TIME-RELATED KEY PERFORMANCE INDICATORS AND PORT PERFORMANCE: A REVIEW OF THEORY AND PRACTICE

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ABSTRACT

The objectives of the thesis are to investigate the existing theoretical frameworks regarding as applied by ports' performance measurement and to find out the differences between theoretical approaches and practical use of time-related KPIs in ports. To answer the specific research question a case study of the Port of Melbourne is applied. The major findings of the study reveal the importance of time-related KPIs in port service quality measurement; integration of the indicators with other groups of KPIs depending on the current goals of the company; and variability of time-related KPIs depending on different groups of users of the information. Besides that, the study shows that in practice there is a limited number of time-related KPIs among the other performance indicators. Originality of this thesis is in its attempt to align the theoretical overview of time-related KPIs in port performance measurement with practical use of these indicators. Practical importance of this study is in its attempt to describe a case of a port's performance measurement, particularly in terms of its time efficiency. However, the study is limited by only one case study. Therefore, one of the directions for future research is a further extended analysis of various case studies, added by historical comparative analysis of port performance measurement systems, particularly in the part of their time efficiency evaluation.

Key words: Port KPIs, Time Related Indicators, Port Performance, Time Efficiency of Port, Maritime Supply Chain

DEDICATION

To

Those who are priceless and paramount for me

The real asset of my life

The source of consolation in the moments of sorrow

The source of courage and strength in weakness

Those who fill the drab canvas of my life with gorgeous colors

MY PRECIOUS PARENTS, Brother and Sisters

PREFACE

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LIST OF ABBREVIATIONS

The UNCTAD: The United Nations Conference on Trade and Development

KPIs: Key performance indicators

NVOCC: Non-vessel operating common carrier

DEA: Data Envelopment Analysis

TEUs: Twenty-foot equivalent units

GRT: Gross registered tons

NRT: Net registered tons

The UN: The United Nations

PoMC: The Port of Melbourne Corporation

The Commission: The Essential Services Commission

EBIT: Earnings Before Interest and Taxes

CHAPTER 1: INTRODUCTION

BACKGROUND AND JUSTIFICATION OF THE STUDY

Rapid growth in cargo volumes in recent years has resulted in port congestion - one of the main causes of disruptions in shipping schedules (Notteboom, 2006). That is why such factors as the risk of late arrivals and the difference between scheduled and actual transit times are of the major importance for both liner and port performance. In a survey conducted by the United Nations Conference on Trade and Development (UNCTAD) in 1992, “on-time delivery” was the major concern of most shippers (UNCTAD, 1992). Thus, time has been one of the most important factors for the customers alongside the cost of the services.

However, despite the relevant improvements in the shipping industry, the overall schedule reliability is low (Yang, Zhang and Lam, 2013). According to the data of the Drewry Shipping Consultant (2012), the average schedule reliability is 72.3 percent. This relatively low figure is caused by a combination of a number of factors. However, over 90 percent of all delays are the result of improper work of ports, particularly in terms of port access and terminal operations (Notteboom, 2006).

Ports are recognized as a significant part of the whole maritime supply chain. Port efficiency often means the speed and reliability of port services. Hence, time factor is to be one of the major factors for port performance measurement. Increased port congestion and waiting times in ports can become a reason of prevention from delivering by shipping lines proper liner services to their customers. Therefore, right choice of key performance indicators (KPIs), including time-related KPIs, for the purposes of port performance’s monitoring, is a key success factor of a port’s competitive advantage.

To illustrate the importance of the time factor in port performance and in the whole maritime supply chain the following example can be given. In 2004 because of congestion problems in the terminal of the port of southern Californian fully loaded vessels were waiting to berth and unload for up to ten days. As the result of such cargo delays, a change in the shipping companies’ behavior have occurred: shipping liners started to either call at more northern ports (in Seattle, Tacoma or Vancouver) or avoid the US west coast and go directly to the US east coast ports (Notteboom, 2006). Thus, due to improper port performance the way trade moved across the Pacific to the US has been changed. Port congestion remains a critical issue for both ports, who need to handle this issue and stay competitive, and shippers and shipping lines, who very often have to change their business strategies.

A port's efficiency basically is in its capacities to load and unload ships. However, the traffic movement is a complex phenomenon, which requires systematic approach to planning and measurement (Oyatoye, Adebiyi, Okoye and Amole, 2011). Traffic movement's problems are often the reasons of delays in the system. It causes ships to queue for berthing space thereby creating congestion. Hence, the whole supply chain depends on performance of ports. Time efficiency, in particular, reflects physical performance of a port and determines customers' satisfaction.

PROBLEM STATEMENT

Growing trade flows have significant pressure on ports and, hence, require higher performance standards from the latter. A port's capacity is closely connected to its velocity (Notteboom and Rodrigue, 2008). Due to improvements of transshipment brought in by containerization a greater quantity of space can be traded with a similar or even lower amount of time. It results in a greater velocity in freight distribution. In other words, the efficiency of port terminals has enhanced the velocity of transshipment and, as the result, changed performance of the overall maritime supply chain.

At the same time, the faster freight moves, the more productive a port can be. Since the 1970s many approaches to port performance measurement have been developed. They have covered vast variety of different categories of both qualitative and quantitative indicators with different focuses on added value, integration of ports in logistic chains and other outcomes (Pitilakis, 2011).

Time-related indicators aim at measuring conceptually very simple parameters, such as the amount of cargo moved by a port in a defined period of time, the speed with which ships are served and the speed with which cargo is transferred to other transport modes. In other words, basic port efficiency indicators mainly refer to time measures and to the volume of traffic received by the port. However, despite the fact that the topic of measuring port time-related performance is well studied, there is no uniform measurement approach, which would be applicable for all ports (Tsamboulas, Moraiti and Lekka, 2011). Each port chooses its own set performance indicators, including time-related measurements, which may vary and create difficulties for benchmarking.

OBJECTIVES OF THE STUDY

Time-related indicators can be set at various levels of performance measurement, starting from human resources' productivity, followed by organization of business processes and customer service. All these indicators reflect contributions of a particular factor to financial and technical port efficiency. Since terminals represent the most essential part of ports, port performance often is linked to its terminal performance (De Langen, Nijdam and Horts, 2007).

Due to the high impact of port physical performance on the efficiency of the whole maritime supply chain and on liner shipping schedules in particular, terminal efficiency is of our primary interest. Thus, the group of KPIs that reflect time efficiency of a port represents the subject of the present study. The question of interest is what time-related KPIs and to what extent they are deployed by ports in practice.

The study's objectives are as follows:

1. To investigate the existing theoretical frameworks regarding time-related KPIs as applied to ports' performance measurement; and
2. To find out the differences between theoretical approaches to time efficiency measurement and practical use of time-related KPIs in ports.

THE STRUCTURE OF THE THESIS

The thesis consists of six chapters. The first chapter gives the general introduction to the research, including background and justification, and formulation of the thesis' objectives. The second chapter presents the literature review, which introduces the significance time-related indicators in maritime supply chain in general, outlines the importance of port performance in the effectiveness of the maritime supply chain and describes approaches to port performance measurement with the focus on time-related KPIs in port performance measurement. The third chapter describes the methodology and data, specifically research strategy and the method; and the description of the case study's structure. The fourth chapter introduces the case study and the major research findings. The fifth chapter presents the discussion of the research findings and gives the directions for further research. The sixth chapter outlines the conclusion, which is followed by the list of references.

CHAPTER 2: LITERATURE REVIEW

OVERVIEW OF THE MARITIME SUPPLY CHAIN'S ACTORS

One of the major impetuses for further globalization, including further trade integration among countries, has been given by the development of container shipping. Invention and further development of container shipping has changed significantly the world economy, particularly in terms of worldwide manufacturing and distribution processes. Nowadays, the share of maritime transport among the other modes of transport is dominant (Tongzon and Oum, 2007). This mean of transport, in particular starting from the period of container shipping development, has made access to exchange goods easier and trade itself faster. Besides that, maritime transport has facilitated the emergence of new global export and import flows.

Two major stages of maritime transportation are ships sailing at sea and ships staying at ports. Two major sectors can be categorized within the shipping industry: the bulk shipping, which offers mainly the transportation of raw materials; and liner shipping, which provides with the transportation of final and semi-final products. Most of liner cargo is containerized. In order to make further analysis of a particular actor of the maritime supply chain understanding of the whole maritime transport chain is needed. The actors of the container transport chain can be divided into five categories based on their roles. In the table 1 the key actors and their roles in the container transport chain are represented.

