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Port benchmark

By

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Abstract

This project, through a literature review, analyses the various performance indicators and metrics used by academics and practitioners. Research reveals that there is not a standard practice that has been agreed among ports, international institutions, and academics and expert in the field of maritime ports about what measures should be used and how to calculate them. Many authors analysed port performance indicators and port efficiency, but common conclusions have never been reached and the field remains characterised by a large consistency.

Given the lack of clear performance measurement frameworks in the port industry, this paper attempts to remedy to this gap. Bichou's (2007) work is presented; in contrast with the traditional fragmented methodologies, it conceptualises ports from a logistics and SCM standpoint. The importance of externally generated data was also stressed in this paper (Pallis & Vitsounis, 2008).

Another attempt to further improve the port performance measurement practices was designed by the author; it is an adaptation of the Prism performance framework to the seaport industry. This framework has been judged appropriate given the complex stakeholder environment that surrounds the port industry.

This paper also presents and analyses a couple of benchmarks performed in practice. The first benchmark is a very interesting initiative by Rankine (2003); it gives industry standards to help ports compare their performance. It has the specificity to be the first project in its kind. The second example is a benchmarking initiative performed by Hong Kong port that focuses on costs and productivity.

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List of abbreviations

AIVP: Association Internationale des Ports et villes (IACP: International Association for Cities and Ports)

DEA: Data Envelopment Analysis

ESPO: European Sea ports Organisation

EU: European Union

MFP: Multi-factor productivity

PFP: Partial productivity indicators

PRISM: Port PeRformance Indicators: Selection and Measurement

ROA: Return on asset

ROI: Return on investment

SCM: Supply Chain Management

SFP: Single productivity indicators

TFP: Total factor productivity

UNCTAD: United Nations Conference on Trade And Development

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Introduction

In today's economies, maritime transportation plays an important role in the national and international trade as well as in the economic growth. The total amount of goods loaded in ports worldwide in 2012 reached 9.2 billion tons (UNCTAD, 2013). The seaborne trade is estimated to more than 80% of the world trade in terms of volume (Bichou, 2009).

A port, according to Oxford Dictionaries, is "*a town or city with a harbour or access to navigable water where ships load or unload*". Alderton (2008) defines ports as "*a town with harbour and facilities for a ship/shore interface and customs facilities*". Another definition provided by Bichou (2009) is "*the interface between land and a sea or a waterway connection providing facilities and services to commercial ships and their cargo, as well as the associated multimodal distribution and logistics activities*". Seaports have different roles; they can be a place for cargoes and passengers handling, ship servicing (bunkering, repair, waste disposal, etc.), shelter in case of adverse weather conditions, the basis for a prosper industrial development and a node in the transport network (Branch, 1986).

In this fast paced environment and the ever growing economy, port efficiency becomes a major factor that allows ports to survive the stiff competition imposed by the shipping and transport industry. Port facilities are characterised by high investment and expensive equipment; under-utilisation and low productivity, apart from presenting higher cost and capital losses, can be lethal and frighten the prosperity and perennity of ports. In the same vein, as ports play a critical role in the global trade, port efficiency can contribute to international economic growth and improve nation's competitiveness (Chin & Tongzon, 1998).

Poor and inappropriate port management can impact negatively a nation's economy and more precisely its international trade. Ports need, thus, to measure and monitor their performance (Thomas & Monie, 2000). This practice is of prime interest for ports because they represent an essential chain in a country's economy.

Port performance measures and indicators are diverse; a wide range of techniques is utilised. However, even though numerous tools exist, their application to different ports remains problematic. Ports are completely different from one another and even within the same port we find diverse activities and operations. In addition, governance and port ownership disparities lead to the absence of a common agreement on what to measure and how to measure it. Another complication is the nebulousness of the concept of efficiency which is difficult to apply to ports operations.

This project aims to serve as a platform for the improvement of Ningbo-Zhoushan port in China. Ningbo ranks 7th in the world busiest ports ranking in terms of cargo tonnage with 349 million tons in 2011. It is also the world 6th busiest container port with a volume equating 16.83 million TEUs in 2012 (JOC, 2013). Ningbo-Zhoushan is therefore a major port in the international maritime landscape, and thus the importance and magnitude of this project.

This paper investigates, studies and analyses port performance measurement practices and benchmark. It tries to provide an answer to the following questions; why is port performance important to measure? What measures should be used to assess port performances? Which framework should be followed when measuring port performance? How do we benchmark ports? The answer to these questions will be provided through a literature review; it will provide a comprehensive background and a thorough understanding of how to tackle the issue of port benchmark. Consequently, and in a larger scope, it will help improve Ningbo-Zhoushan performance. This paper contributes to the literature by providing a literature review on port performance indicators and a multi-dimensional framework for port performance measurement; it is an adaptation of the Prism performance framework to the maritime port industry.

The paper is structured as follows. Section one outlines the methodology adopted for the literature review. Section two presents the importance of port performance measurement and serves as a background for the study. Section three reviews the literature on port performance measurement indicators; it assesses academic publications, professional journal, international and regional organisations as well as port practitioners themselves. Section four lays out the different available frameworks and suggests a methodology to measure performance in a port context. Finally, section five provides some examples of port benchmarks.

I. Methodology

This paper is a literature review centred on port benchmark. The choice went to a narrative (traditional) literature review instead of a systematic literature review for the main reason that port benchmark literature is not very rich, and thus focusing on a specific period of time might curb the quality of data collected and analysed. In addition, the narrative literature review allows gathering, summarising and synthesising a large volume of articles, which go in line with the objective of this paper. It is the author belief that a traditional literature review, in this topic, will return better results than a systematic one. As a result to this approach, some references date back to 1986 and many go back to the 90^{s}. The majority, however is a post 2000 literature, and is thus considered as recent recent.

The literature review was mainly based on world class scientific databases; Business Source Premier (EBSCO), (EMeJ) Emerald, ScienceDirect and Elsevier are the four cornerstones of this paper. Scientific journals that were most utilised in this paper are "*Maritime policy and management*", "*International journal of Operations & production management*" and "*Transportation research A*" as well as many others. A professional journal that was used extensively is "*The journal of commerce*". Many other reports and conferences were used issued from international organisations such The World Bank or UNCTAD or regional and national organisations.

Key words used for the literature review in this paper are various. For the port performance indicators section, key words were "*port performance measurement*", "*port performance indicators*", "*port productivity*" and "*port efficiency*". In the performance measurement framework section, research was based on the following words "*performance measurement framework*", "*Balanced score card*" and "*Prism*". "*Port benchmark*" was used as a key word for the benchmarking section. Finally, the key words for the implementation issues are "*Benchmark issues*", "*benchmark obstacles*" and "*benchmark implementation*".

II. Background

"*What gets measured gets attention*", "*What gets measured gets managed*" and "*What gets measured gets improved*" are all old management proverbs that remain valid nowadays. To get a solid understanding of the problems and issues a business faces, it is essential, first, to measure performance in order to be aware of the presence or not of problems. In order to launch improvement actions, measuring is of prime importance; first it will dictate which part of the business needs improvement and second it will allow assessing whether an improvement took place or not. Business performance measurement is a fundamental component of business management; it allows companies to assess their product/service delivery, to improve the way they operate and help them survive, thrive and compete (Franco-Santos et al., 2007).

Measuring a business performance provides a clear picture of how well a company is performing relative to the set goals and objectives or relative to the competitors. According to Bititci et al. (2002), businesses tend to measure performance in order to monitor and control, drive improvement, achieve alignment with corporate goals and targets, and reward and discipline users and customers.

In modern economies, which are generally characterised by fierce competition, businesses who want to remain effective and competitive have to develop and assess a business performance measurement system. Its results will identify outperforming business areas and dictate the improvement actions. It can also be used as the basis for the benchmark of a firm's performance relative to best practices (Pallis & Vitsounis, 2008).

Global ports, nowadays, are not spared by the above needs. They are businesses that operate in an extreme and competitive environment where performance measurement and improvement are key element to their competitiveness. Port performance measurement is a complicated and multileveled task. The absence of a holistic approach or framework highlights this complexity (Pallis & Vitsounis, 2008).

In the maritime port industry, measuring performance is a vital practice in order to ensure competitiveness and prosperity. This is even more emphasised following the recent port governance reforms. The port industry is experiencing extensive structural changes. The business environment is being altered by concepts such as containerisation, globalisation, privatisation, regionalisation of activities and concentration (Pallis & Vitsounis, 2008). The new environment is characterised by an intense and fierce competition; this is mainly resulting from an increase in shipping companies and terminal operators' concentration. Entry barriers are being lowered, thus enhancing intra-port and intra-terminal competition (De Langen & Pallis, 2007). In addition, ports, in this new environment, are elements in value-driven chain systems and compete as whole supply chains (Robinson, 2002). Moreover, ports are no longer limited to offering traditional and ordinary port services, but they provide a wide range of value-added logistics and integrated transport services (Notteboom & Rodrigue, 2005 and Frontline Solutions, 2002). Furthermore, vertical integration schemes are being launched between terminal operators and shipping companies leading to the creation of novel forms of competition and shaping more intense actors' relations and interactions.

Within this new ever changing environment, maritime ports are more than ever willing to sustain their competitiveness or even improve it. Management decisions and strategies are therefore driven and shaped by these events and conditions (Pallis & Vitsounis, 2008).

Port performance measurement is of major importance for governments and policy makers too; these have an important influence on the port industry administration. When these authorities design or implement policies and strategies, they, first, need to know how well their previous actions performed and if changes are required. Furthermore, the efficient and effective use of port infrastructure improves national competitiveness, and increases trade and subsequently the economic activity of a country. From another perspective, port performance measurement is very important because it helps service providers to develop their market position and users to have a clear idea about the available alternatives (Pallis & Vitsounis, 2008).

In this paper, by "*port*" it is meant seaport. Different words have been used, but they all mean seaport; For instance, in this work seaports were sometimes referred to as "*port*", "*maritime port*" and "*seaport*". They all have the same meaning in this paper. Another important detail to mention is that this paper focuses mainly on container terminal. Even though many of the performance indicators mentioned in this paper can be used and transposed in different types of terminals, the study is meant to address primarily container terminals.

III. Port performance indicators

During the last few decades, extensive research and progress in theoretical and practical port performance measurement have been made. Several authors have studied port performance indicators and performance measurement frameworks. However, these works remain incompatible and fragmented given that they took place at different disciplinary, operational and spatial levels. This inharmoniousness led to the absence of a consensus, a common approach and a single framework for port performance measurement (Bichou, 2007).

Khalid Bichou (2007) links these differences to the lack of a clear definition and taxonomy of performance, perceptual differences among port stakeholders (regulator, operator, customer, etc.) and their objectives, the complexity of operational (type of cargo, ships serviced, etc.) and spatial (port, terminal, quay system) dimensions' boundaries and finally the disparity between ports' operational structures, functional scopes and strategic orientations.

1. Port performance measurement taxonomy

Khalid Bichou (2007) classifies port performance measurements into three categories: Individual metrics and indices, economic impact studies and frontier approaches; the first category is the most commonly used in the maritime port industry, however the two lasts are more used by academics, and government and governing authorities.

