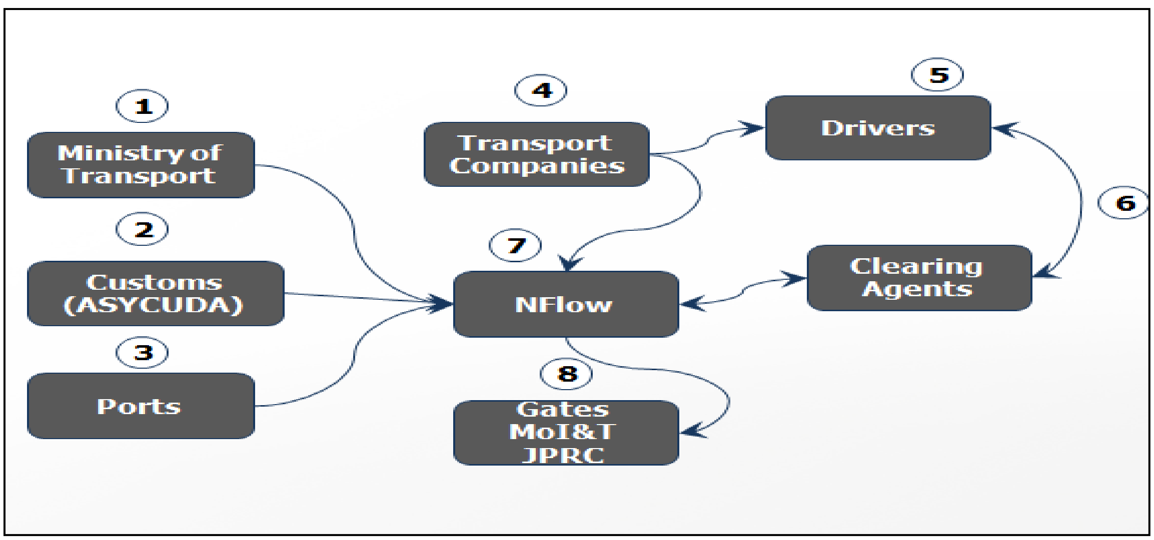

Figure 20: *TCS Work Flow*
Resource (NAFITH, 2015)

Basically, users collect the data and act accordingly as follows:

1. **Ministry of Transport** retrieves and maintains truck data.
2. **Customs** issues declaration clearance.
3. **Ports** issue cargo release.

4. **Clearance Agents** allocate the truck company, and then the truck company allocates truck and driver.
5. **Shipping Agencies** issue the manifest that contains cargo information.
6. **Port Gates** control truck movement.
7. **Banks** issue costs deduction and charges.
8. **Insurance** issue insurance if requested either on cargo or containers' hull.
9. **Trucking companies** dispatch the right truck.
10. **Truck driver** fulfills his task.

In brief, once the permit is requested as per the order of clearing agents or freight forwarders. The clearing agents and forwarders provide a wide variety of data to verify the legitimacy of their request. The clearing agent and the trucking company agree on an e-waybill, then the trucking company submits the information to acquire an e-permit from the NAFITH-TCS system. NAFITH-TCS, accordingly, checks with regulatory authorities, validates this data through an electronic interface, i.e. check with MoT, with customs for cargo clearance, with the port for cargo release, and again, checks with the port for infrastructure capacity.

In accordance with that, NAFITH issues an e-permit to the trucking company, then the trucking company dispatches the truck and coordinates the double moves. The driver receives a permit number so as upon arrival at the entry gate of the marshalling yard, the truck receives its permit document and heads to the ports/hubs through that marshaling yard.

3.4. Summary

This chapter has provided an overview of the transport system and ports in Jordan, and NAFITH as a case study, all of which are considered pillars of hinterland transport in Jordan. Transport and ports have undergone a very wide development, new infrastructures, expansions, and continuous maintenance, both the transport sector and ports are still developing and on the outset of putting many projects into action to optimize the transport services, freight and passengers, and port performance.

The NAFITH truck control system was explained, along with the way in which the system works and integrates stakeholders through the NSW. It is very apparent that trucks are the main mode of land haulage that is fully utilized to transport freight all around Jordan and across borders.

The railway system is considerably smaller due to the capital investment needed to fully depend on railways. Yet, the Aqaba Railway Corporation shares a very significant role in mineral exports transport from Jordanian mines. Regarding inland waterways, Jordan does not have such a system owing to its geographical situation.

Still, many challenges currently face Jordan; importantly, pressure on the whole logistics and transport infrastructure because of the excess of refugees from Syria. Moreover, financial support and funding are still needed to further apply plans and development phases. In addition, a low volume of trade, and reduced use of ports and transport over the last three years has resulted from the international economic downturn and political unrest in the Middle East. The next chapter is the research methodology chapter, where the methodology is used to examine the data and the analytical model is thoroughly operationalized and clarified.

Chapter 4 Research Methodology

4.1. Analytical Model

The relationship between hinterland transport and port performance was explored in chapter two, and the importance of an efficient hinterland transport was examined by reviewing the literature. On this background, it assumed that hinterland transport has an impact on port operational performance. That is, once the hinterland transport improves, port performance improves in some way. Hence, an analytical model, which will be operationalized further in this chapter by hypotheses, will provide the conceptual foundation for this study.

Accordingly, we need to test and analyze this model, which involves the underlying hypotheses between the two variables i.e. the hinterland transport as the independent variable (X) and port performance as the dependent variable (Y), to see the trend and the relationship between them. The issue of port performance is not only one factor; it is four factors that could explain port performance in a dry bulk terminal. These four factors are assumed to be, ship turnaround time, berth occupancy rate, gross berth productivity, and average ship call size.

Regarding the independent variable, hinterland transport, it is assumed to be explained by truck turnaround time only, because, in the port that was chosen, the truck turnaround time is calculated from the marshalling yards' gate-in time to the marshalling yards' gate-out time, that would capture the overall truck movement time. As well, most truck flow is organized and controlled in advance; subsequently, trucks have no problems with gate entry, they don't wait for long time outside the port, as it takes one to two minutes to electronically check the truck's documents, therefore, this indicator is not recorded at the port gates or at NAFITH database. Hence, the other truck performance indicator (truck waiting time before the gate), as per the explanation of these variables in the conceptual framework in chapter two, was excluded.

As can be seen in Figure 21, the analytical model (the truck turnaround time has an impact on the port operational performance); the figure shows the proposed relationship with the expected relationship in signs, plus for positive relationship, and minus for inverse relationship. The relationship is represented by straight arrow as a direct relationship.