Table 1

Actors in the container transport chain

Role	*Actors involved*
Primary customers	Seller (manufacturer/originated shipper/exporter) Buyer (consignee, importer)
Transaction facilitation	Buying agent Freight forwarder or non-vessel operating common carrier (NVOCC) Customs broker

Role	*Actors involved*
Transport task (physical movement of container)	Empty container depot operator Warehouse/container freight station operator Inland terminal operator (e.g. road-rail, road-barge, rail-barge) Road carrier (local, long distance) Rail carrier Barge operator Ocean carrier Port terminal operator Other port service operators
Authorizing/regulatory	Transport authorities Customs authority Import/export licensing authority Phytosanitary, sanitary and veterinary control licensing authority Port authority Import/export statistical agency Other actors (chambers of commerce, consulates etc.)
Financing	Bank (seller's or advising bank, buyer's or issuing bank) Insurance provider (carriage insurance)

Source: OECD, 2005, p.28.

The table 1 by the example of container cargo supply chain helps better understand two basic things: interconnection among the actors and a central role of shipping liners and ports in the whole chain. As it is seen from the table, the most numerous actors are those responsible for the actual movement of containers, such as shipping and port operators, and various regulatory authorities. Nevertheless, for all of the actors, even the smallest and peripheral ones; the ultimate and major goal is to deliver the cargo to the right destination at the right time. As for the container movement process itself, the major actors are shippers and ports. The main stages of this process are the following: transportation containers to port, obtaining export/import clearance, loading containers into a vessel (original lading), carriage by sea, transshipment (last port of lading), arrival, unloading containers, container picking up/ delivery, container shipping (OECD, 2005).

Thus, time delays, which can occur at any stage of the chain, particularly during the process of containers' movement, can cause deviations in the overall time schedule and thereby deteriorate time reliability of the transport service as the result. Due to a high degree of time-sensitivity of the maritime supply chain time factor is an important input variable of the supply chain performance in general, and of efficiency of container movement in particular. Therefore, efficient work at both these stages is of great importance to the overall efficiency of the whole supply chain.

TIME-RELATED INDICATORS IN THE MARITIME SUPPLY CHAIN'S PERFORMANCE MEASUREMENT

According to Edwards and Thomas (2005), performance indicators are pieces of information that are employed for measuring and assessing performance. KPIs are not just the basis for measuring business performance. They are developed to reflect performance results, which are critical for success of the organization. KPIs allow the measurement of performance and realization of benchmarking. Thus, KPIs are the tool for communicating corporate achievements and development over time and in comparison with other companies to various users of the reported information.

Therefore, KPIs must be easy for understanding and monitoring, on the one hand, and complex and covering a wide range of factors – on the other. Due to changing market environment, increasing competition, modification of organizational roles, rapidly changing demands and growing power of information technology KPIs must be regularly revised and updated (Neely, 1998). Besides that, KPIs provide all necessary information for aligning business activities to the business and corporate strategy. KPIs can refer to the quality of product/service, customer service and delivery, costs and financial results, process time and speed, flexibility and resource utilization and many other aspects of a modern organization depending on the industry, market position and other factors.

In evaluating time performance of any supply chain key performance metrics are applied. These metrics are measured on a regular basis and for each specific type of cargo in case of the maritime supply chain. Among such indicators there are the following:

- Fill rate, which reflects the number (or percentage) of orders delivered "on time";
- Confirmed fill rate, which reflects the percentage of orders delivered no later than the day negotiated with the supplier and the customer;

- Response delay, which reflects the difference between the requested delivery day and the negotiated day;
- Delay, which reflects the difference between the actual delivery day and confirmed delivery day (Kleijnen and Smits, 2003).

For instance, the shipping lines the major time performance measures are the transit time and schedule reliability. The transit time as the concept of transport time is the number of sailing days from one port to another one. The broadened definition says that the transit time is the total time on door to door basis. Thus, the broadened transit time includes dwell times at terminals and time in the queue to the port of discharge (Notteboom, 2006). There is a direct connection between the transit time and the inventory carrying costs: the higher the transit time is the bigger inventory carrying cost is. Moreover, unreliable transit times result in higher levels of the safety stock, meaning that the customer keeps more inventories to prevent from stock-out conditions.

Nowadays we can observe the container transport system that is limited by time-tight schedules. The main goal for all shipping lines is designing liner services with short transit times alongside a high degree of schedule reliability. In other words, if you do not provide a proper service to your customers you are no longer competitive. That is why shipping lines try to meet the deadlines as announced in the official schedules. As a consequence of delays in service delivery the reliability of the service provider may decrease, but also additional logistics costs to the customer in the form of unexpected inventory or even production costs may occur. That is not to mention incurring costs on shipping lines in the form of additional operating costs.

The relative importance of each of these performance dimensions may depend on the market segment and its growth stage. For instance, a low transit time represents a requirement of primary importance for a mature market. Therefore, monitoring of this particular factor can be a differentiating feature or even a competitive advantage of a shipping liner. In other situations, schedule reliability can be a most important factor for a client and therefore for a port authorities. Nevertheless, while the relative importance of each factor may vary depending on needs and circumstances, the absolute importance of general time performance remains high no matter what.

Thus, time represents an important factor, influencing the relation between transport and trade. Each additional day of transit time results in one percent reduction in trade volumes (Djankov, Freund, Pham, 2006). A 10 percent increase in time causes the reduction in bilateral trade volumes by 5-8 percent, and results in a reduction in trade value by 5-25 percent depending on perishability of the transported goods (Hausmann, Lee, Subramanian, 2005; Nordas, Pinali, Grosso (2006). Moreover, uncertainty in the delays causes even bigger decreases in trade. In addition to it, delays have greater impact on shipment of time-sensitive perishable goods, such as livestock, for example. Thus, in case of big time delays and high level of uncertainty in shipment companies can shift to more expensive air transportation (Clark, Dollar, Micco, 2004).

Time spent by ships in ports is one of the input variables of the performance of the whole maritime supply chain. Numerous studies have been dedicated to the increase of operational efficiency, optimization of shipping and port operations, and the importance of the time factor in liner shipping in particular (e.g. Bichou and Gray, 2004; Notteboom, 2006; Chung and Chiang, 2011 etc.). Various studies are dedicated to port performance measuring (e.g. Pallis and Vitsounis, 2008; Pitilakis, 2011; Trujillo and Nombela, 1999). However, little attention has been dedicated to the importance of the time factor in port performance, in particular, although time-related indicators are regarded as a part of the port performance measures in general.

Notteboom (2006) was among the first scholars who have analyzed the influence of time factor on liner shipping reliability. He found that the principal source of unreliability has its roots in port performance. Delays and time loss in vessel operations can be caused by several types of reasons, such as port access, terminal operations, maritime passages and unexpected natural reasons. Thus, port congestion is the major factor that negatively affects schedule reliability. Besides port congestion, the second place goes to port/terminal productivity below expectation (loading/discharging); the third most common reason is unexpected waiting times due to weather or on route mechanical problems; then unexpected waiting times in port channel access (pilotage, towage and tidal windows) follow; and the least common causes of schedule unreliability are missed Suez convoy and unexpected waiting time at bunkering site/port.

This idea was also supported by Vernimmen, Dullaert and Engelen (2007), who highlighted that a number of factors influencing schedule reliability are beyond liners' control. In case of occurred delay a shipper can either change the order of ports, or bypass a port, or leave a port with already uploaded containers, or deploy other vessels in combination with the delivery, or attempt to speed up following port turnaround times, or simply speed up between ports (Notteboom, 2006). However, none of the option is a sustainable one and none of them can guarantee that work will be done in accordance with the planned schedule.

One of the difficulties associated with the assessing importance of time factor is the fact that it can be both an input and output factor. For instance, the total time in ports is the result of influence of many factors, including other types of time factors, as dwell time spent by ships in terminals and working, or productive, time. The latter time factors are, in turn, influenced by such time-related measures as labor working time, for instance. Generally, time is a factor that is of great importance for any kind of business because time reflects productivity, which, in turn, has impact on economic performance. However, in the maritime supply chain time output of one actor inevitably becomes an independent input variable for another actor, and ports in this sense are the key points in the whole chain.