1.a. Port economic impact studies

Port economic impact studies can be split into two categories: port economic impact and port trade efficiency (Bichou, 2007). The former is considered as a branch of economic geography; here ports are seen as catalysts for the socio-economic activity of the region they serve and port performance is measured with their ability to create economic wealth (De Langen, 2002). Relevant work in this field can be found in Rodrigue, Slack & Comtois (1997) article and AIVP (2005). Port economic impact studies are generally based on input-output models (Moloney & Sjostrom, 2000 and Le Havre Port, 2000), equilibrium models (Tiwari, and Itoh (2001) and gravity models (Wilson, Mann & Otsuki, 2003). The latter, port trade efficiency, assesses ports in relation to transport and logistics costs and focuses on trade facilitation (Bichou, 2007). Relevant work in this field can be found in Sanchez et al. (2003) and De and Ghosh (2003) articles. Port economic impact studies are criticised for considering ports as regions and not as businesses (Bichou & Gray, 2005).

1.b. Frontier approaches

The frontier approach, unlike the statistical approaches where performance is compared to an average, measures the efficiency in relation to a calculated or estimated frontier. A firm is deemed efficient when its operating curve coincides with the frontier and inefficient when it is away of the frontier. There are two approaches in the frontier concept: parametric and non-parametric. A detailed explanation and comparison of these two methods is provided in Tovar et al. (2003) and Estache et al. (2002) papers.

The parametric approach, also called econometric approach, requires a functional form of inputs and outputs that can be statistically estimated. The frontier function is determined through statistical inference from the observations. The parametric approach presents the inconvenient that it is not a multi-factor practice and that it does not allow for international port benchmark (Kim & Sachish, 1986).

Unlike the parametric method, non-parametric approach does not necessitate a functional formulation; it uses linear programming instead. Most research in non-parametric approaches consists in Data Envelopment Analysis (DEA); it is a methodology that maximises the efficiency ratio for each decision-making unit by solving a series of linear programming problems. The DEA approach offers many advantages: it allows the use of several inputs and outputs, does not necessitate the pre-definition of a function and allows benchmarking (Bichou, 2007). All these factors make DEA a great tool to measure port efficiency.

Frontier models analysed port efficiency on a national level (Liu & Zhuang, 1998) as well as on an international level (Song et al., 2001). Recent studies suggest Data Envelopment Analysis to assess port performance (Notteboom et al., 2000 and Valentine & Gray, 2001). DEA is criticised for its inconsistency; its results are sometimes conflicting. For instance, Cullinane et al. (2002) concluded that a relationship exists between the size of a port and its efficiency; this relationship is characterised by a positive correlation. Coto-Millan et al. (2000) on the other hand, reached the conclusion that larger ports have higher chances of being inefficient. These contradictory outcomes make generalisation difficult. This is due to the complex structural organisation of ports and presents an obstacle to measuring port performance and performing comparison between ports (Bichou & Gray, 2004).

1.c. Performance metrics and indices

Performance metrics and indices are numerical representations that quantify one or many attributes of an object or a process. They must allow comparison against goals, competitors and historical data. Generally, and likewise any other business, port performance measurement uses metrics and indices at different functional and operational levels (Bichou, 2007). Performance metrics can be categorised either into input measures (time, cost, resource, etc.), output measures (throughput, profit, etc.) or composite measures (productivity, efficiency, profitability, etc.) which are in general an output to input ratio.

In maritime transport literature, the lack of consistency and the absence of clear standards on what metrics to be used shifted the focus of port performance measurement from effectiveness and utilisation to efficiency dimensions. Actually, ratios for port performance measurement can be divided into three types: financial productivity measures, Single and

Partial Productivity Indicators (SFP, PFP) and total factor productivity indicators (TFP).

Financial metrics are ratios applied to costing and accounting figures. Their particularity, compared to physical indicators, is the use of monetary values. Financial indicators are widely used in the port industry; the public port finance survey is a document that summarises these indicators in ports around the world (MARAD, 2003). Common measures used in this report are return on investment (ROI), return on assets (ROA), capital structure and short-term liquidity.

Some studies consider ports as business organisations and thus focus only on the financial measurement especially profit based indicators. Leonard (1990) examined port performance from a value-added perspective; his concept of value-added was the difference between revenues and costs. This approach is, however, limited to quay-side operations and abandons other port-related activities. It also has the disadvantage that it assume that all ports have the same price structure and marketing strategy which is far from being the reality (Bichou & Gray, 2004).

Conventional financial indicators are inappropriate for port performance measurement; they offer a narrow view and are unable to assess risks and benefits. Khalid Bichou (2007) states that their inappropriateness is due to the low correlation between financial performance and efficient and effective use of resources. He also adds that "*high profitability may be driven by price inflation and other external conditions rather than by efficient productivity or utilisation*". For instance, high financial performance can result from the use of innovative financing and ownership models (Kaplan, 1984). Another flaw of financial indicators, according to Holmberg (2000), is that these show the result of past actions (lagging indicators). Financial measures are, likewise, criticised because of their limited ability to assess intangible activities such as innovation or staff training and development programmes (Vitale & Mavrinac, 1995).

In the port industry, there is an inconsistency between the nature of ports' investment which are more turned to the long-term and the financial indicators focus on the short-term. Another disparity in the use of financial indicators is the plethora of accounting systems used from one country to another, making the comparison between ports impossible. Several other factors affect financial performance such as market power or access to private equity. For these reasons, physical productivity measures are deemed more reliable than financial indicators (Bichou, 2007).

Physical productivity measurement can be divided into two categories: single productivity indicators (SFP) and partial productivity indicators (PFP). SFPs are defined as the ratio of a single output to a single input. However, PFPs compare a series of outputs to a series of inputs (Bichou, 2007). Inputs can be labour, land or capital, while outputs are usually based on the cost drivers of the activity and the resource measured. Examples of physical productivity measures used in ports are crane throughput per machine hour, berth or quay throughput per square metre capacity and worker or gang output per man-hour. SFP*s* and PFP*s* seek to identify changes in productivity resulting from one or multiple factors. They are widely used in the port literature; Fourgeau (2000) and UNCTAD[1] (1976), among many others, support this point. They are, likewise, used in professional publications such as ports' statistics, trade journals or market reports. However, these indicators only provide a punctual measurement and focus on a single port operation (loading, discharging, storage, etc.) or facility (crane, berth, warehouse, etc.). For this reason, Bichou (2007) describes SFP*s* and PFP*s* as incomplete performance measures.

[1] United Nation Conference on Trade And Development

Multi-factor productivity (MFP) and total factor productivity (TFP) indicators combine multiple inputs and outputs within one measure. TFP*s* try to provide a holistic indication of productivity through the use of total inputs/outputs. This concept synthesise a productivity index using a weighting system for the different cost and production factors. Literature using this concept is yet not rich; only a few studies have used TFP measures. Kim & Sachish (1986) and Bendall & Stent (1987) elaborated research in this field.

MFP and TFP measures offer the advantage of reflecting the impact of a change in combined inputs on total outputs which is not the case with SFP*s* and PFP*s*. However they also have some drawbacks since the results are largely dependent on the technique used and the attribution of weights (Bichou, 2007).

2. UNCTAD guidelines

According to UNCTAD (2013), it is very important to differentiate port performance depending on the type of service offered. In this vein, it is possible, at least in theory, that a port offers satisfactory services in cargo but is judged unsatisfactory or even deplorable in vessel operations. Besides, UNCTAD (2013) highlights the fact that it is nonsensical to evaluate the performance of a port on the basis of a single measure or indicator. Indeed, a clear and significant assessment of a port performance needs to include metrics related to the stay time of ships in ports, the quality of cargo handling and the quality of service to inland transport vehicles during their passage through the port. A strong interrelationship exists between these metrics, resulting in the complexity of port performance measurement. Therefore, it is inappropriate to study these measures individually, however they need to be part of a holistic approach.

2.a. Stay time related metrics

A vessel can undergo many inefficiencies during its passage at port; these can be illustrated by a vessel waiting for a berth to be free, waiting for cranes or operators or waiting for instruction from port operators. For a better understanding and a big picture of a ship's time in port see Appendix A.

The main and fundamental measure of port productivity is the total turn-around time in port. It is the total time spent by a vessel in port and is generally expressed in hours. The time value itself is not completely significant and informative, hence the use of two more meaningful metrics, namely the total turn-around time in port per cargo tonnage and the total turn-around time per cargo composition. These metrics can even be improved and expressed in monetary value for an easier economic analysis.

The performance indicators introduced above use the total time spent by a vessel in port and don't follow a breakdown of the ship's time at port as shown in Appendix A. Two periods are very important in a ship's stay at port: the ship's waiting time for a berth and the ship's time at berth. These two measures are critical and require special attention.

A study elaborated by UNCTAD, "*Berth throughput: systematic methods for improving general cargo operations*", shows that the waiting time for a berth and time spent at a berth are highly interrelated. The study also concludes that a reduction in the time spent by vessels at berths may have a significant positive impact on the waiting time for a berth.

2.b. Cargo handling indicators

A ship's stay at berth can be divided into working and non-working periods; during working periods, cargo handling operations take place. These activities determine the level of quality of the service delivered and are, thus, very important to measure and monitor in order to achieve great performance. UNCTAD divides cargo handling indicators into two groups: output measures and productivity measures. The former reflects the amount of work done in a particular period. The most commonly used output measures are berth throughput, ship output and gang output. The latter, productivity measures, are cost-effectiveness metrics that are presented as a ratio of output to resource used.

Berth throughput is a measure of the total tonnage handled at berth in a specific period of time. It is generally measured on a weekly, monthly or annual basis. However, this indicator is flawed since it just measures the activity volume of a facility and does not inform us on how efficiently it was managed. In addition, berth throughput is only meaningful when differentiated by cargo type, handling technique, route followed and units of measure.

TEU per acre is a berth throughput indicator used by the majority of ports. According to Bill Mongelluzzo (2010) using this metric is useless and does not reflect the port productivity. He adds that delays at gates are by far more important to monitor. Some ports such as Los Angeles and Long Beach ports are known to be light weights and handle 5000 TEUs per acre, some others are heavy weights and handle 25000 TEUs per acre, thus the inappropriateness of using this performance indicator.

Ship output metrics reflects more the cargo handling productivity and efficiency. They "*give a clear indication of how good cargo handling operations are*" (UNCTAD, 2013). Similarly to berth throughput, ship output indicators require the same differentiation. The most frequently used metrics in ports are tonnes per ship working hour, tonnes per ship hour at berth and tonnes per ship hour in port. Large differences among these indicators may denote time losses and inefficient operations at the berth or in the port.

Ordinarily, port performance has been linked to berth productivity (Cullinane et al., 2006). Berth productivity is a measure of the speed at which ships are loaded, unloaded and sent back to sea. It is one of many productivity measures. However, it presents the particularity that it can be measured all around the world, irrespective of where the port is located and using the same criteria (Tirschwell, 2013a). Tirschwell (2013a) believes this finding is a breakthrough; it allows, for the first time, a comparison of ports on the basis of factors other than volume. Even though berth productivity allows port benchmarking, it still has some imperfections; it uses gross berth productivity – no adjustments for labour or equipment downtime – and does not take local realities into consideration such as labour cost or total working hours. Tirschwell (2013a) states that even though it is an imperfect measure, it allows comparison. He adds that further improvement and research will be done.