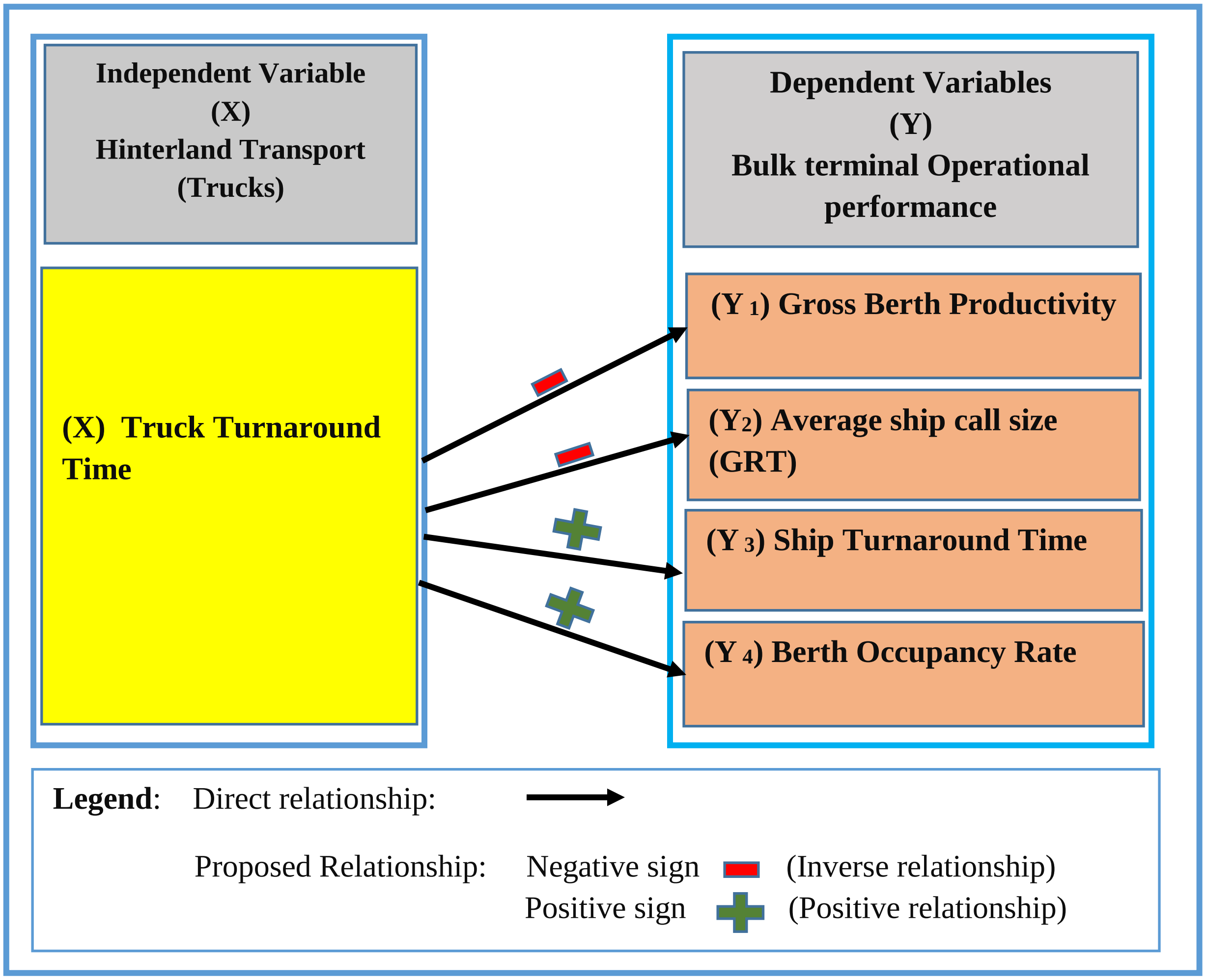

Figure 21: *The Analytical Model*

4.2. Hypotheses

To explain the analytical model that was presented above, four hypotheses, as in Table 13, have been formulated that are assumed to explain the relationship between the hinterland transport and dry bulk terminal operational performance;

Table 13: *Model Hypotheses Variables*

Hypotheses	Dependent Variables (Y)	Independent Variable (X)
Hypothesis 1	Gross Berth Productivity (Y1)	Truck Turnaround Time (X)

Hypothesis 2	Average ship call size (Y2)	Truck Turnaround Time (X)
Hypothesis 3	Ship Turnaround Time (Y3)	Truck Turnaround Time (X)
Hypothesis 4	Berth Occupancy Rate (Y4)	Truck Turnaround Time (X)

1. **Hypothesis one**: Truck turnaround time has an impact on gross berth productivity, meaning that there is a relationship between them. Truck turnaround time is the independent variable (X), and gross berth productivity is the dependent variable (Y).
2. **Hypothesis two:** Truck turnaround time has an impact on the vessel's call size. That is, there is a relationship between them. Truck turnaround time is the independent variable (X), and the vessel call size is the dependent variable (Y).
3. **Hypothesis Three:** Truck turnaround time has an impact on ship turnaround time, which states there is a relationship between them. Truck turnaround time is the independent variable (X), and ship turnaround time is the dependent variable (Y).
4. **Hypothesis Four:** Truck turnaround time has an impact on the berth occupancy rate. This means that there is a relationship between them. Truck turnaround time is the independent variable (X), and the berth occupancy rate is the dependent variable (Y).

4.3. Data and Variables

The data for testing the hypotheses was collected from the Jordanian port of Aqaba i.e. the port performance data, and the truck turnaround time was collected from the NAFITH information system database. The port that was chosen is the main port, specifically the bulk terminal. First, the port data comes from daily observations over ten years, from 1 January 2006 to 31 December 2015, which includes the name of the calling vessel, size of vessel (GRT), port entry/exit date and time, berth entry/exit date and time, work start time at berth and end time, cargo weight, and the number of berths used.

The data was validated by checking the compatibility and harmony with the dates provided, so no data is missed. Also, all ships calls were included and duplicate records were excluded. Data was then used to get the value of the four performance indicators that, in this research, explain the bulk port performance. After that, the data was averaged and consolidated into monthly observations and was ready to be used for further testing and analysis. For the truck turnaround time, it was collected from NAFITH in monthly observations. The resulting data, is based on 120 observations, representing the variables used in the model in monthly observations as follows:

1. Average ship turnaround time: The average total hours that vessels stay in port, buoy-to-buoy time, divided by the total number of vessels called at the port. Figure 22 shows the data of this variable in a scatter plot and trend line. It seems that the ship turnaround time trend decreased with time.

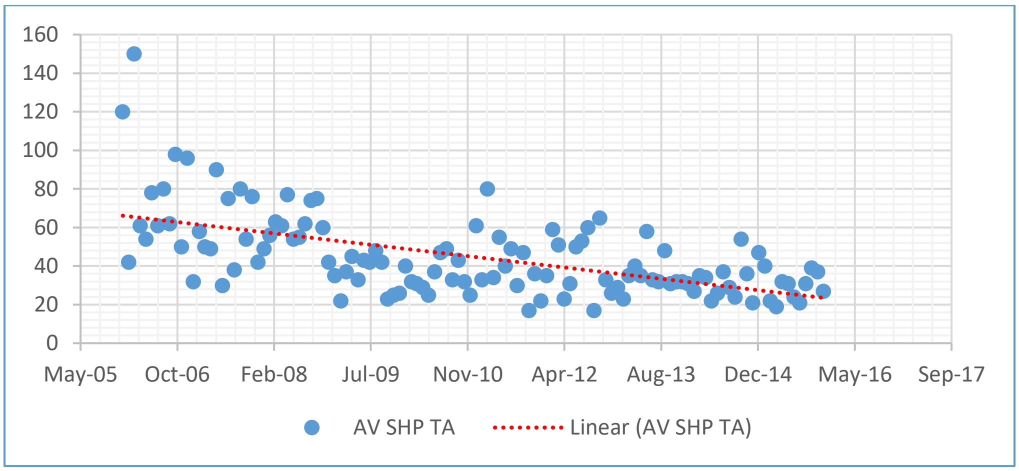

Figure 22: *Average Ship Turnaround Time*

2. Average berth occupancy rate: Total average time of vessels at berth divided by total berth hours available. Figure 23 shows the data of this variable in a scatter plot and trend line, which also indicates a downward trend.

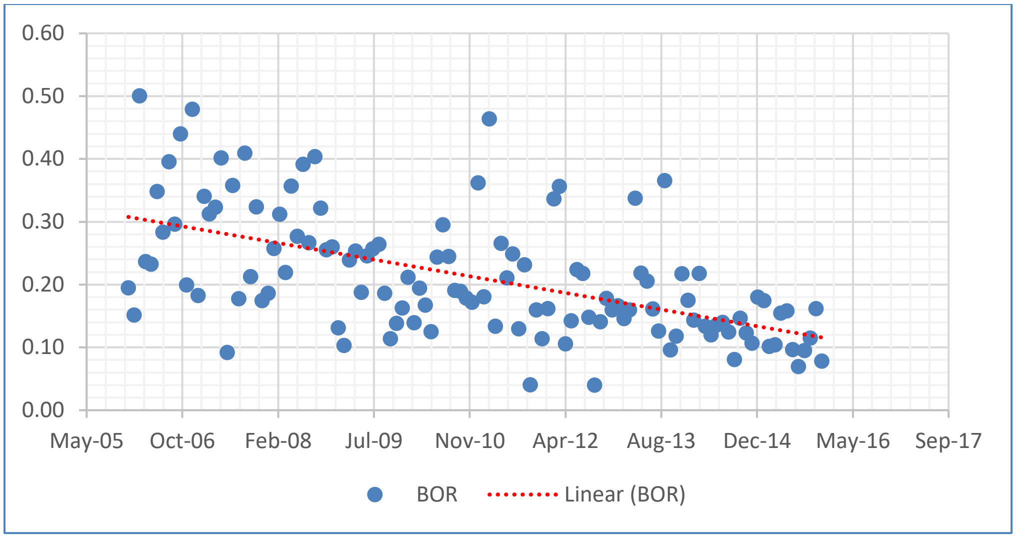

Figure 23: *Average Berth Occupancy Rate*

3. Average gross berth productivity, tons/ hour: The number of tons of cargo, for breakbulk and bulk cargoes, divided by the vessel's total time at berth measured from first line to last line. Figure 24 shows the data of this variable in a scatter plot and trend line. It seems that there is no change in the trend as it fluctuated over time.

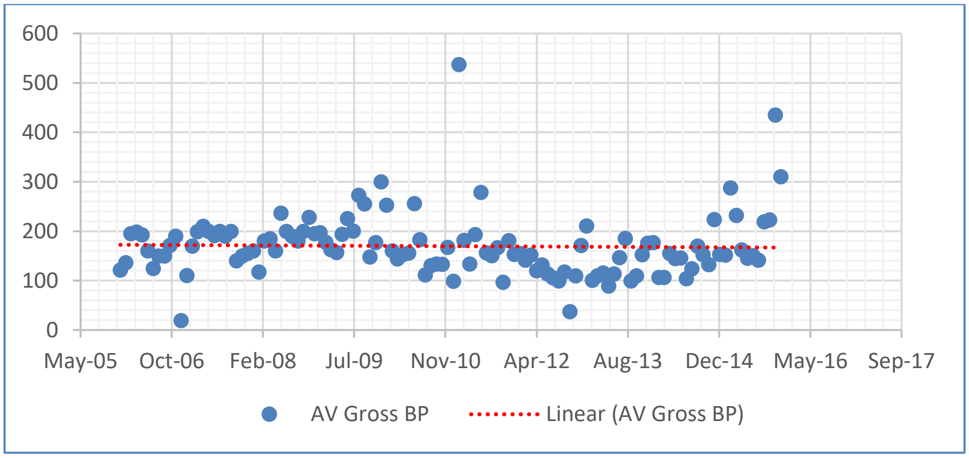

Figure 24: *Average Gross Berth Productivity*

4. Average ship call size: The average of the gross registered tonnage of ships divided by the number of ships. Figure 25 shows the data of this variable in a scatter plot and trend line which shows that the average gross tonnage went up with time.