Therefore, it is very important to understand the significance of the link between the time performance of shipping liners and time performance of ports. If for the shipping liners transit time and schedule reliability are the major time-related indicators then in case of ports, there are such basic time performance metrics as congestion time, ship waiting time, turnaround time, etc. These indicators are related to the time spent by the ship in the port; and they are of the main interest in the present study.

To sum it up, maritime supply chain's actors are constantly balancing the risk of late arrivals and minimizing scheduled and actual transit times. Managing the time factor is an important challenge faced by both shipping lines and ports; and the former are dependent on the performance of the latter. Therefore, port time efficiency plays the most important role in the overall schedule reliability (Notteboom, 2006). Eliminating delays in liner shipping services has significant importance. However, scheduling of liner shipping is directly dependent on ports' access and productivity, both of which are dependent on the time factor. A more detailed description of the role of ports in the maritime supply chain is given in the following part of the thesis.

IMPORTANCE OF PORT PERFORMANCE IN THE EFFECTIVENESS OF THE MARITIME SUPPLY CHAIN

As it was outlined earlier, ports directly impact transit time in its broadened understanding. Short transit time is not only a competitive factor in liner shipping, but also an outcome of a port's performance. Shortening transit time or maintaining the planned schedule is a prerogative for all links of the chain, especially in the transportation of perishable goods and consumer goods with a short life cycle. The importance of port efficiency for costs of trade is proven by many scholars (Sanchez, Hoffmann, Micco, Pizzolitto, Sgut, Wilmsmeier, 2003; Nordas and Piermartini, 2004).

A seaport is “a geographic area where ships are brought alongside land to load and discharge cargo – usually a sheltered deep water area such as a bay of river mouth… and often comprise multiple terminals devoted to a particular type of cargo handling” (Stopford, 2009). Seaports have five key functions: cargoes and passengers handling, providing services for ships such as bunkering and repair, providing shelter for ships in case of heavy sea and storm conditions, offering bases for industrial development, and terminals, thereby forming part of a transport chain (Branch, 1986).

Such characteristics of vessel schedules as liners’ schedule reliability are important for port selection (e.g. Malchow and Kanafani, 2004). Besides that, efficient terminal planning plays a great role in a port’s competitiveness, especially in the ports of non-first call (Vernimmen et al., 2007). Chung and Chiang (2011) have also shown that the time spent in port can be the main source of schedule unreliability. It means that, on the one hand, choosing and arranging the order of the ports is critical for shipping liners, whereas, on the other hand, effective and efficient operational port performance, especially in terms of time-relative indicators, is vital as well.

For ages ports have been important nodes in transshipment of goods from one mode of transport to another. Ports link ships with the railway trains and automobiles. Delays at the port point will inevitably result in the delay of the overall delivery. Therefore, ports represent an important link in production and supply chain. It is an important task for ports to utilize all port facilities and capacities properly. It is important due to the high capital intensiveness of the industry and ports in particular. Therefore, inadequate facilities or under-utilization may cause time delays leading to customer loss or capital losses and higher costs for running the port, respectively (Tahar and Hussain, 2000). Besides that, high importance of ports in the overall trading chain makes port efficiency a vital factor influencing a nation’s international competitiveness as well (Tongzon, 1989; Chin and Tongzon, 1998).

International transport costs directly depend on port efficiency. Port efficiency is considered as the most important factor among other port characteristics, such as port infrastructure, private sector participation and inter-port connectivity (Wilmsmeier, Hoffmann, Sanchez, 2006). There are various studies that quantify the relation between port efficiency and transport costs. Although the impact of efficiency differs in different industries and depends on the stage of economic development, improvements in time efficiency always lead to decrease in trade costs and increase in trade flows.

Thus, alongside the successful geographical location of a port, which is a factor of shippers 'choice, one of the major factors of efficient performance of ports is their speed and reliability (Tongzon and Oum, 2007). Speed is especially important in those industries where products must be moved to the markets on time. Ports represent vital nodes in the logistic chain and the main guarantors to shipping lines of reliable service, including on-time berthing of vessels and stable turnaround time. Thus, port efficiency indicators entail turnaround time of ships and cargo dwelling time. Well-managed ports have a much greater role than just operational benchmarks; they facilitate international trade flows, and in some cases enhance economic development of a particular state, for which maritime services have a key role.

Therefore, efficient operational performance is of great importance for such complex dynamic systems as ports. Under this goal the objectives such as increasing port throughput and utilization of resources (e.g. berths, cranes etc.), reducing handling time, minimizing port congestion, minimizing disruptions, demurrage and operating costs must be achieved (Tu-Chang, 1992). Such commercial and operational determinants as the cargo generating effect of the port, the distribution of container origins and destinations, the berth allocation, and the nautical access are among the major factors for control (Notteboom 2006).

APPROACHES TO MEASUREMENT OF PORT PERFORMANCE

Measuring and following up performance is a fundamental activity of any business. Achievements can be measured against planned targets and goals or, against the results of the competitors' performance. Ports are no exception. Ports represent a complex set of activities with many different sources of inputs and outputs, which makes direct comparisons between even two ports difficult (Valentine and Gray, 2002). Ports' performance indicators mostly focus on productivity measurements. Ports' performance, in particular, has been differently assessing by measuring cargo-handling productivity at berth (Bendall and Stent, 1987; Tabernacle, 1995), by taking into account some particular factor of productivity (De Monie, 1987) or by comparing actual throughput with the optimum level (Talley, 1998).

Thus, in literature there are different definitions of performance (Marlow and Paixao, 2003a). According to Mentzer and Konrad (1991), performance is an investigation of effectiveness and efficiency of a particular activity and the assessment of how the objectives and targets are met. The effectiveness reflects the capability of producing an intended result; and efficiency represents the measurement of produced results taking into account used resources. In other words, efficiency reflects the relation between input and output. Therefore, for the purposes of the current study, we are interested rather in port efficiency than in its effectiveness.

Due to various unexpected circumstances, overall complexity of ports and growing trade flows all over the world, even constant rising port volumes and capacity do not guarantee that there will be berth available on arrival at a port in case the allocated time slots in the ports have been missed. Therefore, port congestion cannot be let by all means because it can completely disrupt liner service schedules. Thus, scheduling a loop and calculating transit times requires taking into consideration the expected distribution in terminal performance, as well as terminal flexibility in dealing with unexpected situations.

High level of port performance is not only important for the whole supply chain, but also is the key to the strong position in the market. In other words, ports' performance must be measured and followed-up for ports' sake. As we can see from the example in the introduction, a mistake in the California's port caused a lower level of customer satisfaction and as the result a lower call efficiency ratio later.

Monitoring and following up efficiency can be beneficial from two perspectives: first, for further improvements of port operations and secondly, this data can provide an appropriate basis for planning future port development (UNCTAD, 1976). Therefore, port performance indicators should be simple measures that are easy to understand and follow up. The indicators can be used for both historical and competitive benchmarks, as well as for investment decisions and port tariff considerations.

The topic of port competition and performance has been the most popular among the scholars researching port issues since the late 1970s (Woo, Bang, Martin and Li, 2013). In 1976, the UNCTAD developed and published a list of port performance indicators. The port performance indicators are divided in two categories, namely financial, which reflect aggregate impacts of port activities on economic results, for example, tonnage worked, labor expenditure, various types of revenues per ton of cargo etc.; and operational, which evaluate ports' operational results, or input/output ratio, or productivity and effectiveness measures (UNCTAD, 1976).

Among the operational indicators there are such measures as arrival time, waiting time, service time, turnaround time, tonnage per ship, fraction of time berthed ships worked, number of gangs employed per ship per shift, tons per ship-hour in ports, tons per ship hour at berth, tons per gang hours, fraction of time gangs idle. It is clear that the majority of all operational port performance indicators reflect time efficiency. From that time this list is recognized as a reference point for researchers.

Because of the rapid growth of the world trade since the middle of 1980s and the increasing integration of national economies across the globe, alongside with the deepening of the international labor division, monitoring a port's performance has become a more difficult and challenging task than it used to be before (Park and De, 2004). Port efficiency does not boil down only to labor productivity, time efficiency, financial results or return on investments. Port efficiency entails many outcomes, including those mentioned above. Besides that, new economic and institutional order introduces new performance expectations in such fields as sustainable development, for example. Therefore, sets of performance indicators have been changing over time being added or replaced by new, more up-to-date ones.