Other measures of productivity are operating time – productivity achieved between first and last lifts; this measure reflects the productivity between the arrival of a ship and the start of the operations, thus reflecting the efficiency of the customs clearance procedures. Another productivity indicator is crane density and the ability to keep cranes in operation. Stay time is also used as a metric; it is the time between the arrival of a ship and the return to sea.

These measures are meant to create a standard approach to measuring port performance, which will in turn create the basis for port benchmark. This activity will help conduct improvement project, especially that port "*productivity stagnated years ago and has not improved despite the presence of larger ships and higher volumes*" as stated by Tirschwell (2013a).

Literature on port productivity is not rich. Besides, there is no consistency in the studies done which makes productivity monitoring over time difficult. Indicators employed in port industry are comparable, however the absence of a common database made comparison between ports complex. In order to create a base for comparison, JOC approached stakeholders that were most motivated about increasing port productivity, namely carriers. This helped carriers identify, understand and improve low productivity, compare carriers together and compare ports and terminals (Tirschwell, 2013b).

Gang output is another widespread used performance metric. It indicates the amount of cargo handled by a gang in a specific period of time. The cargo handled is generally expressed in tonnes and the time window in hours. This measure, as the two discussed above, need to be differentiated, and well defined and described (gang composition, cargo worked, ship's configuration, etc.). An improved gang output metric is the output in man/hour; it removes the complication brought with gang composition (De Monie, 1987).

Productivity measures are slightly different from output measures in the way that they are presented as a ratio output to effort put in. they are generally expressed in monetary values. This concept is very much similar to cost-effectiveness. Generally, ports aim for a least cost per tonne strategy, however this may be altered in case of severe congestion. The most popular productivity measure used in ports is the labour cost per tonnage of cargo handled.

Table 1 summarises the most popular output metrics as identified by UNCTAD.

Table 1: output metrics for port performance measurement as identified by UNCTAD

Category	indicator	
Stay time in ports	Total turn-round time in port	
	Total turn-round time in port per cargo tonnage	
	Total turn-round time per cargo composition	
	Ship's waiting time for a berth	
	Ship's time at berth	
cargo handling	Output measures	Berth throughput

Category	Indicator	
Cargo handling	Output measures	Tonnes per ship working hour
		Tonnes per ship hour at berth
		Tonnes per ship hour in port
		Gang output
		Output in man/hour
	Productivity measures	Labour cost per tonnage of cargo handled

From the aforementioned performance measures discussion, one fact of prime importance stems; port performance cannot be reduced to one single indicator. The complexity of ports' operations, the interrelationships between the different port elements and the need to differentiate according to the type of service make it essential to rely on a set of measures to have a clear and significant evaluation of a port's performance (De Monie, 1987).

3. Literature review findings

According to Pallis et al.'s (2008) literature review on port economics, management and policies, 23 out of 273 published papers in relevant international scientific journals during the period 1997-2006 treated port performance. The majority of these articles – thirteen – applied the DEA methodology. Other articles used the Stochastic Frontier Analysis and TFP. Table 2 shows the metrics used in the literature as identified by Pallis et al. (2008). They pointed out that the performance measurement approach is dominated by internal indicators.

Table 2: Port performance measures – collected by scholars (1997-2006) (Pallis & Vitsounis 2008)

Category	Indicator	Frequency (external)
Capacity related	Labour related	10 (0)
	No of berths	5 (1)
	No of cranes	10 (0)
	Terminal area	8 (0)

Category	Indicator	Frequency (external)
Capacity related	Total quay length	2 (0)
	Other	16 (4)
Financial	Cost related	16 (3)
	Other	19 (2)
Productivity related	Time related	16 (1)
	Other	13 (5)
Throughput	Total cargo handled	3 (0)
	Container throughput	5 (0)
	No of passenger	2 (0)
	Throughput (for every cargo)	6 (0)
	Other	7 (0)
Quality related	Hinterland related	5 (1)
	No of ship calls	3 (1)
	Information related	3 (1)
	Intermodal related	4 (2)
	Other	31 (20)

Studies on port performance are booming, however several flaws exist. Even though DEA and TFP are methods that can be used to measure the holistic performance of a port, most of research papers focus on operations productivity and consider it as the only factor leading to port efficiency (Cullinane & Wang, 2007). In these circumstances, and keeping in mind that performance measurement is a broad concept that encompasses all of the port's activities, Heaver (2006), Pallis & Syriopoulos (2007) and Talley (2007) suggest the addition of metrics other than simply the operational ones.

Reviews regarding the metrics and measures used by the port themselves are quite rare and few in number. A study published in 2007 in the context of port performance research network collected data for the years

2004 and 2005 from 42 ports; data collected represents the performance indicators monitored by ports. Table 3 summarises these findings.

Table 3: Port performance measures – collected by ports (Pallis & Vitsounis 2008)

Category	Indicator	Frequency
Financial measures	Ancillary revenue as % of gross revenue	22
	Average days account receivable	19
	Capital expenditure as % of gross revenue	13
	Debt: equity ratio	23
	Growth in profit (before taxes)	25
	Interest coverage ratio	21
	Port-related profit as % of port-related revenue	19
	Return on capital employed	21
	Terminal charges as % of gross revenue	19
	Yield % on shares, if publicly traded	10
Vessel operations	Average turnaround time per vessel (in hours)	24
	Average vessel calls per week	29
	Average waiting time at anchor	22
	Hours of equipment downtime per month	14
	Length of quay in meters (as capacity measure)	22
	Revenue per tonne handled	19
Container operations	20' TEU as % of total TEU for year	17
	Average revenue per TEU	9
	Average vessel turnaround time per 100 lifts (in hours)	4
	Average yard dwell time in hours	10
	Container port throughput (TEU/metre of quay/year)	18

Category	Indicator	Frequency
Container operations	Departure cut-off time (hours)	3
	Growth in TEU throughput	19
	Import containers as a percent of total containers	17
	Lifts per crane per hour	12
	Percent of containers grounded (ship to rail ops only)	5
	Reliability (qualitative factor)	1
	Transhipment (as % of total throughput)	9
	Yard hectares to quay metres	5
Other measures	Customer complaints per month	15
	Destinations served this year	21
	Employee turnover rate	14
	Employment (full-time equivalents) per tonne handled	7
	Employment (full-time equivalents) per TEU handled	5
	Invoice accuracy percent	7
	Number of customers served	18
	Overall customer satisfaction	15
	Stakeholder satisfaction	7

The survey shows that financial measures receive a great attention from port authorities; they are the metrics that are most used by ports. Performance measurement, in this industry, also focuses on vessel operations and container operations.

In a study of ports in America, Europe and Oceania, reported by Pallis & Vitsounis (2008), a conclusion was reached that throughput volume, port-related employment and value-added are the performance indicators that are most used in the maritime port industry. The Rotterdam port case supports this conclusion and table 4 illustrates the metrics used at this port.

Table 4: Port performance indicators used in the port of Rotterdam (Pallis & Vitsounis 2008)

Year – Period	Indicators
Beginning of the 20th century	Number of ships
	Throughput volume
1990s	Port related employment
	Value added
	Port value added as % of regional GDP
2002	Development in turnover
	Profitability of firms in port
2003	Investment level of private firms in port area
2004	Establishment of (new) companies in port areas

4. ESPO PPRISM Project for a EU harmonisation

In contrast with other transport sectors, apart from the volume statistics, port industry "*do not have a proper set of indicators at European level*" states ESPO, neither does it on a global level (Tirschwell, 2013a). ESPO's PPRISM project (2012) aims to set the foundations of a culture of port performance measurement in Europe. Its target is to determine a combination of relevant and feasible metrics for the EU port system. PPRISM performance measurement system will be presented as a dashboard that includes indicators that are accepted by all stakeholders. This dashboard's essential function would be to assess port performance as a whole, not to publish performances and compare ports.

The analysis of current practices revealed that even though a culture of measuring, monitoring and reporting indicators was established in the port industry, a standard EU approach was missing. PPRISM project offered an opportunity to harmonise the performance measurement system.

ESPO devised 5 categories of indicators to be considered in its performance measurement system; these are market trends and structure, socio-economic impact, environmental performance, logistic chain and operational performance and finally governance.

The market trends and structure indicators are very relevant given the changes in competitive environment that the maritime port industry is experiencing. This category of indicators has the particularity that it is already widely used by port authorities. However the definition of indicators and the methods of collecting them vary from port to port. PPRISM project identified two indicators: maritime traffic and call size. The former is the more popular in the port industry. The latter is the ratio of maritime traffic to vessel traffic which are both widely used by port professionals.

Socio-economic impact measures are very import in the port industry; they create societal acceptance, they are relevant for budget allocation and fund granting and they illustrate a port contribution on the local, regional and national levels. PPRISM project selected employment and added value as the most interesting metrics. ESPO concluded that, in several ports, these indicators are absent. It also found that, even when they are present, there is a wide variability in the calculation methodologies.

In this ever green era, where special consideration is given to sustainability, environmental awareness is increasing within ports; renewable energies and carbon footprint are, more than ever, becoming issues of prime interest for ports. Over the last 15 years, ESPO identified numerous ports that implemented environmental initiative and management system; the most popular amongst these are Port Environmental Review System (PERS) and ISO 14001. PPRISM project identified three environmental performance indicators, namely carbon footprint, waste management and water consumption, and a qualitative measure of a port authority's capability to deliver effective environmental protection and sustainability through appropriate environmental management systems.

Regarding logistic chain and operational performance indicators, ESPO recognises that shippers are the most interested stakeholders. These are particularly interested in connectivity, costs, reliability and ease of transaction. In determining the most relevant performance metrics, ESPO focused on the factors of interest for shippers. Metrics that were identified in the PPRISM project are maritime connectivity which specifies the quality of the connection with oversea destinations, intermodal connectivity which indicates the quality of intermodal connections from the EU ports and finally the quality of customs procedures to measure the ease of transaction.

Port governance has been subject to debates during the last few years, especially after the changes in the economic and political environment. ESPO has been studying port governance since the 1970s and the PPRISM project identified three port governance indicators. The 1st metric is the integration of port cluster; it reflects the port authorities endeavour to integrate the various stakeholders as one port cluster which goes in line with Bichou's (2007) supply chain approach to ports which will be presented later in this paper. The 2nd is reporting corporate and social responsibility which measures a port activity to enhance corporate responsibility. Last but not least, the autonomous management which is an indicator that that measures the extent to which a port authority is capable of launching vital initiatives.

Table 5 summarises the most important performance indicators reported by category as identified by ESPO.

Table 5: Performance indicators identified by the ESPO's PPRISM project

Category	indicator
market trends and structure	Maritime traffic
	Call size
Socio-economic impact	Employment
	Added-value
Environmental performance	Carbon footprint
	Waste management and water consumption
	A qualitative measure of a port authority's capability to deliver effective environmental protection and sustainability through appropriate environmental management systems
Logistic chain and operational performance	Maritime connectivity
	Intermodal connectivity
	Quality of customs procedures
Port governance	Integration of port cluster
	Reporting corporate and social responsibility
	Autonomous management

ESPO's aim, through the PPRISM project, was to establish a common port performance measurement system for the European Union, a standard approach to measuring port performance. Even though this initiative did not create the framework in order to compare ports, it would involuntarily allow and facilitate considerably port benchmark in Europe once all ports start following the ESPO approach.