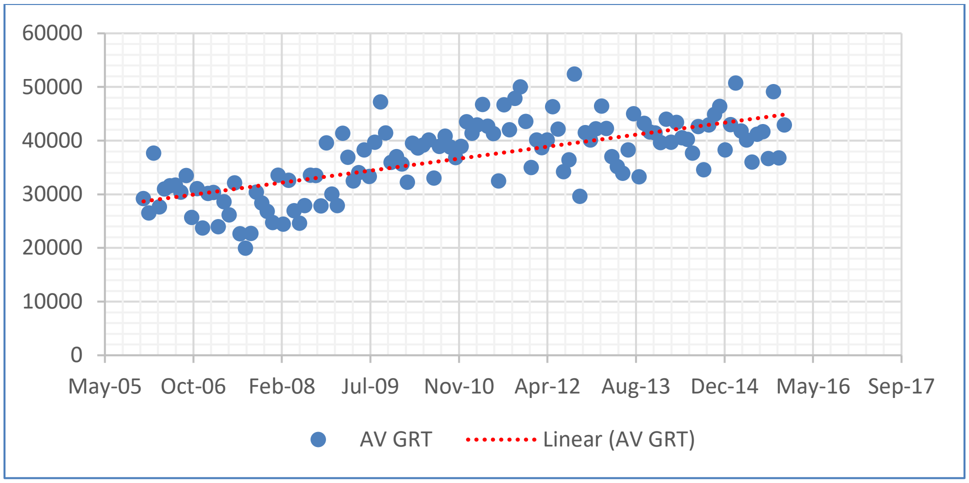

***Figure 25:** Average Ship Call Size (GRT)*

5. Average truck turnaround time: This variable was already calculated and received from the resource in monthly average. Figure 26 shows the data of this variable in a scatter plot and trend line. Importantly, the trend line went down over time, meaning that the turnaround time was becoming shorter.

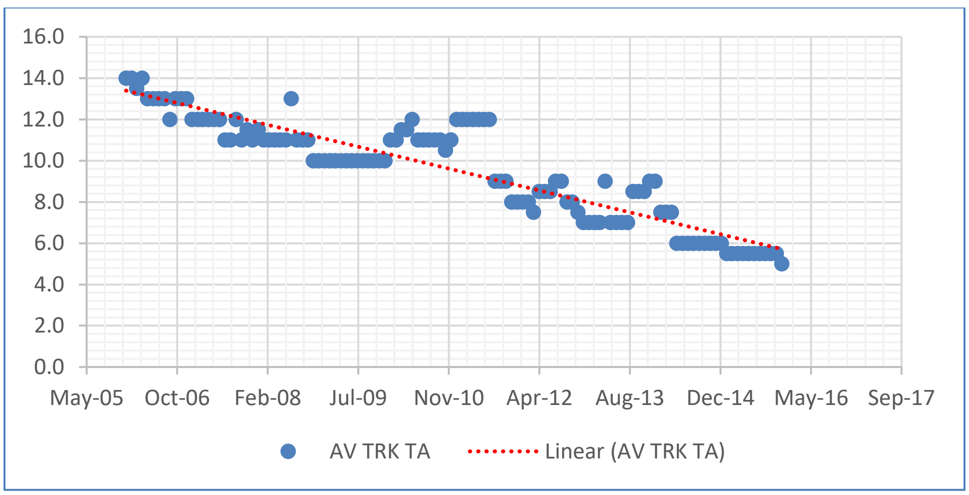

***Figure 26:** Average Truck Turnaround Time*

4.4. Analytical Tools and Tests

To test the hypotheses of the model in a correct and reliable way, a number of tests were performed: correlation test, T-test, unit root test, and simple regression, followed by group statistics.

4.4.1. Correlation

If y and *x* are correlated, it means that y and *x* are treated in an entirely symmetrical way i.e. to measure the degree of linear association between them. Therefore, it is not implicit that changes in *x* cause changes in y or vice versa. There is just evidence for a linear relationship between the two variables (Brooks, 2014). In regression, however, the dependent variable, y, and the independent variable(s), x's, are looked at in a different way, the y variable is assumed to be random in a way (stochastic), that is, to get a probability distribution. Conversely, the x variables are assumed to have fixed values (non-stochastic) in repeated samples (Brooks, 2014).

The aim here is to check the correlation coefficient which is a numerical value between -1 and 1 that articulates the strength of the linear relationship between two variables. When the correlation coefficient is closer to 1, it denotes a strong positive relationship. A value of zero denotes that there is no relationship. Values close to -1 indicate a strong negative (inverse) relationship between the two variables.

4.4.2. T-test

T-test looks at two group scores so as to judge the difference between their means relative to the spread or variability of the two groups' scores. This test is used for a single hypothesis, and it can be performed using the T-table or directly on EViews. The critical value is defined by a 95% confidence level i.e. 5% significance level. The null hypothesis of statistical insignificance is rejected and the alternative hypothesis of significance is accepted if the t-statistic ratio is more than the critical value.

4.4.3. Stationarity and Unit Root Test

If the variables that will be used in the regression are not stationary, it is proof that the standard assumption for asymptotic analysis is not going to be valid. Rather, the usual t-ratios will not follow a t-distribution; subsequently, we cannot validly carry out hypothesis tests for the regression parameters (Brooks, 2014). This test is to check if all variables are stationary at the levels, if not, accordingly, they are differenced into the first or second difference. This test is done by means of the EViews software.

The Augmented Dickey-Fuller test statistic is used here for all the variables. If the t-statistic is more than the critical value on the 5% significance level, then the variable is stationary at the level; if not, it is checked on the first difference or second difference until it becomes stationary. Certainly, the variable has to be differenced independently after that, which will result in giving away one observation.

4.4.4 Regression[14]

To test the hypotheses above and analyze the relationship and trend, we need a tool for that purpose. The simple linear regression tool, Ordinary Least Squares, would be utilized using the EView software. By doing so, we can find the slope and the independent variable coefficient α and β respectively. The coefficient β would show the impact of the independent variable on the dependent variable and the relationship type, either positive or negative (inverse).

The sample of variables, 120 observations, will be run on EViews. Table 14 summarizes the hypotheses by equations, the name of the variables and the abbreviation used on EViews.

Table 14: *Summary of Regression's Equations and Variables*

NO	Equation	Variables	Abbreviation
1	$y1 = \alpha1 + \beta X + \mathrm{u1}$	$y1 =$ Average Gross Berth Productivity	AV Gross BP
		X= Average Truck Turnaround Time	AV Truck TA
2	$y2 = \alpha2 + \beta X + \mathrm{u2}$	$y2 =$ Average Ship call Size (GRT)	AV GRT
		X= Average Truck Turnaround Time	AV Truck TA
3	$y3 = \alpha3 + \beta X + \mathrm{u3}$	$y3 =$ Average Ship Turnaround Time	AV SHP TA
		X= Average Truck Turnaround Time	AV Truck TA
4	$y4 = \alpha4 + \beta X + \mathrm{u4}$	$y4 =$ Berth Occupancy Rate	BOR
		X= Average Truck Turnaround Time	AV Truck TA

[14] Regression analysis: Is tool describing and evaluating the relationship between a given variable, the dependent variable, and one or more other variables, the independent variable. It is an attempt to explain movements in a variable by reference to movements in one or more other variables (Brooks, 2014).

Throughout the regression analysis, and after doing the t-test and the unit root test, the following are checked to further validate the hypothesis tested;

- **p-value**

The p-value of the t-ratio signifies the significance level which has to be less than 5%, and that means the result is not less than 95% at the confidence level. For the p-value, the null hypothesis of statistical insignificance is rejected if its value is more than 5% in the significance level, meaning that we reject the original hypothesis that we test in the regression because the relationship is insignificant. On the contrary, we accept the alternative hypothesis of significance if the p-value is less than 5% in the significance level, which means we accept the original hypothesis that we test in the regression.

- **R-squared**

R-squared is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination, or how well the regression line fits the data. Generally, the higher it is, the better the model fits the data (Minitab, 2016). By checking this measure, we know how good the regression result is.

4.5. Summary

In this chapter, the methodology of testing the hypotheses of the analytical model that explains the impact of efficient hinterland transport on port performance was set up. There are four hypotheses, which will be tested by the correlation, t-test, simple regression (OLS). These will pave the way for the analysis and discussion carried out in chapter five. In short, the regression analysis, with the tests and checkups, will be the tools utilized to find the relationship between variables, along with some descriptive statistics as well. The next chapter is the analysis of the tests of the hypotheses and discussions.