Whereas the set of indicators suggested by the UNCTAD represents the traditional port performance indicators that underlie productivity and effectiveness measures since recently KPIs that can reflect the current status and associated needs of ports, such as additional logistics services, have been developed as well (Tsamboulas, et al., 2011). New indicators suggest that the measurement of ports' efficiency must not be limited by quantitative indicators but also can include qualitative measurements (Antão, Soares and Gerretsen, 2005). Owino, Wang and Pasukeviciute (2006) offer about thirty different performance indicators. Marlow and Paixao (2003b) emphasize the importance of measuring port effectiveness using indicators that can reflect increased visibility within the port and the entire maritime transport chain environment.

Besides various sets of indicators aimed at inter-port performance measurement there are holistic approaches and statistical models of measuring container ports' production efficiency. These models and approaches employ Data Envelopment Analysis (DEA) (Tongzon, 2001; Cullinane, Wang, Song and Ji, 2006; Azevedo, Ferreira, Dias and Palma, 2009). The DEA technique is a useful measurement of port efficiency because it can handle more than one output and does not require prior determination of relations between output and inputs, as it is typical in conventional estimations of efficiency. In the DEA, more than one output can depend on the particular features of the port's operations that are to be evaluated. This technique reflects complexity of the port activities and the necessity of taking into account various input factors whilst measuring a given output.

Examples of the output measures can be cargo throughput and ship working rate. Port inputs can be land, labor and capital (Lee, Kuo and Chou, 2005). Cargo throughput is the total number of loaded and unloaded containers in twenty-foot equivalent units (TEUs). Ship working rate refers to the number of containers moved per working hour per ship. In other words, the ship working rate is the speed with which ships are served. This particular output is closely connected with the total ship turnaround time. Therefore the speed of moving cargoes at berth has significant implications for the port users.

Trujillo and Nombela (1999) argued that all performance indicators can be divided into three categories: physical indicators, factor productivity indicators, and economic and financial indicators. Physical indicators focus on shipping side of port operations and, thus, refer to time measures, which entail such measurements as ship turnaround time, waiting time, berth occupancy rate, and working time at berth (Trujillo and Nombela, 1999). Coordination with land modes of transport can be measured as well. For instance, such measurements as cargo dwell time or the time between unloading cargos and leaving the port can be deployed. Factor productivity indicators generally focus on the maritime side of port operations and measure such input and output relations as labor and capital required to load or unload goods from a ship. As for economic and financial indicators, they mostly refer to the sea access. They can be operating surplus or total income and expenditure related to gross registered tons (GRT) or net registered tons (NRT), or charge per TEU.

Physical indicators are, however, can be considered as one of the most important measures that are applied to evaluating port performance because they reflect the time and processes affecting ships (Holloway, 2010). Therefore, among the most significant indicators to be measured are:

- Ship turnaround time ;
- The average ship waiting time;
- Cargo dwell time;
- Productivity per crane-hour;
- Tons per ship per day.

These indicators do not take into account the regulatory processes within the port and rather reflect a particular aspect of the supply chain, namely port efficiency and container movement. For the purposes of the present study it is physical indicators that we are interested the most.

Ports provide various services for vessels, cargo and inland transport. Therefore, it is possible that a port may be efficient in working with vessel operators but inefficient in working with inland transport operators. That is why port performance can never be boiled down to a single value or measure. However, it is worth noting that such indicator of port performance as throughput volume (per day, for instance) can be considered as the most important and widely accepted measurement of port or terminal output. The majority of studies outline this indicator as the output variable and the primary basis for benchmarking.

Cargo size or throughput volume is determined by several factors, among which there are the following: port location, frequency of ship calls, port charges, economic activity, and terminal efficiency (Tongzon, 1994). According to Tongzon (1994), terminal efficiency is determined by the following factors: container mix, work practices, crane efficiency, and vessel size and cargo exchange. In particular, we are interested in physical port performance indicators as they most directly reflect the input of time factor (Trujillo and Nombela, 1999). Indeed, time factor plays is an important factor in a port's efficiency and can be represented by such parameters as average delays in commencing stevedoring, average delays during stevedoring, and average crane hours per working hour. Thus, referring to ports as operating systems that provide services, managers, foremost, should control time-related KPIs due to their importance in monitoring the whole value chain in ports.

To sum it up, ports cover a wide range of activities such as receiving cargoes, accommodating vessels and linking them the various service providers. Therefore, ports are considered as critical nodes in a globalized and rapidly developing modern supply chain. The requirements of the modern logistics are high frequencies, low transit times and high schedule reliability at the lowest possible cost. Increase of port productivity will result in a reduction of the time that ships have to spend in ports, which, in turn, will stimulate further growth of transshipment.

Among the other factors influencing ports' performance time plays the greatest role being the cause of many constrains for shipping, such as congestion, for example. Therefore, time as a key factor is reflected in many indicators and port performance measurement. However, some of them become the key indicators for management and benchmarking purposes. The following part discusses the place and importance of time-related key indicators in port performance measurement.

TIME-RELATED KPIs IN PORT PERFORMANCE

It is usually the company who decides what and how many performance indicators to use depending on existing challenges faced by it. Proper selection and maintenance of KPIs is a necessary step towards efficient operational and strategic performance of a port. As for time-related KPIs in particular, control over these performances can let a port improve utilization of resources by highlighting problem areas in order to make work less time consuming and more efficient and, hence, can enable to reduce unit cost and perform in overall better than competitors, which is extremely important in the complex and competitive environment of today.

Assessing port performance takes place at all levels. Therefore, for every target KPI decomposition of the target must be done, meaning that everybody starting from the lowest level of operations work on the particular goal; and problems in one area will inevitably result in problems in the other sector of operations. For example, performance of human resources will have an impact on business processes, which, in turn, will influence a choice of customers and will change financial results in the end. However, at the level of the business or even corporate strategic management only several most important and complex KPIs are selected.

Among the key time-related KPIs for ports there are total time, waiting time, maneuvering time, berthing time, productive time and idle time. Schematically the matrix of operating process and time-related KPIs can be shown in the table 2.

Table 2

Time-related KPIs for ports

	Arrival at port	*Start maneuvering*	*Arrival at berth*	*Operations start*	*Leave the berth*	*End maneuvering*	*Leave port*
Total time							
Waiting time							

	Arrival at port	*Start maneuvering*	*Arrival at berth*	*Operations start*	*Leave the berth*	*End maneuvering*	*Leave port*
Maneuvering time							
Berthing time							
Productive time							
Idle time							

Port operations excluded from the particular type of time

Port operations included to the particular type of time

Source: Cariou, 2012.

In the table 2 there are types of time in the columns and types of port activities in the rows. With dark cells factual duration of a particular type of time is defined; light cells mean that the chosen type time does not refer to the chosen type of activity. For example, idle time is the time after arrival at berth until the beginning of operations at the port (a dark cell in the table) and after operations at the port till the departure from the berth (a dark cell in the table); operations are excluded (a light cell in the table).

Using the table 3 it is easy to determine different types of time periods depending on the place of the operation in the port operational process. Thus, for instance, idle time covers the periods between arrival at the berth and the start of operations and between leaving the berth and end of maneuvering. Productive time is operations themselves (e.g. loading and unloading freights). Berthing time is the time that includes both idle and productive times. Time of maneuvering entails time from the beginning of maneuvering till the start of operations and from the end of operations till the end of maneuvering. Waiting time measures the time between arrival at the port and arrival at berth and between leaving the berth and leaving the port.

Chen-Hsiu and Kuang-Che (2004) suggest that port system efficiency can be measured by the average time ship spends in a queue. Thus, both shippers and port users are interested in reducing the waiting time in the queue. The total time, or turnaround time, covers all time from the moment when a ship arrives at port till the moment it leaves the port. Turnaround time is one of the determinants of port competitiveness as quick turnaround time results in reduction of port congestion and larger port throughputs.

The port authority normally gathers statistics, which provides average turnaround times as well as the average turnaround time per ship on a monthly and yearly basis. Ship turnaround time of stay of a vessel is influenced by several factors, such as the volume of cargo and its composition, and available facilities (Chung, 1993). Thus, turnaround time itself sometimes does not tell much about operational activity and performance of the port. Therefore, breaking the basic ship turnaround time down for various types of cargo and destinations can be necessary.