This great initiative should be imitated on a global scale in order to create a global, standard, worldwide recognised system to measuring port performance. UNCTAD, as an international organisation, could launch this programme, but such an initiative can also be triggered by a port or a group of ports.

5. Standardisation initiative for port performance indicators

Port performance indicators literature is characterised by a high level of inconsistency; each author used its own set of metrics, some author even used the same metrics but with different computation methods. In addition, there is no clear classification of these metrics; some authors adopted a classification based on the methodology (Bichou, 2007), some other took a macro-economic viewpoint (ESPO, 2012) while other considered port functions and operations (UNCTAD, 1976).

A clear, standard and consistent port performance classification is an essential first step towards the rationalisation of port performance measurement. Having a well-defined taxonomy of port performance metrics can lead to a better use of these by practitioners as well as a more organised approach world-wide. In this regard, I used and combined the different classifications found in the literature to create a standard taxonomy. This classification goes in line with all those found in the publications; it hierarchizes and organises them into different levels of analysis.

Khalid Bichou (2007) provides the most general classification and adopts the highest level of analysis; economic impact studies, frontier approaches, and individual metrics and indices envelop all the performance measurement methods. In a second level, Economic impact studies split into port economic impact and port trade efficiency, frontier approaches split into parametric and non-parametric, and individual metric and indices split into financial metrics, SFPs/PFPs and TFPs. Figure 1 illustrates the overall classification as well as all the sub-categories.

Under the roof of economic impact studies we can find the market structure and trend as well as socio-economic impact (ESPO, 2012). These include maritime traffic, call size, employment, value-added, destinations served (Pallis & Vitsounis, 2008).

Port trade efficiency concerns trade facilitation and port formality procedures. Indicators include the number of documents required, notification period prior to arrival, port processing time (HKMD, 2006) and quality of customs procedures (ESPO, 2012).

Frontier approaches are explained in more details in the previous section. They consist of a methodology for measuring a port performance. DEA is the most commonly used approach and is a sub-category of non-parametric approaches.

Individual metrics and indices are split into financial, SFPs and TFPs. Financial metrics can either be related to profitability such as ROI and ROA, or related to port charges. SFPs and PFPs are individual metric that can be relative to capacity, productivity, throughput, stay time or environmental performance. Please refer to appendix B for a full listing of the metrics found in the literature. Regarding TFPs, these are generally indices composed of a set of weighted metrics such as the Logistics Performance Index.

This classification aims to create a common terminology. By doing so, a common basis for port performance measurement can be created. It is a first, basic, yet essential step towards making performance measurement a consistent approach among ports and port related literature.

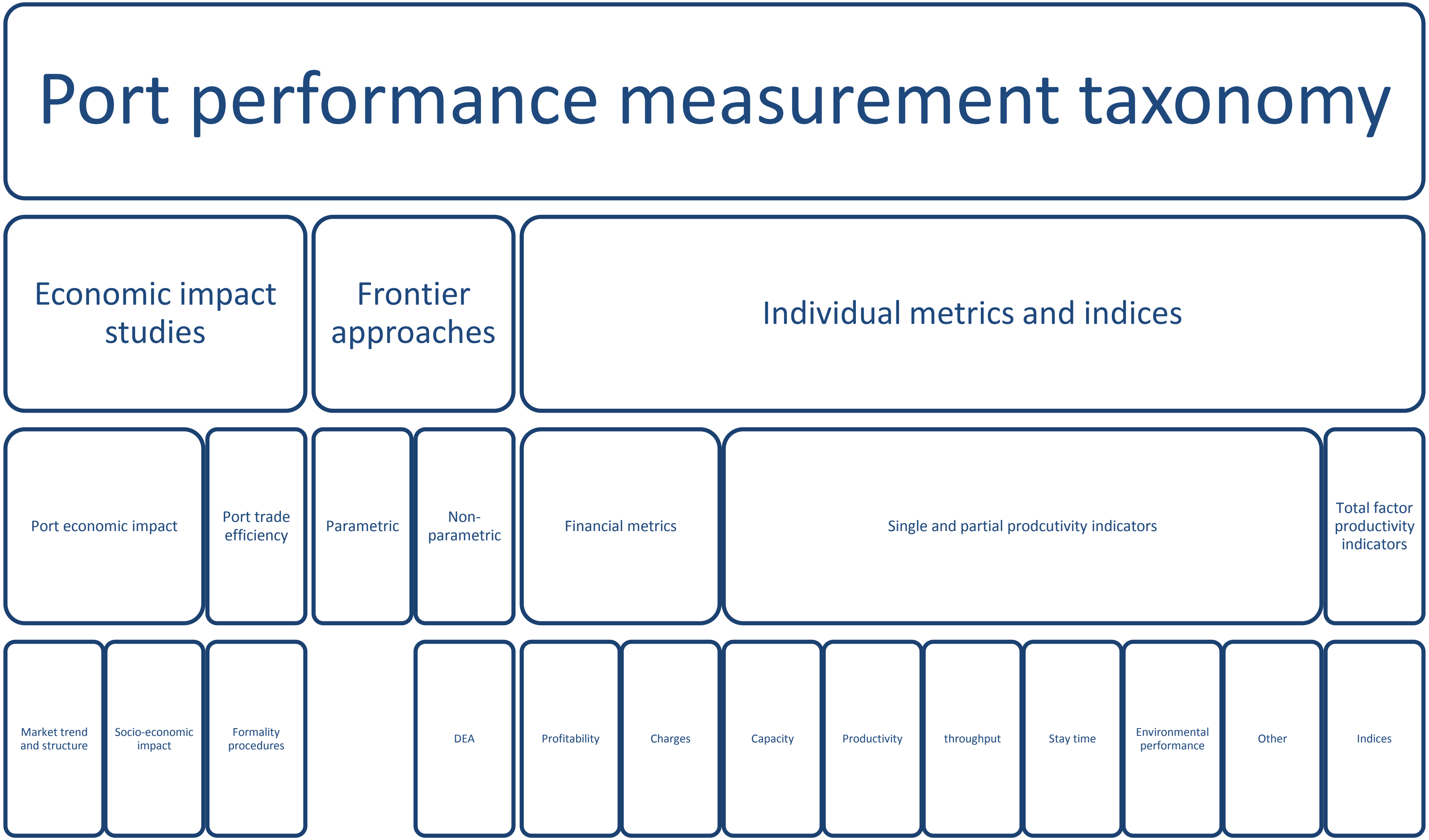

Figure 1: Performance indicators taxonomy (by the author)

IV. Performance measurement frameworks

1. Performance measurement related literature

1.a. A global dissatisfaction with the traditional performance measurement systems

All the above mentioned indicators and metrics are a limited view of maritime port performance; reducing port performance measurement to financial and vessel operations metrics – internal efficiency – only allows a partial analysis of port operations. It does not reflect the overall port performance neither allows undertaking a holistic and comprehensive approach to port performance; it is just an efficiency evaluation of ports. Assessment of the effectiveness from the user's viewpoint is still limited due to the lack of externally gathered data. The frequency of collection of this type of data is very low compared to internal measures and the methodology of collection is very vague and unclear (see Table 2). New metrics and a clear methodology have to be developed. These should not only satisfy the internal port needs in monitoring productivity and performance, but should also be significant to all the interested stakeholders (Pallis & Vitsounis, 2008).

In the context of maritime ports, there is no clear definition of performance measurement system. The guidelines presented in the previous chapter can be used as a basis to develop a port performance measurement framework. Such a system, in contrast with what is generally happening in the port industry, should combine internal efficiency with the user's perspective of a port system; external data should be given special considerations (Pallis & Vitsounis, 2008).

During the last years, scholars have communicated their dissatisfaction with the traditional performance measurement process based on the accounting system and financial metrics. Neely (1999) states that a financial evaluation only focuses on the short term, lacks strategic focus, is unable to reflect quality level, encourages only local optimisation, does not bring a continuous improvement environment and, last but not least, it does not provide understanding on what customers need or how competitors are doing.

Two of the financial evaluation's flaws stated above are linked to customers, namely the lack of data regarding quality and the lack of customer orientation (does not reflect what the customer wants). Port industry is experiencing a stiff competition and ports seek to differentiate from competitors to gain market shares (Chlomoudis et al., 2003). This differentiation goes first through a thorough understanding of how well a business is performing especially in the customer-related dimensions. This kind of information can only be obtained through external data. Ports have to ensure that value is delivered to customers and the only way to assess this is the voice of the customer and the externally generated information (Pallis & Vitsounis, 2008).

1.b. Emerging performance measurement frameworks

The last thirty years witnessed a revolution in the field of performance measurement. Practitioners as well as academics turned their attention to this emerging discipline (Neely, 1998). Research found that firms that use balanced performance measurement frameworks are more likely to achieve greater results (Lingle & Schiemann, 1996). Neely (1998) states that a good performance measurement system "*enables informed decisions to be made and actions to be taken because it quantifies the efficiency and effectiveness of past actions through acquisition, collation, sorting, analysis, interpretation, and dissemination of appropriate data*". In other words, a decent performance measurement system includes individual metrics to measure efficiency and effectiveness, a holistic set of metrics that help evaluate the overall performance of an organisation and adequate infrastructure that allow data collection and analysis for decision making.

In a performance measurement framework, the most challenging step is the determination of a set of metrics that reflect the performance of a firm. Several frameworks were developed to help organisations determine the most appropriate measures that define the overall firm's objectives (Bourne et al., 2000). The flaws of the traditional performance measurement systems and their rejection by scholars gave birth to new performance measurement frameworks. These recent methodologies are considered multi-dimensional; this characteristic comes from the fact that they incorporate non-financial, external and future looking metrics on top of the financial ones. Several multi-dimensional frameworks were developed such as the results and determinants framework, the SMART pyramid (Kennerly & Neely, 2002), the balanced scorecard (Kaplan & Norton, 1992) and the performance Prism (Kennerly & Neely, 2000). The last two are the most commonly used (Pallis & Vitsounis, 2008).

DuPont, in the beginning of the 20th century, developed the pyramid of financial ratios. This methodology used several financial ratios at different organisational levels. Johnson and Kaplan (1987) criticised this approach because of its failure to detect changes in the competitive environment. It was also criticised for providing a historical view, only using lagging indicators and encouraging short-termism (Bruns, 1998).

These shortcomings of the purely financial approach prompted companies to consider non-financial measures in addition to the financial ones, in order to have a more comprehensive picture of an organisation's performance. It is believed that General Electric first used a balanced framework in the 1950^{s} (Bruns, 1998), however this approach became more popular in the 1980^{s} and 1990^{s}. The intensive research in this field led to the development of a set of balanced or multi-dimensional frameworks.