Chapter 5 Empirical Analysis and Discussion

5.1. Hypothesis One

Hypothesis one states that the truck turnaround time has an impact on gross berth productivity. To test this hypothesis a number of statistical tests, and analyses were carried out, and their values are summarized in Table 15. In addition, using the simple regression, OLS, the data was imported to EViews, and the regression was run; see Figure 27.

Table 15: *Tests Summary*

Variables	Dependent variable (y) AV Gross BP	Independent Variable (X) AV Truck TA
Stationary test	Stationary at levels	Stationary at 1st difference
Correlation	0.038518	
T-test	T-statistic (0.549) <u>less than</u> the critical value (1.984)	
***p*-value**	58%	
R-squared	0.2578 %	
Independent variable coefficient (β)	(1.338880)	

Dependent Variable: AV_GROSS_BP
Method: Least Squares
Date: 08/21/16 Time: 20:10
Sample: 2006M02 2015M12
Included observations: 119

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	157.2865	23.91425	6.577103	0.0000
AV_TRK_TA	1.338880	2.434804	0.549892	0.5834

R-squared	0.002578	Mean dependent var	170.0283
Adjusted R-squared	-0.005947	S.D. dependent var	64.31830
S.E. of regression	64.50928	Akaike info criterion	11.18816
Sum squared resid	486889.3	Schwarz criterion	11.23487
Log likelihood	-663.6955	Hannan-Quinn criter.	11.20713
F-statistic	0.302382	Durbin-Watson stat	1.374388
Prob(F-statistic)	0.583441		

Figure 27: *Simple Regression*

As can be seen in Table 15, the two variables are almost not correlated. The correlation coefficient is close to zero, 3.8 % correlated, and the T-test did not reject the null hypothesis of insignificance because the t-statistic is less than the critical value. Moreover, the unit root test showed that the dependent variable is stationary at the levels, and the independent variable is stationary at the first difference. Similarly, in the regression, the *p*-value was more than 5% in the significance level, which means that the null hypothesis of insignificance was not rejected. Finally, the R-squared is very low which means that the regression line does not fit the data in high percentage.

In light of this, the independent variable is not statistically significant in this hypothesis i.e. it does not significantly impact the dependent variable. In conclusion, hypothesis one was rejected and there is no relationship between the truck turnaround time and the gross berth productivity.

5.2. Hypothesis Two

Hypothesis two states that the truck turnaround time has an impact on the average ship call size (Gross Registered Tonnage). To test this hypothesis, a number of statistical tests and analyses were carried out, and their values are summarized in Table 16. In addition, using the simple regression, OLS, the data was imported to EViews, and the regression was run; see Figure 28.

Table 16:*Tests Summary*

Variables	Dependent variable (y) AV GRT	Independent Variable (X) AV Truck TA
Stationary test	Stationary at 1st difference	Stationary at 1st difference
Correlation	- 0.5688	
T-test	T-statistic (7.363) more than the critical value (1.984)	
***p*-value**	0%	
R-squared	31,7 %	
Independent variable coefficient (β)	(-1591.761)	

Dependent Variable: AV_GRT
Method: Least Squares
Date: 08/21/16 Time: 16:27
Sample: 2006M02 2015M12
Included observations: 119

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	51981.12	2123.281	24.48151	0.0000
AV_TRK_TA	-1591.761	216.1796	-7.363141	0.0000

R-squared	0.316652	Mean dependent var	36832.64
Adjusted R-squared	0.310811	S.D. dependent var	6899.282
S.E. of regression	5727.603	Akaike info criterion	20.16065
Sum squared resid	3.84E+09	Schwarz criterion	20.20735
Log likelihood	-1197.558	Hannan-Quinn criter.	20.17961
F-statistic	54.21585	Durbin-Watson stat	1.148374
Prob(F-statistic)	0.000000		

Figure 28: *Simple Regression*

As shown in Table 16, the two variables are moderately correlated. The correlation coefficient is 56.9 % in a negative correlation, and the T-test rejected the null hypothesis of insignificance because the t-statistic is more than the critical value, the null hypothesis, however, states that the independent variable is insignificant. Moreover, the unit root test showed that the dependent variable is stationary at the first difference and as well the independent variable is stationary at the first difference. In the regression, the *p*-value was less than 5% in the significance level (zero percent) which means that the null hypothesis of insignificance was rejected too. Lastly, the R-squared is relatively low, 31,7 %, which means that the regression line fairly fits the data in this percentage.

Accordingly, the independent variable is statistically significant in this hypothesis i.e. it significantly impacts the dependent variable. The independent variable coefficient (β) is (-1591.761) which means that an increase of one unit in the independent variable, the truck turnaround time, would decrease the dependent variable, the average ship call size (GRT) by 1591.761 ton. In conclusion, hypothesis two was not rejected and the relationship between the two variables is significant. Therefore, truck turnaround time has an impact on average ship call size (GRT).

5.3. Hypothesis Three

Hypothesis two states that truck turnaround time has an impact on ship turnaround time. To test this hypothesis as indicated earlier, a number of statistical tests and analyses were carried out, and their values are summarized in Table 17. In addition, using the simple regression, OLS, the data was imported to EViews, and the regression was run; see Figure 29.

Table 17: *Tests Summary*

Variables	Dependent variable (y) AV SHP TA	Independent Variable (X) AV Truck TA
Stationary test	Stationary at levels	Stationary at 1st difference
Correlation	0.5602	
T-test	T-statistic (6.990) more than the critical value (1.984)	
***p*-value**	0%	
R-squared	30%	
Independent variable coefficient ($\boldsymbol{\beta}$)	(4.51)	

Dependent Variable: AV_SHP_TA
Method: Least Squares
Date: 08/21/16 Time: 23:44
Sample: 2006M02 2015M12
Included observations: 119

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.269157	6.336950	0.200279	0.8416
AV_TRK_TA	4.510349	0.645190	6.990732	0.0000

R-squared	0.294630	Mean dependent var	44.19328
Adjusted R-squared	0.288601	S.D. dependent var	20.26698
S.E. of regression	17.09408	Akaike info criterion	8.532005
Sum squared resid	34188.28	Schwarz criterion	8.578713
Log likelihood	-505.6543	Hannan-Quinn criter.	8.550972
F-statistic	48.87033	Durbin-Watson stat	2.016247
Prob(F-statistic)	0.000000		

Figure 29: *Simple Regression*

Table 17 above shows the result of the simple regression, which indicates that the two variables are positively correlated. The correlation coefficient is 56,02%, which is considered moderately correlated. Moreover, the T-test rejected the null hypothesis of insignificance, which is the independent variable is insignificant, because the t-statistic is more than the critical value. As for the regression, the unit root test showed that the dependent variable is stationary at the level and the independent variable is stationary at the first difference. Likewise, the *p*-value was less than 5% in the significance level, zero percent, which means that the null hypothesis i.e. the independent variable is insignificant, was rejected. Finally, the R-squared is relatively low, 30 %. This percentage means that the regression line fairly fits the data.

Accordingly, the independent variable is statistically significant. That is, it significantly impacts the dependent variable. The independent variable coefficient (β) is 4.51, which means that an increase in one unit in the independent variable, truck turnaround time, would increase the dependent variable, average ship turnaround time by 4.51 hours. In conclusion, hypothesis three was not rejected and the relationship between the independent and dependent variables is significant. Therefore, truck turnaround time has an impact on average ship turnaround time.

5.4. Hypothesis Four

Hypothesis four states that truck turnaround time has an impact on berth occupancy rate. To test this hypothesis, a number of statistical tests and analyses were carried out, and their values are summarized in Table 18. In addition, using the simple regression, OLS, the data was imported to EViews and the regression was run; see Figure 30.

Table 18: *Tests Summary*

Variables	Dependent variable (y) BOR	Independent Variable (X) AV Truck TA
Stationary test	Stationary at levels	Stationary at 1st difference
Correlation	0.579	
T-test	T-statistic (7.890) <u>more than</u> the critical value (1.984)	
***p*-value**	0%	
R-squared	35 %	
Independent variable coefficient $(\boldsymbol{\beta})$	(0.024)	

Dependent Variable: BOR
Method: Least Squares
Date: 08/21/16 Time: 23:41
Sample: 2006M02 2015M12
Included observations: 119

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.015680	0.029764	-0.526811	0.5993
AV_TRK_TA	0.023910	0.003030	7.890087	0.0000

R-squared	0.347293	Mean dependent var	0.211869
Adjusted R-squared	0.341714	S.D. dependent var	0.098959
S.E. of regression	0.080290	Akaike info criterion	-2.189684
Sum squared resid	0.754235	Schwarz criterion	-2.142976
Log likelihood	132.2862	Hannan-Quinn criter.	-2.170718
F-statistic	62.25347	Durbin-Watson stat	2.220309
Prob(F-statistic)	0.000000		

Figure 30: *Simple Regression*

As clearly shown in Table 18, the result of the simple regression signifies that the two variables are positively correlated. The correlation coefficient is 57,9. Moreover, the T-test rejected the null hypothesis of insignificance, which is the independent variable is insignificant, because the t-statistic is more than the critical value. Likewise, regarding the regression, the unit root test showed that the dependent variable is stationary at the level, and the independent variable is stationary on the first difference. The *p*-value was less than 5% in the significance level (zero percent), which means that the null hypothesis (the independent variable is insignificant) was rejected too. Lastly, the R-squared is 35 %; this percentage means that the regression line fairly fits the data.