Besides that, splitting total time into time at berth and time off the berth and within each seems also quite reasonable because such record for each service activity and the amount of delay (idle time) can help in indicating the reasons for the delay. For instance, the ratio between the waiting time for berth and the time spent at berth, or the waiting rate, represents an important indicator of congestion status. In addition, the duration of delay time, which equals to total berth time combined with time waiting to berth minus the time between the start and end of ship working, shows how well working time is being used. These delays can occur because of labor disputes, equipment breakdown, port congestion, some ship problems or bad weather etc. One can find reasons for delays by following up indicators of a particular sector of activity of performance.

The major target in any supply chain is the customer satisfaction. From the point of view of the exporter/importer, a port’s performance can be measured using such indicators as the dwell time of cargo in a port, which is measured as the time (in days) that a ton of cargo stays in the port. Thus, a high dwell time is an indication that the port’s efficiency is not high. However, since this time measurement does not have a breakdown according to the various procedures before shipping or delivering the cargo, such as, for example, customs clearance, waiting for instructions, waiting for a ship or other mode of transport, it is difficult to identify areas where improvements can be made for increasing dwell time (Chung, 1993).

Pitilakis (2011) has offered the database of port performance indicators, suggested at some point of time by different scholars. The final table contains 168 indicators, covering such fields of performance as inventory functions, engineering processes, operational activities and reliability; economic and financial results, demand, and safety and security. The author of the present study has selected 28 time-related indicators from the whole list of measures. The table 3 gives the summary of the selected time-related port performance indicators.

Table 3

Time-related port performance indicators

	Indicator	*Type*	*Description*	*Reference*
1	Service time of ship (average total time; service time)	Port quality indicator; operational indicator; productivity indicator (element measure – berth); ship processing measure.	- Average time needed to transfer different types of cargo from ship mooring to the departure of hinterland transport of the port production chain. Can be estimated for each one of the following categories: dry bulk, liquid bulk, break bulk, and container. - Vessel service time (hours); - Average service time per vessel at each berth.	UNCTAD (1976); Le-Griffin and Murphy (2006); Lawrence (1973); Pachakis and Kiremidjian (2004); Shabayekand Yeung (2002).
2	Fraction of time berthed ships worked	Operational indicators		UNCTAD (1976)
3	Berth time (average vessel time at berth)	Operational indicators	- = {(lifts per ship) + (number of crane assigned) + (Q/C productivity)} + (berthing and un-berthing time); - Total hours alongside berths divided by the total number of vessels berthed.	Nam, Kwak and Yu (2002); Chung (1993); Tahar and Hussain (2000).
4	Ship working rate	Efficiency parameter		Tongzon (2001)
5	Arriving late	Operational indicators		UNCTAD (1976)
6	Time spent in the queue			Tahar and Hussain (2000)

	Indicator	*Type*	*Description*	*Reference*
7	Overall average service times of the operators	Operational indicators	- Overall average service times of the operators within the study period; - Number of vessels going to each operator in each month; - Average service time of each operator (hour).	Shabayek and Yeung (2002)
8	Pre-berthing detention	Efficiency parameter; "Port discharge process" performance indicators.	- The time during which a ship waits before getting entry into a berth. Can be estimated for each one of the following categories: dry bulk, liquid bulk, break bulk, container. - Ship's waiting time to be berthed; - Waiting time before berthing.	Peter and Paixão Casaca (2003); Tahar and Hussain (2000).
9	Overall transit time	"Port discharge process" performance indicator		Peter and Paixão Casaca (2003); McLean and Biles (2008)
10	Tow waiting time	Operational indicators		Bush et al. (2003)
11	Average waiting rate		Total hours of vessels waiting to berth divided by total hours alongside berths	
12	On time deliveries			
13	Time ships spend empty and/or unloaded			
14	Time ships spend loaded and waiting			

	Indicator	*Type*	*Description*	*Reference*
15	Average waiting (idle) time (waiting time of ship (day) or idle time at berth (percentage))	Operational indicator; efficiency parameter; cargo transfer product indicator; ship processing measure; "port discharge process" performance indicators.	- The time when a vessel remains idle at berth expressed as a percentage of the total time of the vessel at berth. Lower idle time would mean early completion of cargo handling and readiness for more vessels. Can be estimated for each one of the following categories: dry bulk, liquid bulk, break bulk, container. - Ship's waiting time to start discharging operations; - Boat waiting time (idle time).	UNCTAD (1976); De Langen, Nijdam and Horst (2007); Lawrence (1973); Peter and Paixão Casaca (2003); Nam et al. (2002); Pachakis and Kiremidjian (2004).
16	Average waiting (idle) time for berth	Operational indicators	Total hours of vessels waiting for berth divided by total number of vessels berthed	Chung (1993)
17	Average waiting (idle) time due to rain		Total hours of work stoppage due to rain divided by the total number of vessels worked	
18	Average waiting (idle) time other causes		Total hours of stoppage attributed to the cause divided by the total number of vessels worked	
19	Dwell time		Total number of cargo tons multiplied by days in port divided by total tonnage of cargo handled	
20	Average vessel time outside		Total hours in port - total hours berth alongside divided by total number of vessel calls	

	Indicator	*Type*	*Description*	*Reference*
21	Time waiting for cargo to be transferred from one mode to another	"Port discharge process" performance indicators	Time in storage and time from quay to storage	Peter and Paixão Casaca (2003) Peter and Paixão Casaca (2003)
22	Time for goods to be cleared			
23	Ship's time spent in route deviations			
24	Time spent carrying out ship repairs due to engine breakdowns			
25	Total time delays			
26	Time spent in transferring cargo from storage to net mode of transport		- Time spent in transferring cargo from storage to net mode of transport (including loading time); - Storage time at ports.	
27	Awaiting departure of next mode of transport		Time spent by cargo awaiting departure of next mode of transport (road or rail)	
28	Time spent in carrying out logistics activities required by customers that add value			

Source: Adapted from Pitilakis, 2011.

Among all port performance indicators, ship turnaround time is identified by Chung (1993) as one of the major measures of vessel performance. Ship turnaround time indicates the duration of such ship's procedures as entering, unloading, loading and departing from a port. Thus, the indicator reflects the collective performance of a port vessel. However, since for this generalized performance indicator ports use different sets of parameters, comparison of the ports is very often difficult. Nam et al. (2002) outlines the average port time, average berth time, average berth occupancy ratio, and average waiting time among the primary performance indicators. Peter and Paixão Casaca (2003) highlight possibility of determining port performance holistically with the help of such indicator as the overall time that cargo spends in port.

Thus, time indicators of port performance measurement include turnaround time, waiting for berth time, cargo dwell time, queuing times at port gates, document processing and customs clearance time, working time at berth and many other time-related performance indicators. In general, time-related KPIs show how efficiently ports serve the customers. According to the World Bank, the vessel turnaround time is the major measure of vessel performance (Chung 1993). Indeed, turnaround time, or the time between ship arrival and departure, for many years has been described as one of the major indicators measuring time efficiency of ports, although it is not reported by ports regularly (De Langen, Nijdam, Horst, 2007).

To sum it up, port throughput, being the major port performance measure, is significantly influenced by time-related indicators that represent the core measures of terminal and vessel efficiency. Hence, for the purposes of analysis of port performance the following supplementary time-related indicators can be used: ship turnaround time, average berth time, average vessel time outside, average berth occupancy ratio, average waiting time and many other indicators, which can be found in the table above (table 3). The study question is what measures are used by ports in practice as KPIs. The following chapters will discuss this question in more details.

CHAPTER 3: METHODOLOGY

RESEARCH STRATEGY AND METHOD

The primary objective of this thesis is to investigate the existing theoretical frameworks regarding as applied by ports' performance measurement and to find out the differences between theoretical approaches and practical use of time-related KPIs in ports. In order to answer the research question the qualitative research method is applied, which helps in getting a holistic view of the topic and due to the small sample quantitative methods are not applicable.

In the present study the case study method is used. According to Yin (1984), there are three categories of case studies: exploratory, descriptive and explanatory. Exploratory case studies are for exploring a phenomenon in the data of the researcher's interest; thus this type of case studies can be considered as a prelude to the future research. Descriptive case studies aim at describing the natural phenomenon occurring within the given data. These cases are based on a descriptive theory, which is developed before the particular research. Explanatory case studies are for examining the data so the particular phenomenon in the data is explained.