Keegan et al. (1989) suggested a balanced performance matrix. This tool divides indicators, on one axis into "*cost*" and "*non-cost*", and on the other axis into "*external*" and "*internal*". Despite its simplicity, this matrix is able to cover all the performance measures (Neely et al., 1995).

Wang Laboratories developed the SMART (Strategic Measurement and Reporting Technique) pyramid (Lynch & Cross, 1991). In the same vein as the previous tool, SMART includes External as well as internal performance measures. It uses a concept of cascading metrics so that metrics in a department or division level are consistent with firm's vision.

Fitzgerald et al. (1991) developed the results and determinants framework which divides indicators into two groups. The first group includes metrics related to results such as competitiveness or financial performance. The second group focuses on the drivers of those results such as quality, innovation or flexibility. This framework combines lagging and leading indicators; therefore it facilitates early problem detection and improvement initiatives.

Kaplan and Norton (1992) developed the most popular performance measurement framework, namely the balanced scorecard. This approach to performance measurement integrates four different viewpoints: financial, customer, internal business, and innovation and learning perspectives. Regardless of its popularity, the balanced scorecard was criticised in the literature and academics identified many drawbacks; it was reproached the fact that it did not include features that earlier frameworks developed. For instance, it does not include the competitiveness dimension introduced by Fitzgerlad et al. (1991) in the results and determinants framework. Another example is its inability to cover all the performance indicators as do the performance measurement matrix.

1.c. The performance Prism framework

This review of the different performance measurement frameworks highlights some key characteristics that have to be present in a good performance measurement system. It has to be balanced and multi-dimensional; it should include financial and non-financial measures, external and internal measures, and efficiency and effectiveness measures. A good performance measurement system has also to be clear, simple and easy to understand. Moreover, it needs to be comprehensive and be integrated across the different functions and the hierarchy (Neely, 2002).

From the above discussion on performance measurement frameworks, we notice that no framework developed so far satisfies all the aforementioned criteria; each one in turn fails to fulfil them in a different way. A framework known as performance Prism has been developed to overcome the shortcomings of these frameworks and satisfy the success criteria identified earlier (Neely, 2002).

The performance Prism framework addresses the issue of performance measurement with a special focus on stakeholders as shown in Figure 2. Teddy Wivel[2] considers stakeholders as an essential element to achieve performance; he even says that "*It will not be possible to create shareholder value without creating stakeholder value*" (Crowe, 1999). In contrast with the traditional approaches that consider shareholders as the main stakeholders, Prism tackles the topic with a wider view and includes customers, employees, other investors, suppliers, regulators and pressure groups. Most of these have been incorporated in the balanced scorecard and variants of it, however regulators and pressure groups are novelties (Neely, 2002).

Once all the stakeholders identified, Prism considers the strategy followed to achieve stakeholder satisfaction (Neely 2002). Measures have to be implemented in order to monitor whether the strategy has been communicated and achieved or not (Neely 1998).

[2] Senior partner in the Danish arm of Ernst and Young.

The 3rd and 4th elements of the performance Prism methodology are the measurement of the processes required to deliver the objectives and the capabilities needed to support and enhance the processes. These two facets have never been addressed in a performance measurement framework before (Neely, 2002).

The last Prism facet closes the loop and returns to stakeholder consideration which is central to the Prism framework. Whereas the first Prism aspect looks at maximising stakeholder satisfaction, the last aims to maximise stakeholders' contribution to the organisation (Neely, 2002).

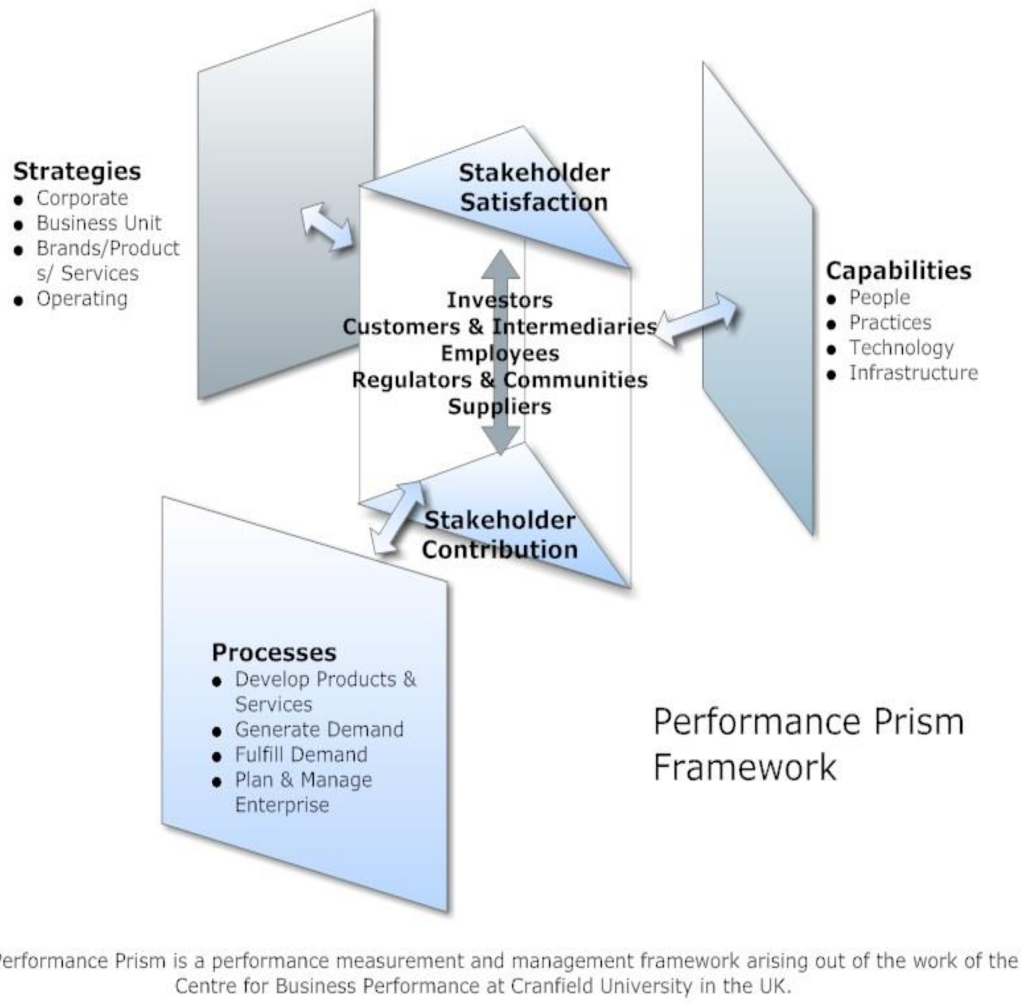

Figure 2: Prism performance measurement framework (Neely, 1999)

In the port industry, applications of the multi-dimensional frameworks presented above are yet limited and customers' perspective is most of the time neglected. Assessing port user's satisfaction would be a valuable tool in ports performance measurement (Pallis & Vitsounis, 2008).

2. An integrative performance measurement system – a Logistics and Supply Chain Management approach

Khalid Bichou (2007) attempted to develop an integrative performance system. He identified discrepancies for developing such a methodology; the main problem is that even though the existing frameworks identify performance dimensions, their definition and uses remain highly inconsistent. One example is the use of the concept of productivity; it can be the economic concept meaning the efficiency of resource allocation, the technological concept which is the ratio of outputs to inputs used in production and it can also be the engineering concept which is the ratio of the actual to the theoretical output of a process (Ghobadian & Husband, 1990). Edwards (1986) supports this point stating that even in a management accounting environment, productivity is misused.

The performance concept has always been debated and the choice of the dimension or combination of dimensions that define a firm's performance is challenging. In the port literature, the same issue prevails and a relationship between indicators and performance has been difficult to establish. In the port industry, performance measurement systems are generally divided into either measuring internal efficiency or external effectiveness, they barely take both into consideration. In order to fix this flaw, Khalid Bichou (2007) suggests the implementation of multi-dimensional performance measurement frameworks that integrate both operational and strategic activities.

2.a. Bichou's Characterisation of successful performance measurement system

In his research, Bichou (2007) defined four criteria that constitute a good performance measurement system; these are comprehension, consistency, usefulness and multi-dimensionality. Comprehensiveness means encompassing all the relevant activities in the process and including all the interested stakeholders. This criterion is very difficult to integrate to port performance measurement given the complex interrelation between port institutions and functions. The challenge here is to determine which viewpoint to take (regulator, operator, customer, etc.). The traditional standpoint is the port authority perspective, however this can be very intricate when an outside institution governs a port.

The second criterion, consistency of the system, is the coherence with other approaches and performance measurement frameworks. Consistency also means alignment with firm's objectives and its future direction. This is very important for port performance, especially following the industry changes from measuring the internal efficiency to analysing the supply chain efficiency (Bichou, 2007).

Performance measurement has also to be useful; by usefulness, Khalid Bichou (2007) means the capability of the system to guide decision-making. Performance measurement practices need to be simple and avoid over-complexity because it leads to ignoring the system.

Last but not least, port performance measurement needs to be multi-dimensional. Even though port performance measurement has been largely addressed in literature, researches incorporating "*operations, design and strategy within the multi-institutional and cross-functional port context*" are lacking states Khalid Bichou (2007). Obstacles that can confront the multi-dimensional criterion are the identification of all the interested port stakeholders, the differences between operational and strategic viewpoints in ports and finally the complexity and interdisciplinary scope of ports. A performance measurement system should thus integrate the different processes and functions involved in ports and link them.

2.b. A Logistics and SCM perspective for ports

Traditionally, performance measurement in ports focused on sea access and maritime activities rather than land-side connections. Nowadays, there is an urging need to improve land-side performance indicators. This need has been driven by the stagnation in port efficiency and land-side operations (Eno Transportation Foundation, 1999). Land-side efficiency is also important when addressing issues of port capacity and capacity expansion (McKenzie et al., 1989). Bichou & Gray (2004) believe that "*a logistics and supply chain approach may achieve better use of port capacity*".

Cargo output and production functions are the commonly used measures for port activities. Performance is measured either using a single factor productivity throughput such as output per worker (UNCTAD, 1983) or output per wharf (Frankel, 1991), or using a total cargo handling productivity measure (Talley, 1998).

The international trade system, and more specifically ports, involves a high level of integration of logistics and supply chain (SCM) activities. However these concepts are generally ignored in port performance measurement. Conceptual and organisational differences and diversity within ports explain the wide range of indicators used in the port industry and highlights the complexity of port performance measurement. As long as no standard approach or commonly agreed framework exists, the subject of what and how to measure will remain debatable (Bichou & Gray, 2004).

In the maritime port literature, only a few studies covered the issue of logistics and supply chain management in ports. Even though academics highlight the importance of ports as important parts of the distribution system, most of the studies focus on one or a few components of ports' operations. Port logistics started being addressed in literature in the last three decades; UNCTAD through its series of monographs as well as the

World Bank addressed this issue (Bichou & Gray, 2004). A distinction between General Logistics Services (GLS) and Value-added Activities or Logistics (VAL) was established, the concept of "*Distriparks*" was introduced and the importance of logistics operations in dry ports was pointed (Harding & Juhel, 1997).