Accordingly, the independent variable is statistically significant. That is, it significantly impacts the dependent variable. The independent variable coefficient (β) is 0.024, which means that an increase in one unit in the independent variable, truck turnaround time, would increase the dependent variable, berth occupancy rate, by 0.024 percent. In conclusion, hypothesis four was not rejected and the relationship between the independent and dependent variable is significant. Therefore, truck turnaround time has an impact on berth occupancy rate.

5.5. Discussion

The result of testing the hypotheses of the analytical model that endeavors to explain the assumption that hinterland transport has an impact on port operational performance were tested in this chapter. Unlike the initial assumption of the four hypotheses, only three were valid after being subjected to some tests and the regression tool. The regression was utilized to shed light on the relationship between each hypothesis' variables.

As indicated earlier, the port operational performance in the port of Aqaba's dry bulk terminal was explained by four performance indicators i.e. ship turnaround time, berth occupancy rate, gross berth productivity, and ship call size. With regard to hinterland transport, as assumed, it was explained by truck turnaround time from the marshalling yards outside the port city.

The issue of identifying and explaining the impact of hinterland transport (truck turnaround time) on port performance is not the only factor that may impact port performance due to the fact that port performance is composed of many subsystems that influence the performance, and one of them is hinterland transport.

However, in the Jordanian port, NAFITH case, there were no major changes or reforms in the ports, except for the concession agreement to run the container terminal by a global terminal operator i.e. APM, which is run separately in one terminal outside the main port. The port infrastructure and superstructure were almost the same over the sample period. For example, the cranes and other handling equipment were not exchanged or witnessed any improvement.

In this sense, the major change was the development and organization of trucks by the truck control system, NAFITH-TCS, which started in 2006. Hence, the major dominant and prevailing factors on port performance were not highly impactful in that period, which made the case favorable for examining the impact of hinterland transport on port performance. The following is a discussion of the results and findings of the hypotheses.

5.5.1. Hypothesis One

Regarding the first hypothesis, which is that truck turnaround time has an impact on gross berth productivity, it was rejected because of the very low correlation between the two variables. Also, in the simple regression that was carried out, the independent variable was not significant i.e. it has no impact on gross berth productivity although the trucks come to the quay on time and are ready to load or unload the cargo, and the truck turnaround time gradually declined in the same period. See Figure 31.

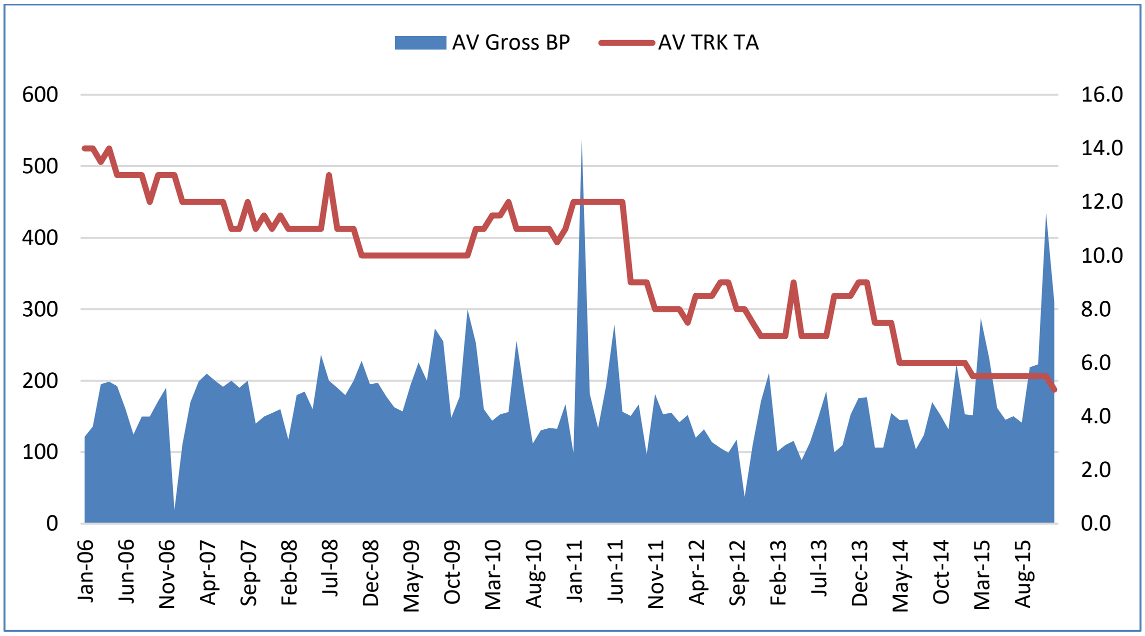

Figure 31: *Gross Berth Productivity & Truck Turnaround Time*

Gross berth productivity is an indicator that measures the tons of cargo handled in the dry bulk terminal divided by the ship's total time at berth measured from the first line to the last line (Tons/hour). As can be seen in Figure 31, berth productivity changed in an irregular way over the ten-year period; it went up and down with some spikes at some points.

Berth productivity, as defined earlier, is a function of the berth time and amount of cargo handled, including both import and export. However, the handling equipment and labor are considered some of the factors that improve berth productivity i.e. they expedite the ships berth time by introducing less idle time; hence, less berth time and more gross berth productivity, if properly utilized or enhanced by further equipment or more labor.

On the other hand, the amount of cargo handled (Figure 32), in this case, played a part in the variability of this indicator. The more the monthly cargo, the longer the ship berth time is, which is believed to have contributed to the fluctuation in the level of productivity because of the longer time taken to handle the cargo by equipment and labor.

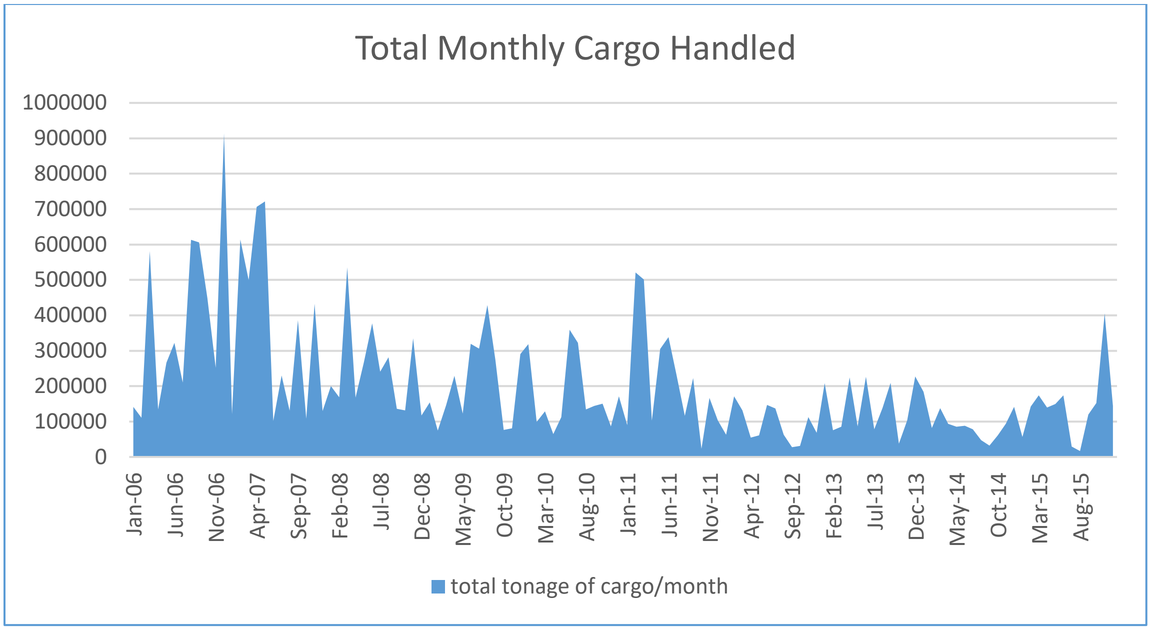

***Figure 32:** Monthly Cargo Handled During the Observation Period*

The issue of cargo traffic fluctuation, both import and export, cannot be controlled due to supply and demand matters as well the many crises that hit the region, such as, Syrian and Iraqi wars dramatically reduced and influenced the amount of transit cargo for those countries.