For the purposes of the present study the exploratory-descriptive case study is used, which attempts to find examples of time-related KPIs in the Port of Melbourne and to find the evidence of alignment between the practical and theoretical sets of time-related KPIs. In other words, combination of descriptive and exploratory strategies can help raise new questions opening up the door for further examination of the observed phenomenon.

To answer the research question the following sources of secondary data are deployed: annual financial and other types of corporate reports; reports and other types of documents developed by the relevant official bodies and organizations; and formal and informal publications about the research topic. Besides that, articles from the various maritime economics journals and books, as well as working papers of the United Nations (the UN), the UNCAD and other relevant international organizations. All these sources help get in-depth understanding of the phenomenon under the study and provide an answer to the research question.

THE STRUCTURE OF THE CASE STUDY

As the case study the Port of Melbourne is used. In the first part of the case study a general description of the port is given, namely the form of ownership, the management bodies and their major responsibilities, and the overall impact of the port's economic activity on the regional and state economies. This part gives the general understanding about the management system in the port. Besides that, it in general estimates the port's current state and its important position in the local and state economies. Thus, this part of the case study highlights the importance of the port's efficient performance not only for the port itself but for the region in general.

The second part of the case study introduces the approach to performance measurement currently employed by the port. It describes the basic KPIs introduced by the company and explains justification of their choice. This part is important for general understanding the overall system of performance measurement in the port and the reasons (i.e. the strategic goals of PoMC) of the choice of particular KPIs. Besides that the major KPIs, required by the Commission to be reported by PoMC, are presented in this part. This information helps better understand the set of all KPIs measured and reported by the port to different users of information, that is external users of the annual reports, such as, for instance, customers, competitors, suppliers and the Commission itself. All in all, this part helps in defining the place of time-related KPIs in the overall set of KPIs.

The third part focuses on time-related KPIs and gives the description and methodologies of this category of KPIs' calculation. This part of the case study narrow down the description to the particular set of time-related KPIs in order to understand specifics of the chosen indicators and their role in the port's performance measurement. Time-related KPIs are presented in two groups: one group, which is set by PoMC, and another one, which is developed by the Commission. The case study ends with the conclusion concerning the overall description of the deployed time-related KPIs and their disclosure.

CHAPTER 4: PRESENTATION OF THE CASE STUDY AND RESEARCH FINDINGS

REVIEW OF THE PORT OF MELBOURNE

The Port of Melbourne is the busiest port in Australia. It is located in Melbourne, Victoria. The port has been operating for over 170 years and it was already a busy port early in the history of Melbourne. Since July of 2003 the Port of Melbourne has been managed by the corporation created by the State of Victoria. The Port of Melbourne Corporation (PoMC) owns around 510 hectares land with 34 commercial berths at five docks and river wharves (Allen Consulting Group, 2010).

The Port of Melbourne is the most visited Australian port, accounting for around 80 percent of all ships visiting Australia, being among the largest container port with the 50th in size throughput in the world (American Association of Port Authorities, 2005). In the Australian context, he Port of Melbourne is the largest container and general cargo port. The Port of Melbourne serves about 38 percent of the total Australian container trade, accounting for more than 3 400 commercial ship calls annually. In absolute numbers the volume of annual international and coastal trade is around $75 billion. According to estimations, the contribution to the Victorian economy is more than $2.5 billion per year (Allen Consulting Group, 2010).

Thus, the Port of Melbourne is the key international port for imports and exports in Australia. PoMC is a state-owned company, whose primary object is to manage and develop the port in consistency with the vision and strategic objectives of the Transport Integration Act (2010). In other words, PoMC is the strategic manager of the Port of Melbourne. All the land within the port boundaries belong to PoMC; and it is responsible for the development of both the water and land sides of the port. PoMC has also functions of the Vessel Traffic Service Authority, which means that it governs all vessel movements through the port. Besides that, PoMC collaborates with relevant responsible state bodies and aims at effective integration of the port with the various systems of infrastructure in the Victoria (Essential Services Commission, 2011).

PoMC is also expected to facilitate the sustainable growth of trade and the integration of port infrastructure with the other relevant systems outside. PoMC also aims to ensure the availability and cost efficiency of the port services; to establish and effectively manage port channels; to promote operational development of the port and to provide necessary for it land, waters and infrastructure. Also, PoMC's responsibilities include managing or controlling the management of the port; provision of services for the operation of the port; maintaining navigation aids in the port waters; and general direction and controlling the movement of vessels in the port (Transport Integration Act, 2010).

Another important state body, which takes active participation in the Port of Melbourne's economic regulation, is the Essential Services Commission (the Commission). It is the regulator of ports in Victoria. The Commission does not intervene into the price forming but plays an important monitoring role. Currently, PoMC is the only subject to the price monitoring regime regulated by the Price Monitoring Determination of 2010. If there are any complaints raised by the Minister for Ports the Commission also has the right to investigate. In 2011 the Commission issued the Information Notice to PoMC, which outlines the detailed reporting requirements for PoMC.

Thus, the Information Notice contains all required performance indicators that must be monitored and reported by the port on an annual basis until the end of June, 2015 (Essential Services Commission, 2011). The details of the Information Notice and annual reports of the Port of Melbourne, particularly in their part where performance indicators are described, are presented and analyzed in the following parts of the study.

THE PORT OF MELBOURNE'S PERFORMANCE MEASUREMENT

The Port of Melbourne is one of those ports, which have long-term strategic visions. As it was stated earlier, it is the leading port among Australian ones. It is at the top place in terms of TEUs, total number trucks, time spent from the entry gate to exit gate (the minimum figure) (Lubulwa and Wang, 2011). In the world ranking, which is based on the port performance index, the Port of Melbourne occupies the 36th place out of 138 measured ports (Cheon, 2007). Thus, the Port of Melbourne is among the most efficient ports in the world. However, it faces a number of port-specific challenges and threats, which are to be met for further development.

The port is expected to be at its full capacity in 2015 (Dowling, 2011). In the long-term perspective, freight volumes at the Port of Melbourne are expected to quadruple by 2035. Growing freight volumes in Victoria are going through the Port of Melbourne. However, its existing infrastructure is insufficient to accommodate the predicted growth. Besides that, an increase in the port's capacity requires better integration with local road and rail infrastructure.

Moreover, freight terminal facilities must be able to process frights quickly and efficiently with minimal negative social and environmental impact.

There are strategic challenges and opportunities for PoMC, which can influence the port's strategic plans and capacity delivery prognoses for the next several years. These challenges and opportunities are as follows (Port of Melbourne Corporation annual report 2012-2013, 2013):

- *Broader economic and climatic conditions*. This challenge is associated with growing imports to Australia defined by growing population and prosperity, and growing exports from the country supported by climatic conditions and the strength of the local currency. Therefore, the international conjuncture is of primary importance for the port's management.
- *Port and city growing and planning together*. Since the port is closely integrated into the city of Melbourne, aligned planning is important and understanding of all benefits and challenges associated with this proximity is necessary. It means that the port's plans regarding operational and economic requirement of the port and the wider maritime supply chain must take into consideration, for instance, urban realm and public and private transport requirements of the city.
- *Container shipping industry economics and dynamics.* Currently, the global shipping industry is in the period of change. The tendency in the industry shows that there is increasing number of alliances in the shipping services together with reduction in direct port calls.
- *Port and freight supply chain productivity.* Due to the importance of the port to the State's import and export flows and Victoria's economy in particular the productivity of the port and the whole supply chain is extremely important. Therefore, focusing on the supply chain's members is needed in order to improve the outcome.
- *Port and freight supply chain competition*. There are many changes in the different ports, individual terminals and the various logistics players, which are to be monitored. Among such changes there are appearance of new competitors, shifts in ownership and changes of owners, and development of supply chain vertical integration.

- *Port financial stability*. For the purposes of effective long-term performance in terms of producing trade and economic outcomes, there is need in sufficient investments in port infrastructure and facilities. Therefore, PoMC must be able to sustain significant incomes and profits for further capacity and productivity improvements.