The majority of researches addressing the importance of ports as logistics centres focus on their nodal role and intermodal transport, and ignore the integration of the various activities performed within a port. Most research papers focus on ports' aspects individually without integrating them in a holistic logistics and SCM framework. One example of non-addressed port issues is the total cost of cargo throughout all the port operations up to the ultimate customer (Bichou & Gray, 2004).

Alderton (2008) and Caude (1998) believe that even though recent privatisation made it easier to port operations to adopt an integrative logistics approach, the lack of integration is due to the complex port organisation and management. Fleming and Baird (1999) link the difficulties in managing port activities from a logistics viewpoint to a lack of "*competitive community spirit*". The high number of stakeholders as well as the complexity of the organisational structure of seaports constitutes the key complication for developing an integrative logistics framework for port management (Bichou & Gray, 2004).

The notion of Supply Chain Management extends the concepts exposed earlier to the integration of all the entities of the supply chain (Carter & Ferrin, 1995). The various companies and links in the supply chain should operate as a whole, as one entity (Shefel & Klaus, 1997). In the port industry, there are only two supply chain integration concepts that were widely addressed in the literature, namely intermodalism and organisational integration (Bichou, 2007). Tongzon et al. (2009) also considered relationship with users, value-added services and channel integration practices.

Research articles addressed the issue of developing a framework of system thinking and process integration for intermodalism (Muller,1999), and for integration and partnership in order to achieve an effective intermodal system (Hayuth, 1987). Most studies on intermodalism focus on container ports (UNCTAD, 1995 and Haralambides et al., 2002). An article, comparing USA, Japan, Korea and Australia, studied how intermodal capabilities impact on international supply chains (Morash & Clinton, 1997). Another paper concludes that organisational coordination is a key factor for a successful intermodal system (Everett, 2001).

Regarding the organisational integration, the logistics channel is experiencing substantial restructuring (Notteboom & Winkelmans, 2001); examples of this restructuring are carriers' ownership or management of ports, freight forwarding agencies, logistics providers and IT companies (Thorby, 2001 and Evangelista & Morvillo, 1999). Sometimes organisational integration conflicts arise; for instance, integration between shipping lines or freight forwarders and ports is difficult (Taylor & Jackson, 2000).

2.c. A Logistics and SCM performance measurement framework

The growing consideration of seaports as logistics centres pushed Khalid Bichou (2007) to propose an integrative framework for port performance measurement. He addressed the issue with a Logistics and Supply Chain Management philosophy, assuming that the SCM approach is holistic and takes into consideration the different entities within a system as well as the interaction between them. In his work, Bichou (2007) considered three channels namely the logistics, trade and supply chain channel. The former is composed of specialists that ensure the flow of cargo. The two others are characterised by the ownership of the shipment; the difference is that the trade channel considers the industry, however the supply chain channel addresses the firms' level.

The three channels exhibit constant interactions. These are made more complex in the port context by the fact that single institutions can have several functions and thus belong to different channels simultaneously. For instance a carrier can be, at the same time, the port authority and the service provider. This duality can bias port performance measurement practices. Bichou (2007) states that the Logistics and SCM conceptualisation of ports has been efficient in removing this bias. Figure 3 depicts the interactions between the different channels.

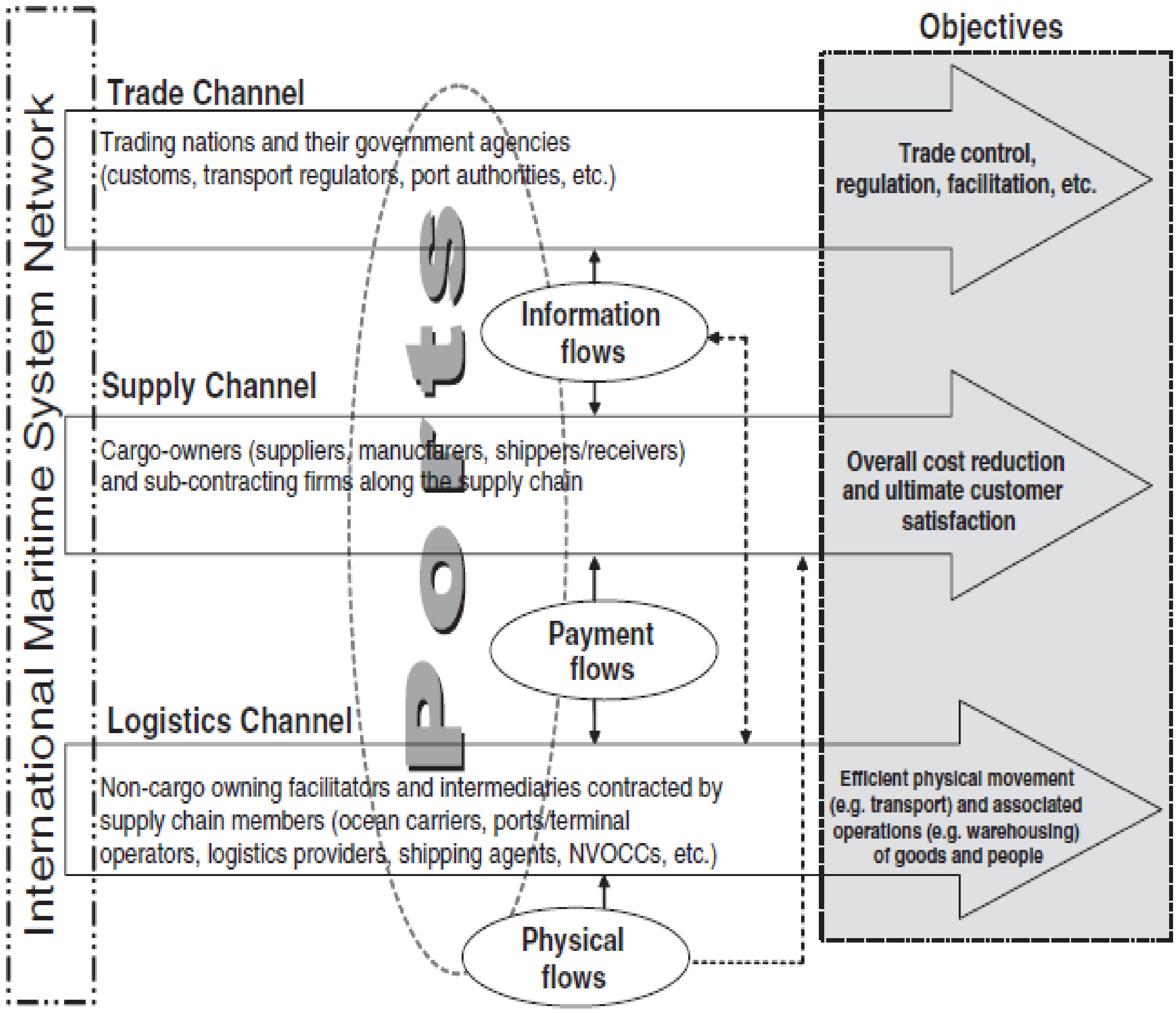

Figure 3: Channel typology and the components of the port network system (Bichou, 2007)

Traditional port performance measurement frameworks are characterised by a fragmented and inconsistent approach; it considers either efficiency or effectiveness and either an operator or regulator standpoint. The shortcomings of the traditional approach to port performance measurement represent a limitation to their universality and to worldwide port benchmark. For this reason Bichou (2007) attempted to analyse and develop port performance measurement with a Logistics and SCM approach.

Bichou’s attempt was an initial framework proposition. The primary model was developed through a series of questionnaires to port managers. It was then tested by a panel of port managers, international institutions, academics and consultants. A rapid conclusion was reached; there is, globally, dissatisfaction with the indicators currently used in the seaport industry and logistics techniques are rarely integrated. In order to rectify this situation, Bichou (2007) developed his model that has a logistics facet and a supply chain facet. The former is linked to the operations, while the latter is related to strategy. In both facets, the framework begins with a process mapping of the components of the three channels. It then assesses and combines the internal and external performance to reach the port performance index. Figure 4 illustrates Bichou’s Logistics and Supply Chain Management approach to port performance measurement.

This model was appreciated and considered valid as a first initiative by the majority of the port’s panel. However, half of the participants identified shortcomings for this framework which are accountability issues and process continuity. They also mentioned the difficulty of determining the boundaries of the logistics processes as a limitation for this framework. In the supply chain aspect, difficulties in understanding and designing the channel typologies were pinpointed. These are due to a lack of reliable information or to the intricacy of channels.

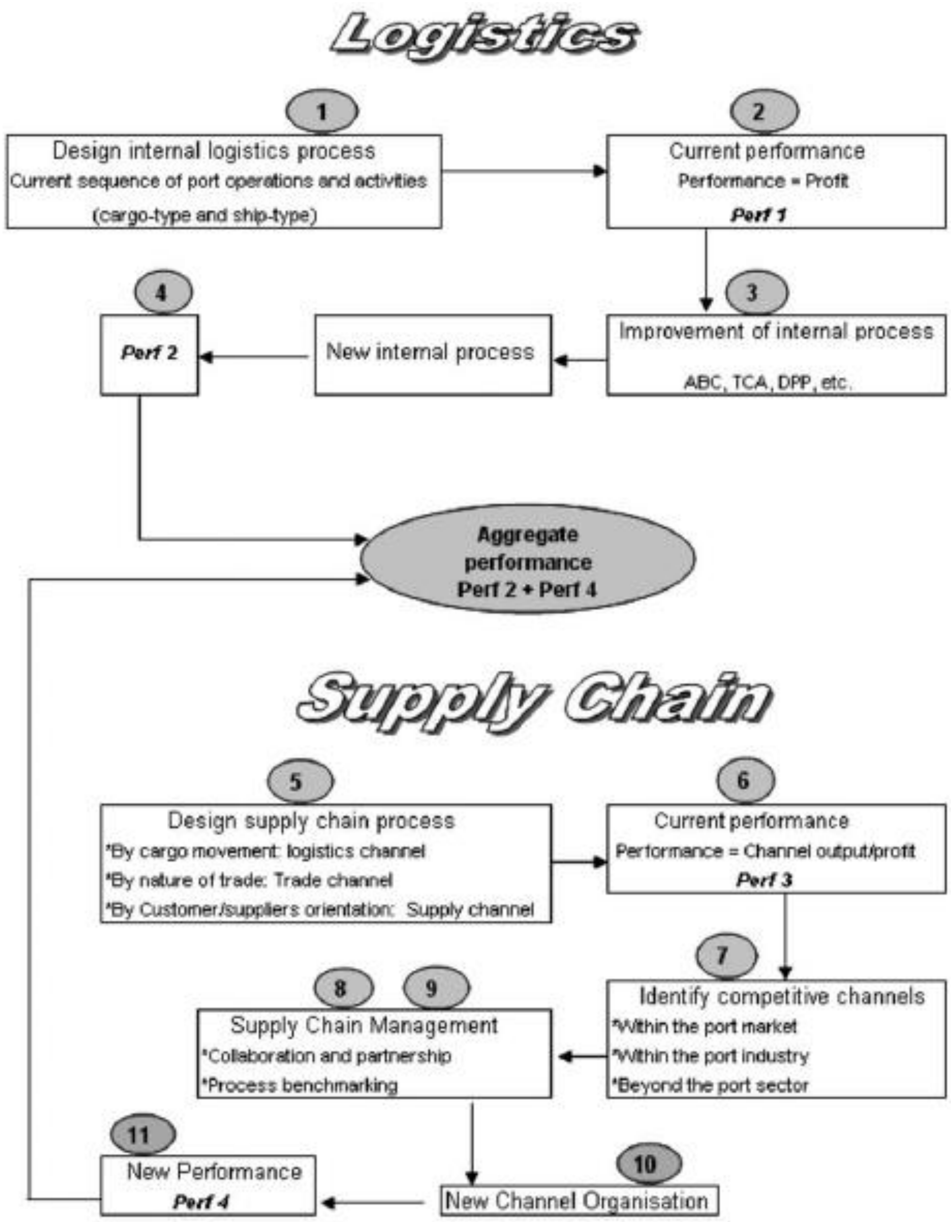

Figure 4: An integrated Logistics and SCM framework for port performance benchmark (Bichou, 2007)

The rest of the panel (institutions, academics and consultants) encouraged this approach and praised Bichou's (2007) initiative. The combination of internal process modelling and external channel design was highly appreciated as well as the detailed aspect of the framework. On the other hand the panel called for the quantification of the approach.