Despite this, there was improvement in ship waiting time due to trucks being ready with less congestion and reducing turnaround time at the terminal. It could be argued here that the port needs to tackle this problem by improving the berth productivity factors, such as reducing the idle time, and improving equipment and labor utilization for better productivity. The bottom line for the gross berth productivity issue is that once the port wants to improve its productivity, it purchases cranes, rebuilds the berth infrastructure, expands the gates, and improves the inland transports connectors. There are no significant advances or game changes. It is simply that terminal operators are getting the ship out very quickly by employing more cranes over more shifts (JOC, 2014). So, berth productivity is influenced by truck turnaround time, but not to a high extent because the other mentioned factors are more powerful and dominant.

5.5.2. Hypothesis Two

Concerning hypothesis two, truck turnaround time has an impact on ship call size **(**GRT). According to the simple regression that tested the relationship, it was significant, and there is a relationship between the independent variable, the truck turnaround time, and the dependent variable, the average ship call size. However, the correlation was moderate, with fair R-squared.

The GRT was low at the beginning of 2006, around 29 thousand on average, and then started increasing gradually until 2015, up to 43 thousand on average. On the contrary, in the same ten-year period, as can be seen in Figure 33, truck turnaround time was high in 2006 then decreased until it reached its lowest at the end of 2015, from 14 hours to 5 hours. The relationship, as per the regression result, is explained by the independent variable coefficient, -1591.761, inverse relationship i.e. once the truck turnaround time goes down one unit, the average ship size (GRT)goes up by around 1591 tons.

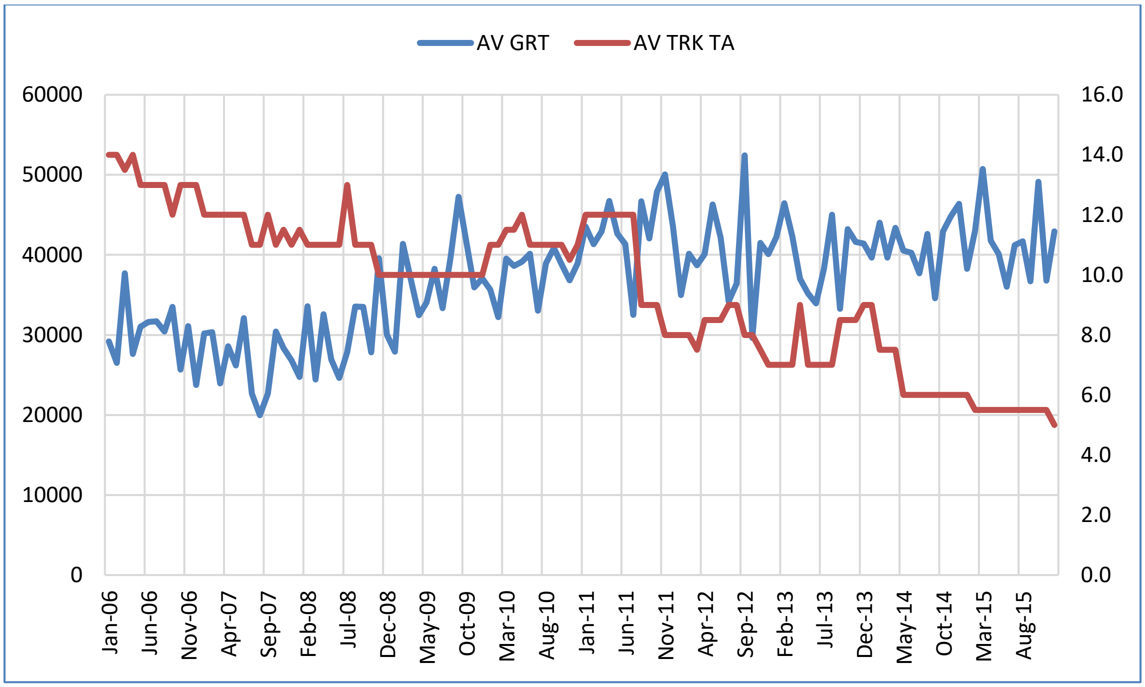

Figure 33: *Average GRT & Truck Turnaround Time*

Of course, this relationship explains a long-term trend, not a short-term one. For example, even if the truck turnaround time starts increasing, the ships' GRT will not change directly as explained by the coefficient, but would take time until GRT goes down again.

This increase in the GRT is due to many factors, such as the increase in import and export of cargoes, and a general increase in ship size. Importantly, the trucking services for the port improved with less truck turnaround time, which could attract bigger ships, as their waiting time is now less. Also, if the issue is with inland transport, ships might be satisfied particularly with good hinterland transport and they do not have to wait long outside the port due to non-availability of trucks and congestion. Moreover, that would enhance the door-to-door service.

5.5.3. Hypothesis Three

With respect to hypothesis three, the relationship between truck turnaround time and ship turnaround time was not rejected after the tests that were performed. The result showed moderate correlation, significant t-test and the regression that illustrated the relationship gave significant result. It was evident, as can be seen in Figure 34, that there was a change in the ship turnaround time indicator from 2006 to 2015, which somehow matched the trend of the change in truck turnaround time. The average ship turnaround time was around 150 hours at the beginning of 2006. It gradually declined until it reached 27 hours in 2015.

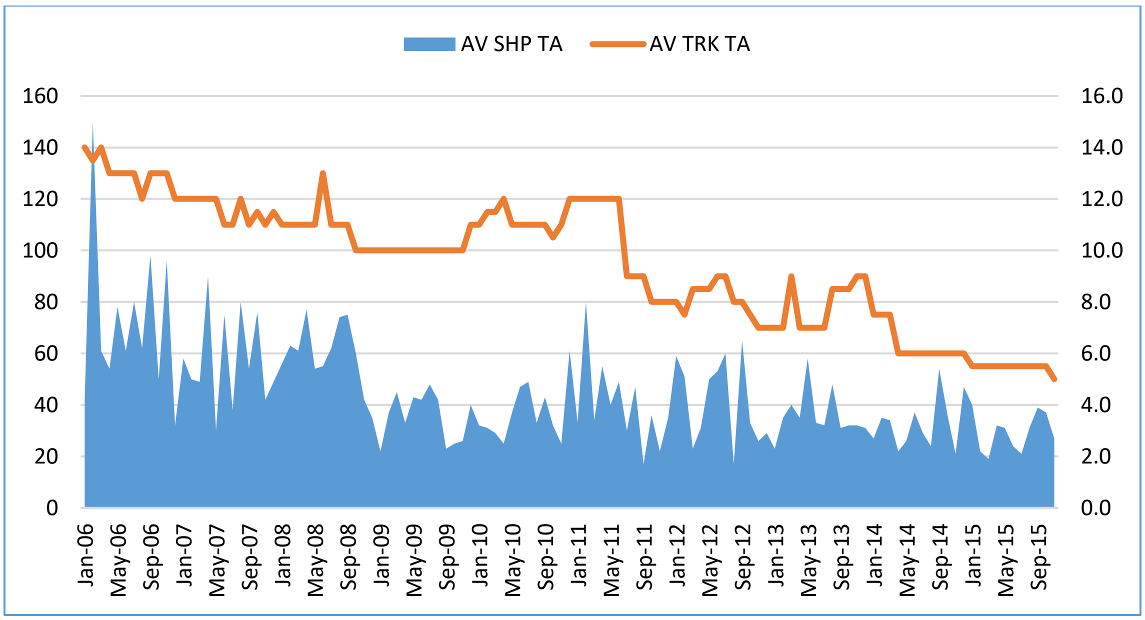

Figure 34: *Average Ship Turnaround Time & Truck Turnaround Time*

On the other hand, truck turnaround time was high in 2006, around 14 hours. It declined gradually until 2015, to around 5 hours. According to the regression result, for each hour the truck turnaround time goes down, the ship turnaround time decreases by 4.5 hours.

Moreover, the reduction in ship turnaround time reacts with the reduction in truck turnaround time in the short run. This does not take a longer time; however, in the long run, this also influences ship turnaround time due to the fact that ships tend to wait less outside the berth, resulting in less congestion and, consequently, shorter turnaround time.

Certainly, truck turnaround time influenced the trend of ship turnaround time, but this impact is not 100% explained by the reduction of truck turnaround because there are other dominant factors that impact ship turnaround time. As can be seen in Figure 34, there were many spikes in the observations of ship turnaround time, which could be explained by the presence of other factors influencing ship turnaround, berth time and berth productivity for example, ships and cargoes sizes fluctuation due to seasonality and supply and demand forces. Meaning that, sometimes when the cargo is massive, the ship turnaround increases owing to the time taken to unload or load the ship at the berth. In this case, truck turnaround time may impact ship turnaround time but not to a high extent. In general, ship turnaround improved and was reduced along with the reduction in truck turnaround time.

5.5.4. Hypothesis Four

The fourth hypothesis stated that truck turnaround time has an impact on the berth occupancy rate. It was not rejected because the tests were significant and, as indicated earlier by the simple regression, the two variables of this hypothesis are up to 58% correlated and the relationship is significant; therefore, the hypothesis was not rejected. As can be seen in Figure 35, the berth occupancy rate trend declined with time, similar to the truck turnaround time.