In order to meet all the above challenges and opportunities PoMC has developed goals for the port, among which there are as follows:

- Goal 1 – Delivering world class port facilities and services;
- Goal 2 – Driving integrated freight transport outcomes;
- Goal 3 – Enhancing Australian and international trading activities;
- Goal 4 – Ensuring sustainable business performance;
- Goal 5 – Nurturing a shared port-city vision;
- Goal 6 – Developing talented and committed people (Port of Melbourne Corporation annual report 2012-2013, 2013).

All the goals are aligned to the relevant projects and therefore to the relevant performance indicators. The Port of Melbourne has developed an integrated set of KPIs and metrics, which aim at the assessment of operational efficiency of both the port and corporation. The set of indicator and metrics was developed by taking into consideration the Essential Services Commission's recommendations.

In its Information notice for PoMC, the Commission focuses on three broad categories for KPIs' planning until the year of 2015:

- Prices and revenues;
- Service quality (channel services, berth services, landslide interface, trade facilitation), and
- Financial performance.

For each of these categories, the Commission has identified relevant KPIs, which are obligatory for PoMC to report (see table 4).

Table 4

KPIs for the Port of Melbourne (developed by the Commission)

Category	*KPI*
Prices and revenue	Schedule of tariffs Weighted average change in reference prices Percentage of revenue by type (ship based, time of use, cargo based) Revenue per unit Cost per unit Margin per unit
Service quality	Percentage of container vessels arriving at the berth outside advised arrival time Percentage of vessels delayed (berth not available) Berth utilization, percent Percentage of vessels visiting the port that are draught constrained Moves per berth hour Truck turnaround time A number of shipping lines visiting the port Throughput of containerized and non-containerized cargo Percentage of users reporting satisfaction in customer surveys Number of complaints made to the Commission
Financial performance	Earnings Before Interest and Taxes (EBIT) Actual and target rate of return Return on capital

Source: Essential Services Commission, 2011, p. 5.

Thus, the KPIs, presented in the table, must be publicly reported by PoMC. However, some of the KPIs may be considered by PoMC as a confidential data and with the permission of the Commission they might represent a commercial secret. All the published indicators together with the information presented in the annual reports can be used to benchmark PoMC's performance against the port's past achievements and other major Australian ports.

It is important to note that there have been introduced some new and adjusted KPIs, a measuring the level of service and efficiency of port operations received by port users. These indicators are moves per berth hour, percentage of container vessels arriving at the berth outside advised arrival time, percentage of container vessels arriving at the berth outside advised arrival time, percentage vessels delayed, and revenue per unit, cost per unit and margin per unit KPIs. The Commission requires the port to provide it with the reports more often than annually. It will be only beneficial for port users. The quarterly reporting is preferred. The KPIs for the Port of Melbourne for years 2013-2016 are presented in the table 5 together with their alignment to the port's corporate goals.

Table 5

KPIs for the Port of Melbourne (developed by PoMC)

KPI (to be measured and managed by PoMC)	*Unit of measurement/calculation*
Goal 1 – Delivering world class port facilities and services	
Container ships delayed (berth not available) – on window	Percentage of total container ships
Container ships delayed (berth not available) – off window	Percentage of total container ships
Berth occupancy (Swanson Dock East and Swanson Dock West)	Percentage of time alongside berth
Navigational aids available (vital)	Percentage of time in operation
Goal 4 – Ensuring sustainable business performance	
Return on capital employed	Adjusted operating profit after tax/ Average total capital employed
Interest cover ratio	Free funds from operations + Interest expense)/Interest expense
Expenses vs. revenue	Operating expenditure/Operating revenue
Gearing ratio	Total adjusted borrowings/Total equity
Leverage ratio	Total adjusted borrowings/(Free funds from operations + Interest expense + Capitalized lease rental)
Capital expenditure vs. budget	Actual capital expenditure/Budgeted capital expenditure
PoMC charges vs. Sydney	Percentage ratio of $ TEU (international containers)
Security regulations	Number of breaches
Safety regulations	Number of breaches

KPI (to be measured and managed by PoMC)	*Unit of measurement/calculation*
Environmental regulation (number of PoMC's breaches)	Number of breaches
Goal 5 – Nurturing a shared port-city vision	
Customer (commercial) satisfaction rating index	Satisfaction index rating (biennial survey)
Goal 6 – Developing talented and committed people	
Staff turnover	Percentage of new starts against departures (full-time equivalent)
Satisfaction level of staff members	Percentage of staff satisfied (biennial survey)

Source: Port of Melbourne Corporation annual report 2012-2013, 2013

Besides the above mentioned KPIs, which are subject to measurement and management of ports, there are performance metrics, which are to be monitored by PoMC. Thus, for achievement of the goal 1, or delivering world class port facilities and services, the following performance metrics are monitored:

- Container crane rate, measured as a percentage of five mainland ports' average;
- Berth utilization, or TEU per berth meter;
- Increase in number of vessels which operated at draught > or =11. 6 meters, measured as a percentage increase from the previous year;
- Reportable incidents in the port, defined as a number of incidents.

For monitoring improvements towards the goal 2 - driving integrated freight transport outcomes – the following performance metrics are applied:

- Port throughput carried via rail, measured as a percentage of total mass tones;
- Truck utilization, or TEU/truck movement into or out of port;
- Port interface costs vs. Sydney – imports, measured as a percentage ratio of $ per TEU;
- Port interface costs vs. Sydney – exports, measured as a percentage ratio of $ per TEU.

Performance metrics for the goal 3, or enhancing Australian and international trading activities, are as follows:

- Cruise ship arrivals per season, measured as a number of vessels;

- Trade volume growth (revenue tones), evaluated as a percentage growth in revenue tones.

Thus, the list of recommended by the Commission KPIs is extended with the specific indicators, relevant for the next three years (Essential Services Commission, 2011). Among these additional KPIs, there are safety, security and environmental regulation KPIs; staff turnover and satisfaction level of staff members – two KPIs, which are of greater importance rather for the port itself than for the Commission. Financial and economic indicators are added with additional interest cover ratio, gearing ratio and leverage ratio. As far as service quality KPIs are concerned, most of these indicators are reported by the port to the Commission but are not reflected in the annual reports. Thus, the report information reveals only container ships delayed, berth occupancy and navigational aids available.

At the same time, reports to the Commission cover some additional measures. In the category of the service quality there are such important additional KPIs as percentage of vessels visiting the port that are draught constrained, moves per berth hour, truck turnaround time, a number of shipping lines visiting the port, throughput of containerized and non-containerized cargo, percentage of users reporting satisfaction in customer surveys, number of complaints made to the Commission. In the category of prices and revenues, there is additional information concerning revenue, cost and margin per unit, changes in prices and schedule of tariffs. As far as the category of financial performance is concerned, the port reports to the Commission information about EBIT and actual and factual rates of returns.

To sum it up, the performance indicators used by the port are structured into several categories, differing based on the user of information. Thus, for the external users of the port's annual reports, KPIs are enclosed in six groups depending on the particular strategic goal of the company. These goals basically cover such categories as customer service (goal 1 - delivering world class port facilities and services; supply chain development (goal 2 – driving integrated freight transport outcomes); economic development of the region (goal 3 – enhancing Australian and international trading activities); sustainable development (goal 4 – ensuring sustainable business performance); regional infrastructure development (goal 5 – nurturing a shared port-city vision); and human resources development (goal 6 – developing talented and committed people).

However, for the use of the Commission the KPIs, reported by the port, are structured into three groups, namely prices and revenues, service quality and financial performance. For the purposes of the present study the category of the service quality and the group of customer service (goal 2 – driving integrated freight transport outcomes) is of the major interest. The category or the group of service quality and customer service includes quality and efficiency measuring indicators, among which there time-related KPIs. This group of indicators is analyzed below.

TIME-RELATED KPIs IN THE PORT OF MELBOURNE'S PERFORMANCE MEASUREMENT

One of the major functions of the Commission is monitoring of service quality in the port. It enables the Commission to ensure that the prices for the port's services are reasonable and fair. Moreover, monitoring of service quality enhances PoMC to maintain and improve customer service; to make performance transparent; and to provide feedbacks to the port. In order to understand the quality and reliability of provided services the Commission has developed the number of indicators for measuring the service quality of the port, among which there are time-related KPIs.