Bichou's (2007) Logistics and SCM approach to port performance measurement has been highly praised by port professionals, academics, external consultants and international institutions. Even though it still has shortcomings, it is a valuable initiative towards the improvement and standardisation of port performance measurement; its widespread application can lead to easier port benchmark around the world. However Bichou's proposition has not been tested yet in the real world; it is still a theoretical suggestion that needs practical validation.

The logistics and supply chain management framework presents some similarities with the Prism performance framework; these lie in the common focus on stakeholders and processes which are two facets of the Prism framework. Indeed, through its channel classification, the Logistics and SCM framework helps consider all the port stakeholders. The three channels, namely logistics, trade and supply chain channel, offer a structured way to identify port stakeholders and help to avoid overlooking important elements. In a similar vein, Bichou's approach focuses on processes which represent an integral part of the Prism framework.

3. An adaptation of the Prism framework to the port industry

The Prism performance framework is a recent framework, a new approach to business performance measurement. In the early 2000s, several firms in UK adopted it for its advantages in comparison with the traditional frameworks. DHL international and the House of Fraser are examples of successful implementations of this methodology (Neely et al., 2001).

The maritime port industry, however, did not experience yet such implementations. It is the author opinion that this framework can help standardise the approach of port performance measurement, and therefore offer a basis to port benchmark. The different facets will create common points of interest for ports and will guide the performance measurement process by creating a structured way to identify the critical elements to measure.

Due to the absence of port performance measurement frameworks in the literature, I found it useful to suggest one. Given the advantages of the

Prism framework and the fact that it already made its proof in other industries, I believe that it can be adapted to the port industry. If we add to this the stakeholder orientation of the performance Prism framework which goes in line with the complex stakeholder environment surrounding ports, Prism presents itself as great alternative for port performance measurement. The following section provides an adaptation of Prism to seaports.

3.a. Facet 1: stakeholder satisfaction

There is no clear or widely accepted definition of the term "*stakeholder*". The classification of stakeholders is highly correlated to the purpose, context and circumstances, leading to a fuzzy understanding of who can be considered as a stakeholder and who cannot (Donaldson & Preston, 1995). In general, stakeholders can be defined as "*individuals or groups (companies, authorities, etc.) that have a definite interest in the existence and well-functioning of the activity or organisation concerned*" (Winkelmans & Notteboom, 2007).

In the context of seaports, stakeholders are numerous and a distinction between a narrow and broad analysis is necessary. In a narrow sense, port stakeholders are shareholders, managers, employees, port users, service providers and other economic players such as port customers (trading companies, shippers, importers, exporters), industrial companies (power plants, chemical companies, assembly plants, etc.), supporting industries (ship repair, inspection services, towage and pilotage services, ship chandlers, waste reception, etc.). If we consider the broader perspective of port stakeholders, we will add community stakeholders such community groups, environmentalists, civil society, the general public, the press and other non-market players such as regional and national institutions or policy makers (Banomyong, 2007).

According to the Prism performance measurement framework, stakeholder satisfaction is the first facet. Hence, metrics measuring this aspect are essential. These need to address all the port stakeholders in order for the framework to be a holistic and comprehensive approach. Most traditional approaches only considered a very narrow view; they only measured internal port productivity and ignored many stakeholders. The PPRISM project (ESPO, 2012) is one of the rare initiatives that took a global stakeholder view; indeed it considers economic trends, socio-economic impact, environmental measures, logistics metrics and port governance, thus addressing diverse port stakeholders.

Metrics needs to be adapted to stakeholders' needs. Every single stakeholder must have measures that can reflect and assess its satisfaction. In this regard, environmental measures are used to assess environmentalists' satisfaction, financial metrics and more precisely profitability measures are of prime interest for shareholders and managers, indicators related to the level of service provided are important for port users, customers and service providers, and finally civil society, general public and the government can be interested by the impact of ports on economic growth and employability.

Port literature and port performance measurement practices considered a wide range of stakeholders. However, this practice is flawed by the fact that these are rarely considered simultaneously; on an individual basis, each port considers a set of stakeholders that is incomplete, however if we look at all ports around the world we can conclude that almost all stakeholders have been considered. One stakeholder, that is not less important than the others, did not receive much attention from academics and practitioners, namely employees. Neither port authorities measured employee satisfaction nor researchers considered this aspect of stakeholders. This dimension can be measured through metrics such as employee retention or through regular surveys.

Stakeholders can evolve over time. No list can be considered definitive; some stakeholders can be added to the list while others can be removed.

These changes generally result from modifications in the global environment – economic, competitive and cultural. For this reason, it is important to have a stakeholder relationship management system that allows monitoring (Winkelmans & Notteboom, 2007). Omitting this function can lead to neglecting important stakeholders and thus not measuring the right metrics.

3.b. Facet 2: strategy

The 2nd facet of the Prism performance measurement framework being strategy, ports need to define their strategy in order to deliver value and satisfy stakeholders. Generic port strategies are developing and maintaining world class infrastructure, retaining and growing market shares, improving technology and achieving sustainability, optimising land use, creating a positive workplace culture, increasing stakeholder and community awareness and support, and finally strengthen financial performance (The port of Los Angeles, 2012). Appendix C provides a detailed example of a port strategic plan (Port Everglades, 2009).

Metrics used in ports should address these points. As for the 1st facet of Prism, these elements are already widely used in the port industry but unfortunately in an inconsistent way. Only the point regarding the creation of a positive workplace culture has been ignored by academics and practitioners. On the other hand growth of TEU, profitability metrics, environmental measures and technology related ones (crane density, crane technology, etc.) are all examples of metrics used for this facet of the Prism framework.

3.c. Facet 3: processes

The 3rd facet that constitutes the Prism framework is the processes. All port processes need to be identified first, then specific measures to assess their performance need to be determined. The following processes are a non-exhaustive list of port operations: Pilotage, towage, mooring/unmooring, loading/unloading, warehousing, custom clearance, administrative operations, minor operations, etc.

This facet of the Prism framework has been extensively addressed by the port industry professionals as well as from scholars. Given that the traditional approach is based on internal port efficiency and productivity, the process facet is the aspect that was most addressed in traditional port performance measurement frameworks. All the productivity metrics measure the performance of port processes; whether they are related to berths, yards, hinterland or administrative procedures, they assess the efficiency of a process. As for the previous facet, process metrics are not used consistently and need to be used in a more standardised way.

3.d. Facet 4: capabilities

The 4th facet of Prism is capabilities; these can be defined as a combination of people, practices, technology and infrastructure that allow the execution of processes. Given that this concept is new, this facet is the least widely understood (Neely et al., 2001). In the seaport industry, capabilities are employees, contractors, 3rd and 4th party logistics providers, cranes, equipment, forklifts, ERPs and specialised software, CCTVs, scanners, X-rays, control equipment, berths, total port area, warehouses, roads, gates, rails, intermodal connections, procedures (SOPs), management rules, governance, etc.

Metrics relative to port capabilities are often used in port performance measurement. However, some of them do not enjoy a widespread and global use. For instance, while cranes, berths and warehouses are widely assessed by port authorities, other capabilities such as the security related ones (CCTVs, scanners, X-rays and control equipment) or governance and management related ones are less addressed by academics and professionals. Indeed, the HKMD (2006) considered the damage per 1000 TEU which have neither been assessed by most of the top 20 major ports nor suggested by scholars. Same thing applies to governance and intermodal connectivity which were suggested by the ESPO (2012) in its PPRISM project but not yet widely considered by practitioners. For this reason and in order to have a holistic performance measurement framework, all capabilities have to be included in the assessment methodology.

3.e. Facet 5: stakeholder contribution

The last facet of the Prism framework is the stakeholder contribution. This aspect can be considered as opposite to the 1st facet. They both assess the relationship between the organisation and its stakeholders; the 1st facet focuses on the contribution of the organisation to the stakeholders, however the second looks at the contribution of stakeholders to the organisation. These two facets define a symbiotic relationship between the stakeholders and the organisation. This aspect is a characteristic of the Prism Performance framework; it is a unique element that differentiates it from all the performance measurement frameworks that were proposed in the literature (Neely et al., 2001). Stakeholder contribution can be conceptualised for employees, for instance, by the provision of suggestions and ideas or for environmentalists by the presentation of greener and more sustainable practices.

This aspect has never been considered neither in the port related literature nor by port professionals. Given its novelty, it has not even been widely considered in other sectors. Both DHL international and the House of Fraser adopted this framework. For more details about these two cases refer to Neely et al. (2001).

Stakeholder contribution needs to be measured in order to assess the level of synergy and symbiosis between the organisation and its stakeholders. As one of the determinants of performance, the nature of this relationship is very important to monitor. Metrics that can be used in this regard are number of employee/suppliers/service providers' suggestions and new ideas, number of suggestions from community stakeholders, reinvested benefit from shareholders, number of projects initiated by managers, etc. At the same time, the quality and efficiency of the relationship can be assessed through metrics such as the number of suggestions implemented as a percentage of total suggestions or the percentage benefit reinvested.

3.f. Discussion

The Prism performance framework with its stakeholder orientation – 1st and 5th facet regarding stakeholder satisfaction and stakeholder contribution – offers a comprehensive approach to port performance measurement; it allows a multi-dimensional assessment of all the aspects of a port. In addition, this unique methodology permits the evaluation of the relationship between the port and its stakeholders. The Prism performance also avoids the shortcomings of the previous performance measurement frameworks as discussed in the previous section.

Prism performance framework, in addition to being multi-dimensional and allowing a transversal measurement of port performance, goes in line with Pallis & Vitsounis (2008) suggestion of incorporating externally generated data when measuring port performance. The stakeholder orientation, by nature, requires external interaction with every single element in order to measure the overall performance.