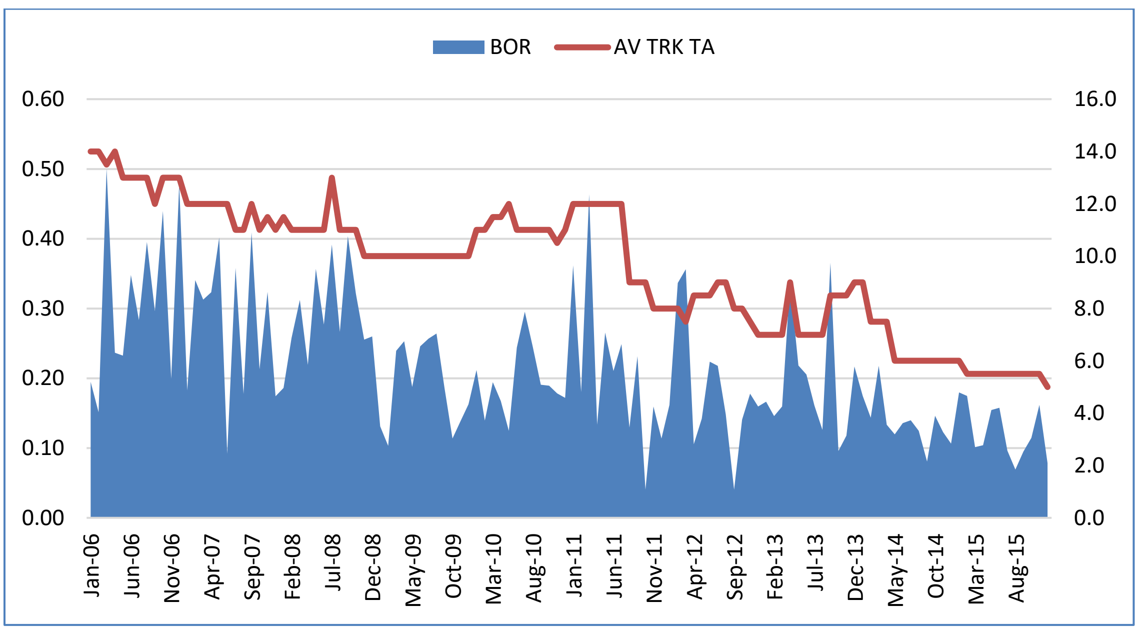

Figure 35: *Average Berth Occupancy Rate & Truck Turnaround Time*

The coefficient of the independent variable, truck turnaround time, is 0.24, meaning that a decrease of one hour in truck turnaround time would decrease the berth occupancy rate by 0.024%. As with the previous hypothesis, the rate goes down with time i.e. it does not respond instantly; it takes time. It can be concluded that there is an impact on the berth occupancy rate in the long term relationship, owing to the improvement in truck turnaround time.

The berth occupancy rate is the total berth time of vessels divided by the berth hours available. The bulk terminal is open 24 hours, which means that berth occupancy rate goes down i.e. there is no ship congestion issue. Further, it could be argued that even if, in that period, the truck turnaround time improved and went down, it may not influence the berth occupancy rate because it is a function of berth time and berth availability time. The answer is that with those dominant factors, once the trucks are there on time, not late and not jammed, resulting in quay congestions, it helps to decrease the ships berth time to some extent, and that was clear in this case as it went down. However, it fluctuated sometimes, and that is due, as foreshadowed above, to the influences of other dominant factors.

In summary, hinterland transport, specifically truck turnaround, improved and declined gradually from 2006 to 2016, which had an impact on port operational performance of the bulk terminal. The four indicators that were selected to explain the port performance had a significant relationship with the truck turnaround time, except for the gross berth productivity.

The improvement, reduction, in the ship turnaround time, the growth in the GRT of calling vessels, and the reduction of berth occupancy rate, all occurred after the truck turn around went down and in a long term relationship i.e. they did not respond simultaneously, they took a long time. On the other hand, however, the trucks performance is not believed to be the sole factor of this improvement of performance factors; there are still another strong and dominant factors that impact the port performance. But, the role the organized hinterland played, generally, did have a positive impact and would be factored in on port performance.

We can conclude here that NAFITH-TCS has an impact on the port performance, the dry bulk terminal, which reflects the improvement after the system has been applied. In general, this result would demonstrate that the efficient hinterland transport has an impact on the port operational performance among the other factors that impact the port performance.

5.5.5 Discussion of NAFITH Case

The concept of the Truck Control System (TCS), which was applied by NAFITH, has materialized and facilitated transport and trade that originates from Aqaba ports to all around Jordan. It has incorporated a number of important stakeholders, such as ports, border centers, customs, shipping lines, trucking companies and trucks, clearing agents/forwarders, shippers, consignees, and insurance companies. TCS reflects how the organization and the technologies introduced have enhanced the supply chain cycle, synchronized the fleet of trucks under one umbrella, and linked all stakeholders in an augmented single window system.

By doing so, the system cuts down all non-value added services, removes zero-value intermediaries, reduces multi-port access complexities, and introduces the double moves to carry cargo i.e. once a truck comes to the port it has two jobs, discharging and loading. Regarding communication technologies, the system employs the Internet and electronic data interchange (EDI). Further, it uses multiple communication and delivery channels such as the Web, SMS, and mobile. This is very important for better visibility upstream in the supply chain.

Such a behavioral approach of inland transport definitely introduces many benefits and significant impacts, such as impacts on ports, trucking companies, and governmental entities. The advantages and benefits, that are explained and summarized as follows, are in accord with NATHAN research, statistical data from the port of Aqaba and NAFITH-TCS.

- **Port operation**: The reliability of such service reduces the need for large inventories and allows just-in-time operations. The port traffic noticeably increased from 17,2 million tons in 2006 to 18,3 million tons in 2015, equivalent to compound annual growth of 6.7%.

  Moreover, the impact on port operational performance, which was discussed thoroughly earlier in this chapter, was clear through the ten-year period that was examined i.e. the system's control of capacity management and integration with users expedited ships discharge, reduced ship turnaround time, and improved berth occupancy rate. Further, it reduced truck turnaround time and truck numbers inside the ports, which eventually decreased congestion both at sea and land side.

- **Truck operation**: The fleet had about 12600 trucks in 2005. The fleet increased with 2.4% compound growth until 2014, up to 16000 trucks (MoT, 2014a). However, cargo import and export increased significantly, and, on the other hand, the frequency of truck calls into the ports increased. The number was 2200 at the beginning of the system, now it is 3500 calls per day. For equality among trucks and drivers, the system limited the number of truck calls to nine calls monthly; it was recently increased to 11.

  The organized truck flow through border crossings and to ports saved time and cost, and minimized the queues and holdups compared to the pre-NAFITH situation in the city and port of Aqaba. It grants trucking companies early notice of expected ships offloading time. By doing so, however, the pressure on the national fleet decreased i.e. the truck turnaround time was significantly reduced, less traveling time for trucks, less waiting and idle time, and truck turnover time decreased. Truck turnover time was, in the past, measured in weeks; now it is measured in hours; thus, this enhanced the efficiency of the national truck fleet.

After the project started, the time taken for trucks to enter and leave Aqaba city, truck turnaround time, was around sixteen hours in 2009, compared to the time before the project, which was 24-36 hours per trip. It was estimated that the average time saved per permit, one trip, differed by a range of 8 to 20 hours in 2009 to a range of 12 to 24 hours as projected for 2015, according to NATHAN statistics (2011), which used NAFITH statistical data for these findings.

On the other hand, the total time saved in 2006 was 3,6 million hours, and in 2009 it was 6,1 million hours. Further, the total number of permits increased from 736,550 in 2006 to 804,272 in 2009. Moreover, as projected by NATHAN research (2011), the time saved in 2015 was up to 12,4 million hours, and the number of permits increased to 1,034,416.

- **Safety benefits**: The number of truck road accidents went down. In the past, once the port ordered trucks or released cargo, hundreds of trucks rushed at the same time and sped up to get a good position in the queue. Moreover, truck drivers were not complying with safety measures because there was no regulatory body to observe the cargo loads and other related safety measures. Likewise, the safety of other drivers improved, namely non-users, because of fewer speeding trucks and thus less accidents.

- **Other collateral advantages:** There were advantages for streets and highways, as the regulations for truck loads were put in place, and reduced truck movement decreased the pressure on infrastructure. Also, environmental advantages were noticed due to reduced emissions from idle trucks, unregulated movements and trucks flow, and lesser fuel consumption. The cargo transport cost saving went up, which is a benefit for customers and users of the system.

  Moreover, the system created a foundation platform; it enabled MoT to update its database, which registers all trucks and trucking companies by the available technology i.e. use of internet based application. As such, it creates reliable statistics on the performance of the transport segment.

Finally, the truck control system turns out to have some problems. Like any other system, there are issues that need to be addressed, such as the lack of special training for drivers. Some drivers have died in fatal accidents, where safety measures were compromised. The solution is having an Authorized Economic Operator (AEO) that should apply to all; all drivers should be authorized. They should require an operating license to do the work.