Time-related KPIs developed by the Commission are as follows: percentage of vessels delayed (berth not available; on window and off window), percentage of container vessels arriving at the berth outside advised arrival time (advised at 24 hours prior to actual arrival, and inside 24 hours prior to actual arrival), moves per berth hour. Besides the KPIs related to the time series trends' measurement for the maritime transport industry users of the port, there is one KPI indicating the service quality for the road transport industry users as well. It is truck turnaround time.

The description, methodologies of KPIs' calculation and required data for calculation are presented in the table 6.

Table 6

Time-related KPIs in the Port of Melbourne's performance measurement

KPI	*Description*	*Methodology*	*Information requirements*
Percentage of vessels delayed (berth not available; on	Measures the percentage of vessels that are delayed due to a berth being	To be calculated separately for vessels that are "on window" (scheduled arrival of vessel) and "off window" (unscheduled	Reported KPIs for: • container vessels (on window, off window); • motor vehicles (on

window, and off window)	unavailable.	arrival of vessel), and also separately for containers and motor vehicles. • containers KPIs = the number of container vessels that are delayed (berth not available) as a percentage of total container vessels; • motor vehicles KPIs = the number of motor vehicle vessels that are delayed (berth not available) as a percentage of total motor vehicle vessels.	window, off window). Required data for each of container and motor vehicle vessels (on window, off window): • number of vessels delayed (berth not available); • total number of vessels.
Percentage of container vessels arriving at the berth outside advised arrival time (advised at 24 hours prior to actual arrival,	Measures the percentage of container vessels that arrive at the port outside of the advised arrival time.	• KPI (at 24 hours) = the number of vessels that are outside the most recently advised arrival time at 24 hours prior to actual arrival, as a percentage of total vessels; • KPI (within 24 hours) = the	Reported KPIs for container vessels for: • advised arrival time at 24 hours; • advised arrival time within 24 hours prior to actual arrival. Required data for
Moves per berth hour	It indicates the speed at which ships are serviced at the port.	Calculated for container operations: • KPI = net crane rate (moves per hour) x crane intensity (average number of cranes deployed to the vessel while alongside). Time series to be reported to compare service levels over time.	Reported KPI for containers only. Required data for containers: • net crane rate (moves per hour); • crane intensity (average number of cranes deployed to the vessel while alongside).

Source: Essential Services Commission, 2011.

Thus, percentage of vessels delayed (berth not available) both for on and off window is an indicator reflecting sufficiency of the port's investment in infrastructure and facilities. Percentage of container vessels arriving at the berth outside advised arrival time is a measurement of the quality of the port's customer service. For instance, in case the port does not have sufficient infrastructure and facilities, arriving at the port vessels will have to wait before being berthed. Although some delays of vessels may have reasons different from the inefficient work of the port, monitoring the time series trend is a significant step in understanding changes in service standards. Moves per berth hour are also an indicator of the port productivity and the service quality. It measures the speed of serving ships at the port.

All the above KPIs are reported by PoMC to the Commission on a regular basis. As far as PoMC's annual reports are concerned, the set of time-related KPIs partly differs from the above indicators. Thus, time-related KPIs reported in the port's annual report are as follows: container ships delayed (berth not available; on and off window), which is measured as a percentage of delayed ships of the total container ships; berth occupancy, which is the percentage of time alongside berth; and navigational aids available, which is the percentage of time in operation. Time-related KPI's reported in the annual report aim at achieving PoMC's goal of delivering world class port facilities and services.

Thus, the main time-related KPIs used by PoMC in the port's performance measurement are container ships delayed (berth not available; on and off window), berth occupancy, navigational aids available, percentage of container vessels arriving at the berth outside advised arrival time, and moves per berth hour. In other words, the Port of Melbourne monitors various measures that indicate service quality and therefore reflect sufficiency of the port's investment in infrastructure and facilities. In sum, all time-related KPIs are reported in order to monitor progress towards achievement of the goal of delivering world class port facilities and services.

CHAPTER 5: DISCUSSION AND DIRECTIONS FOR FURTHER RESEARCH

DISCUSSION OF THE RESEARCH RESULTS

Within the present study the inductive case study approach is applied in order to investigate the existing theoretical frameworks regarding as applied by ports' performance measurement and to find out the differences between theoretical approaches and practical use of time-related KPIs in ports. By the example of a particular port, the Port of Melbourne, the following results concerning the alignment between the theoretical frameworks and practical application of time-related are observed:

1. KPI is something that is changing over time because they are aligned with current goals of a port. KPIs are formed based on the analysis of weaknesses and strengths of the port, as well as understanding the opportunities and threats that exist in the environment. Thus, time-related KPIs aim at overcoming the port's existing challenges and using opportunities. Therefore, the choice of KPIs is aligned with the existing challenges and opportunities and is a subject to change in case of changing inside and outside environment.
2. The level of information disclosure about target and factual measures of any kind of KPIs depends on the user of this information. Thus, in case of time-related KPIs, the Port of Melbourne in its annual reports for such users as customers, competitors and other external users reveals three basic KPIs. They are container ships delayed, measured as a percentage of total container ships; berth occupancy, measured as percentage of time alongside berth; and navigational aids available, measured as a percentage of time in operation. However, for use of the Commission, the port reports additional time-related indicators, such as percentage of container vessels arriving at the berth outside advised arrival time, moves per berth hour, and truck turnaround time, which indicates the service quality for the road transport industry users only.
3. Although the total time, or ship turnaround time, in theory is granted the important role, in practice (by the example of the Port of Melbourne) this

indicator is not measured as a KPI. As for the particular case study, all time-related KPIs deployed by PoMC indicate percentage of delays because of the external and internal reasons (berth unavailability), in particular, time spent by ships in berth and in operation. Besides it, there is a KPI indicating the port's productivity in terms of the speed at which ships are served.

4. In practice, time-related KPIs are part of operational service quality KPIs together with such indicators as berth utilization, throughput, level of customers' satisfaction and number of complaints, number of shipping liners visiting the port and percentage of container vessels visiting the port that are draught constrained. Referring to the table 3 by Cariou (2012) we can conclude that in case of the Port of Melbourne measurements of waiting time, berthing time, productive time and idle time are of the major importance.
5. All in all, from the all the possible time-related KPIs described in relevant literature, the Port of Melbourne measures and monitors most widely spread indicators, which are easier for measuring and understanding and therefore for improving by both the managerial decision makers and employees' operations. Besides that, the overall number of time-related KPIs used by the Port of Melbourne is minimal. It makes monitoring and following up on results an efficient and easy procedure.

LIMITATIONS OF THE STUDY AND DIRECTIONS FOR FURTHER RESEARCH

The research has some limitations such as lack of quantitative data and small sample represented by one case study. Therefore, one of the directions for future research is a further analysis of various case studies. Besides it, a quantitative analysis of the possible relations among the KPIs, particularly between time-related KPIs in ports, can be valuable as well. Another limitation is connected with the lack of data and disclosed reports concerning KPIs of a port performance due to belonging of the latter to management accounting, which is rather internal confidential information. However, due to state ownership of the Port of Melbourne all necessary information about KPIs is available, which is not the case for many other ports.

The fruitful direction for future research is the benchmarking of several ports in terms application of performance indicators and balancing them. Another direction for the research is the analysis of the relation between different groups of KPIs, for instance, quantitative relations between financial and service quality KPIs, or quantitative relations between various time-related indicators at different levels of a port's value chain. Besides that, historical comparative analysis can be done in order to understand changes in goal setting and choice of KPIs, accordingly.

CHAPTER 6: CONCLUSION

Based on the present research the following conclusions can be made:

1) Maritime literature offers a wide range of time-related indicators, which constitute the important part of the overall port performance measurement. The literature review shows the evolution of approaches to port performance measurement in general and to time efficiency measurement in particular. This evolution can be explained by changing port environment and conjecture and, hence, new management challenges that have been occurring. Thus, among the offered by the literature variety of time-related KPIs in practice the most useful are those which reflect the current state of the port and therefore are developed to achieve its strategic goals.
2) In practice, there is a set of time-related KPIs, aligned with performance indicators, which are given a high importance in the literature. Among such indicators there are indicators measuring delays and reflecting various reasons of these delays (e.g. the percentage of delayed ships on and off window); indicators measuring berth occupancy (e.g. berthing time); and operational productivity of the terminal or the port (e.g. the percentage of time in operation, moves per berth hour). All in all, all time-related KPIs presented in the case study aim at measuring the port's customer service standard.

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