Another issue is the Waybill, which is not available for all cargoes, only for containers. The question is who pays for the delay of the truck and the driver i.e. demurrage. Hence, the waybill should be compulsory for all cargo transport.

Chapter 6 Conclusion

6.1. Summary

The research aimed at identifying the impact of hinterland transport on port operational performance. The study developed a framework of an analytical model to measure that impact and then it was statistically tested. It was proposed that hinterland transport has an impact, and significant correlation, on port operational performance.

The literature of this case was supportive and wide with regard to the importance of hinterland transport to ports and the whole supply chain. However, studies that directly examined the relationship between hinterland transport and port performance were scarce, i.e. there were no studies that pointed out and tested quantitatively the relationship between hinterland transport and port operational performance. Moreover, port performance is very difficult and complicated to measure. That is, seaports offer a wide range of various services, and as well, manage the terminals in a different context. Hence, the researcher opted for a case study where hinterland transport has improved and is organized in a fairly efficient way.

The objectives of the research were answered throughout this dissertation. The objectives of the research were to; (1) analyze and identify the concepts of hinterland transport and port performance in a broader sense; (2) explain and identify how efficient hinterland transport (trucks) influence ports in general; (3) describe and identify the relationship between hinterland transport and port performance; (4) determine the impact of the NAFITH truck control system on Jordanian port operational performance. The first two objectives were answered in the second chapter, literature review, and the third objective was answered in the same chapter by adopting a conceptual framework and an analytical model that describes the relationship and the impacts of hinterland transport on port performance. The fourth objective was answered in chapters four and five, which showed the impact of NAFITH-TCS on the performance of Aqaba port’s dry bulk terminal via hypothesis testing and analyses.

The case study that was utilized to fulfill the objectives focused on the NAFITH project, which organized truck flow through a truck control system, with the port of Aqaba. After examining the literature on port performance and hinterland transport in a general and wider context, the study started to examine the NAFITH project and tried to determine the impact on the port performance, from 2006 to 2015.

It seemed that some port performance indicators improved with time i.e. the streamlined and less congested hinterland transport brought about some changes on the port performance. Interestingly, it was obvious that the organized truck flow, in conjunction with a bigger system that materialized NSW, had some significant improvement. Therefore, the researcher went on with the assumption that hinterland transport has impacts on port performance.

As aforesaid, port performance is very complex It contains many subsystems that cannot be easily boiled down to a few subsystems. They all cascade into each other in a certain way and time. What is important is the knowledge that one of the key links of good port performance is the hinterland transport that loads and discharges cargo from and into the port in a very swift way, such as the case of dry bulk terminals, where the trucks come to the quays. Such a robust transport system would yield some positive impacts on port performance.

The dry bulk terminal was favorable in this case because it is engaged directly with the trucks flow. So, related variables were chosen from the bulk terminal in Aqaba’s main port, using time series data for ten years. Similarly, the hinterland transport was derived from the truck control system that was applied by NAFITH.

The researcher decided, after a study of the literature in chapter two, to choose four performance indicators that belong to the dry bulk terminal (UNCTAD, 1976; World Bank, 2007b; OECD/ITF, 2016) in the port of Aqaba and examine them vis a vis the truck turnaround time of the NAFITH system. It is believed that those four indicators could, in a way, capture the impact of the improvement of the hinterland transport, specifically organized trucks flow.

The analytical model, which was formulated by four hypotheses, was analyzed and discussed in chapter four and five. The hypotheses had the four performance indicators and truck turnaround time; they were tested by correlation test, t-test, and the linear regression as the analytical tool. The factors of hypotheses are the truck turnaround time as the independent variable and gross berth productivity, average ship call size, the ship turnaround time, and berth occupancy rate as the dependent variables. The outcome of the tests supported and validated three hypotheses and rebutted one which is the hypothesis of gross berth productivity.

Gross berth productivity could not capture the improvement and the impact of hinterland transport owing to the fact that there are more dominant factors, which may strongly impact this variable, such as the delays which occur because of quay and labor productivity issues like equipment breakdown, labor disputes, ships problems, and/or lack of efficient equipment.

The remaining three port performance indicators witnessed an improvement along the ten-year observation period. They reacted slowly with time, i.e. the reaction to organized hinterland transport takes time. Nonetheless, it is undeniable that those findings showed the improvement of the port performance in general, which was aligned with the organized and more efficient hinterland transport during that period of observation. Additionally, what made the result clear and reliable was that the port of Aqaba did not have major changes as in the case of building new berths or buying new equipment, meaning that there were no major changes that could have stimulated the port performance.

Meanwhile, it cannot be totally presumed that the changes, or improvements, are only due to efficient hinterland transport as there are some dominant and prevailing factors that shape port performance, but certainly, the improvement of hinterland transport can be positively included and taken into account as part of the larger set of port performance factors.

In conclusion, the result of the study provided guidance for the measurement and identification of relationship and impacts of hinterland transport on port performance; moreover, it adds to the findings and exploration of the interplay between the two research components, hinterland transport and port performance. In addition, the NAFITH system contributed, through the truck control system, to the port and the city of Aqaba through many advantages, such as less congestion at the gates of the port, more streamlined truck flow, and shorter truck turnaround time each time the truck calls the port.

6.2. Implications

The advantage of finding the relationship and the impact of hinterland transport on port performance has implications from different standpoints. From a methodological perspective, this research developed and tested an analytical model for finding the relationship between hinterland transport and port performance, as well, it added to the existing knowledge by providing evidence of the correlation between the aforementioned variables.

The use of statistical techniques, correlations, t-test and regression analysis to define the relationship and impacts of hinterland transport is a powerful tool. They provide an opportunity to further test the relationship in different ports using different hypotheses. Some of the hypotheses were valid and supported empirically and statistically the fact of association between the related variables.

From the hypotheses testing, there are three potential variables that are impacted by truck turnaround time, which is an indication of the impact of efficient hinterland transport on port operational performance. Those variables are ship turnaround time, berth occupancy ratio, and average call size of ships. Focusing more directly on truck turnaround would also contribute to better port performance, particularly the previously-mentioned indicators of port performance.

This kind of interplay explains and helps to better understand and value the relationship and impacts of hinterland transport on the port operational performance of a dry bulk terminal and truck transport, once the transport is improved and organized. Moreover, the relationship and further impacts are very obvious in the long term as the result of having efficient hinterland transport takes time to impact port performance.

Ports, however, need to identify the performance indicators that are impacted by hinterland transport, as they differ from one port to another. It is necessary to find what really impacts the performance indicators. Subsequently, improvement should be directed to optimize and further organize the hinterland transport to enhance port performance positively.

6.3. Limitations and Further Areas for Research

Like any other research, there are some limitations that come along with the findings and results. There are many performance indicators that could be associated with hinterland transport and then tested; however, it was challenging to include all of them and verify the relationship. Similarly, the hinterland transport performance indicators were limited to truck turnaround time. Some other indicators can describe hinterland transport, especially in the scope of this study, yet, those were unavailable or may be not have been observed in general.

The overall representation of the dry bulk terminal does not comprehensively reflect the relationship of whole port performance with hinterland transport. Importantly, there are some other terminals like general cargo terminals, wet bulk terminals, and container terminals. It is possible that this uneven weighting of the dry bulk terminal in this study, may be influenced if more terminal performances were included to account for the holistic port performance.

The substantial difference in the impacts on the indicators might have been as a result of other dominant and more powerful factors that affect them; moreover, those dominant factors differ from one port to another, depending on how the ports are performing in general.

However, more importantly, the findings of this research, the relationship between hinterland transport and port performance, cannot be inferred to another port because each port organizes and utilizes transport in a unique way. In other words, the advantage here is the knowledge of the relationship, which could be put into application in any port by its own means and as well prompt many ports to further observe and identify the impact of hinterland transport on port performance.

In light of this, in spite of the above limitations, the research, the impact of hinterland transport on port performance has expanded the knowledge of the relationship. The research was carried out without significant limitations. Most importantly, the research was executed with the belief that there is nothing perfect, particularly research design. Hence, if the research is prudently designed, weak points can be mitigated and the research can effectively achieve the sought after objectives. All in all, maximum efforts and best potential have been exerted to ensure that the work is ethical and relevant to the objectives of this research.

On the other hand, regarding further areas for research, this research is experimental in nature and additional research is required to determine, explore and assess the interrelationship of hinterland transport and port performance. Moreover, the number of measured variables used in this research is limited; adding more and different variables and using various techniques would add some diverse results.

The analytical model would also be enhanced by more inputs that would explain the impact of hinterland transport using various quantitative and qualitative approaches and methods such as the use of questionnaires and interviews.

This research is a very broad topic and engages many complex factors; as a result, it cannot completely confirm the questioned impacts and relationship due to its limited scope and context.

Future research should test the relationship issue in other terminals such as wet bulk, general cargo and container terminals, and other ports in different countries. Certainly, different settings will require distinctive variables, so that additional components will be distinguished. Nevertheless, the relationship between truck turnaround time and performance indicators that was elucidated here can always be tested using the hypotheses of the analytical model proposed in this research.

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