Given all its advantages and potential benefits on port performance measurement, Prism should be used more widely in this industry. A standardised approach needs to be created in order to form a common basis for performance measurement and thus facilitate port benchmark around the world. However, if this study suggests a global use of the Prism performance framework, more work need to be done in order to determine the appropriate metrics to be used for every facet of the framework. Most of the commonly used indicators already fit in the Prism framework, however some parts have not been considered by academics and practitioners such as the stakeholder contribution facet.

V. Benchmarking

1. A background on port benchmark

"Benchmarking can be defined as a process for improving performance by constantly identifying, understanding and adapting best practices and processes followed inside and outside the company and implementing the results. The main emphasis of benchmarking is on improving a given business operation or a process by exploiting "best practices", "not best performance"" (Neela, 2002). In other words, benchmarking is a performance improvement process based on a comparison with best practice businesses. There are different types of benchmark; these are presented in Appendix D.

Port benchmark refers to the application of the benchmarking concept to ports. It can be applied either to a whole port or to part of it, a certain function or a specific operation. Gordon Rankine (2003) links a good benchmark to the availability of data issued from practical experience rather than theory and academic research. He also adds that industry generated data allow identifying best practices and determining targets. Generally data is collected from trade associations and organisations with international experience. Historical data is also very important since it permits benchmarking against its own past performance and assess the impact of past strategies and decisions.

Benchmarking can be applied to identical and similar processes making it a straightforward practice, but it can also be used laterally across different sectors, called then generic or process benchmarking (Rankine, 2003). For instance, ports can benchmark against world class manufacturing warehouses in order to improve their warehousing operations. Bichou (2007) pinpoints the fact that process and generic benchmarks are scarce or even inexistent in the port literature.

Even though port benchmark has not been yet widely addressed by scholars and professionals, container terminal presents more adequacy to this practice. While a common agreement is reached on the fact that ports are very diverse and different from each other, container terminals are narrower and present common operations. As a result, if ports in general do not offer a common basis for comparison, container terminals allow the use of industry standards for benchmark. Their management shifted to a numbers game with performance indicators, frequently considered as benchmark. However, there is no single approach that can be applied to all terminals. In this regard, Patrick Fourgeaud says that "*in most cases, it is not possible to determine benchmarks which would be applicable for any port, and that all expressions of port performance do not address the same requirements. Therefore, carefully identifying problems to be monitored and taking into account the main characteristics of the commercial activity should lead to more accurate indicators and targets*".

In order to benchmark container terminals, values should be assigned to a series of factors. When considered as a whole these values reflect the terminal's performance and identify its weaknesses. These can be overcome by analysing what competitor ports with better performances do differently and try to imitate them or adapt their way of doing. This practice allows evaluating whether labour and capital resources are used in an optimal way or not. Therefore, it allows delaying capital expenditure for new equipment and infrastructure when efficiency can be increased to improve performance.

Before considering port or terminal benchmark, it is essential to keep in mind that this practice depends on many factors such as type of trade, size of terminal and local factors. These factors are very important to take into consideration in order to ensure a quality output and avoid misleading results.

Even though mega terminals with high throughput, such as Rotterdam and Singapore ports, should always be examples to follow due to the way they shaped the state-of-the-art systems and equipment to meet their needs, benchmark should first start with direct local competitors of similar size and then move to larger ports, in different geographical areas to embrace best practices.

Every port is unique and exhibits its own constraints; whether these are relative to its size, shape, linkages with the hinterland, multimodal connections, navigation or governance, they make each individual port different from another. One example that highlights this consideration is the fact that crane productivity has a direct impact on the percentage of container offloaded and loaded. Given that crane moves per hour is highly dependent on the technology used, which in turn depend on the location of the port, benchmarking across boarders can sometimes mislead. For this reason, when gathering data, it is essential that information related to local factors and specifications is available.

Port benchmark can be applied on various aspects of terminals. It can focus on charges, level of service or productivity of labour and capital; consequently, we can have three types of benchmark according to the focus.

Data is generally collected through trade directories, annual reports, marketing information and interviews. Good sources of data on terminals are available in publications such as "*OECD's Bench Marking of Intermodal Freight Terminals*" (2002), "*Global Container Terminals*" (2002), "*International Benchmarking of the Australian Waterfront*" (1998) or "*Port benchmark for assessing Hong Kong's maritime services and associated costs with other major international ports*" (2006).

2. Rankine's Benchmark – an industry standards approach

According to Rankine (2003), in order to have relative figures and more significant numbers, it is better to use the ratio throughput to available quay length, number of quayside cranes or to the area of the terminal. This approach offers a more comprehensive benchmark rather than just using the traditional throughput or volume; it translates how well a terminal is performing regardless of volumes operated. The output of this benchmark can help decide whether a terminal needs to expand and invest capital or whether performance improvement is simply possible through an increase in productivity.

For this reason, Rankine's benchmark only considered Productivity benchmark. He believes that productivity metrics that have to be considered can be classified into vessel measurements, yard measurements, gate measurements and equipment measurements. These measurements are explicated in more details in table 6.

Table 6: Productivity measures used in productivity benchmark by Rankine (2003)

Type	Description
Vessel measurement	Number of lifts per crane operating hour
	Average delay per vessel departure
	Number of lifts per vessel hour
	Number of lifts per quay labourer hour
Yard measurement	Average truck cycle time
	No. lifts per "yard crane" operating hour
	Net container lifts per gross container lifts
	TEUs stored per hectare of terminal
	Mean storage dwell time
	Mean stack height
	Number of lifts per yard labourer hour
Gate measurement	Entry gate delay per arriving truck
	Exit gate delay per departing truck

Type	Description
Gate measurement	Trucks per gate per operating hour
	Trucks per gate labourer hour
Equipment measurement	Equipment availability – available/required
	Mean time between failures
	Mean time to repair per failure

It might be harder than it seems to benchmark against these measurements for two reasons; first there is no industry standards or reference point to compare with, second it is sometimes difficult to collect data from comparable ports. However, it is still useful for a terminal to compare with its own past performances. Another reason that Gordon Rankine (2003) did not mention is the fact that methods for measuring performance indicators vary between ports.

Gordon Rankine (2003) also identified other metrics that are commonly used in productivity benchmark; these are workforce productivity (TEU/employee/year), quay crane productivity (TEU/crane/hour), berth productivity (TEU/m of berth length) and yard productivity (TEU/hectare of yard). He also recognised some less popular measurement used in productivity benchmark such as yard equipment productivity (TEU/unit/hour), Vessel turnaround (hours), Berth occupancy (% age), Dwell time in yard (days), Vehicle turnaround time (minutes) and loss or damage (per 1000TEU). In what follows some industry standards will be provided regarding these metrics as well as how to measure them. These can provide a basis for benchmarking container terminals.

Labour or workforce productivity is generally measured by dividing the TEU per annum by the total number of staff employed in the terminal. Drewry (2002) provides industry standards for medium-sized[3] terminals

[3] Medium-sized terminals: 210.000 TEU per annum

and large[4] terminals; for medium-sized terminals the figures are around 900 TEU/man, for larger terminal they can rise to 1.100 TEU/man.

Generally, low figures are synonym of the necessity to implement better training, clearer working procedures and the optimisation of staff utilisation (Rankine, 2003). However, as every port has its peculiarities and its specific manpower issues, and since the industry standards measured by Drewry (2002) are based on global figures, it is essential to investigate deeper taking into account dockside, yard, gate and administration staff. This confirms Rankine view stating that local factors have to be taken into consideration. For instance, in terminals where robotics are extensively used, the staffing level is lower; which have to be taken into account to avoid misleading interpretations.

When it comes to yard productivity, it is defined as the ratio of TEU handled per annum to the total area of the terminal. This metric offers the advantage that both annual volumes and total areas of terminals are easily accessible, in contrast with dwell time and vehicle turn-around that are not always easy to access to (Rankine, 2003). Therefore this benchmark can be applied directly to assess ones position in regards to competitors. The industry standard (Drewry, 2002) is considered to be 20.000 TEU/Hectare/year. In larger ports an increase by 50% can be observed.

This indicator was, however, severely criticised by Bill Mongelluzzo (2010) as stated earlier. Ports with large area and using low stack height will return low figures for yard productivity. This does not mean that these ports are inefficiently managed; it can be that they have large available spaces and should be interpreted as the presence of room for extension. On the other hand, some ports such as Hong Kong and Singapore have limited spaces and are obliged to proceed through high density stacking techniques and advanced logistics systems (Rankine, 2003).

[4] Large terminals: 500.000 TEU per annum

The dwell time is a measure of the performance of the clearance procedures; it measures the time between delivery and dispatch. Delays can result due to the terminal or regulatory authority procedures and requirements. In practice, a dwell time between 5 to 7 days is deemed acceptable. Generally, ports allow 3 to 4 days before applying charges for importer’s goods (Rankine, 2003). This is why this metric is of prime interest for shippers.

Measuring the average dwell time can be misleading; indeed, as export dwell time is considerably shorter than import dwell time, it is very important to consider the nature of the activity and the operations. It is also important to take into consideration the local practices and customs which have a direct impact on the dwell time.

One metric that have not been considered by all the academics and professionals is the vehicle turn-around time. It measures the time spent by vehicles collecting or discharging their cargoes. It is a good measure for the efficiency of the gatehouse and yard procedure (Rankine, 2003). This performance indicator provides a more holistic view. As ports are considered as supply chain and logistics hubs (Bichou, 2007), this metric goes directly in line with this consideration. An average vehicle turn-around time from entry to exit is between 25 and 30 minutes. It can decrease to around 10-15 minutes in large single user terminals.

This metric exhibits one inconvenient; it is of little interest to port customers. Sometimes trucks are stuck in traffic outside the gates, leading to delays. Even though this area is out of the control of the port , it is a vital area of the terminal business and improvement there are essential to enjoy full benefit of low vehicle turn-around time. For this reason, Bill Mongelluzzo (2010) suggests the use of the metric delays at gate.

Another metric that have not had much attention in the literature and by professionals is the loss or damage. This indicator gives the amount of

TEU per annum that were damaged, lost or stolen as a percentage of the total TEU handled in the terminal. Even though this metric is not exclusively related to productivity, it gives an insight on whether insufficient resources are applied to security or not (Rankine, 2003).

Berth productivity is defined by Rankine (2003) as being the total amount of TEU handled at berth divided by the length of the quay berth. This performance indicator, in contrast with berth occupancy and crane productivity, is easily computed and data is widely available. Appendix E summarises the berth productivity in some of the major European ports.

An industry standard has been established for berth productivity. It is around 1000 TEU/m and it serves for terminal planning. The European average is 850 TEU/m and in the states it is around 550 TEU/m. Some exceptions exist such as Hong Kong port which achieves 1500 TEU/m.

Quay crane productivity is measured by the number of move per ship working hour. In traditional container terminals 20 to 25 moves per ship operating hour is a normal value. This metric measures the performance of the whole system operating the crane, and not the crane itself. It is dependent on the type of crane and the level of technology used (Mongelluzzo, 2012); the best-in-class cranes (Post Panamax gantry cranes) can achieve between 35 and 45 moves per hour. Crane productivity is also correlated to some other factors such as the size of vessel and reliability of the crane.

Even though Rankine (2003) acknowledges the existence of three types of benchmark, namely charges, level of service and productivity benchmarks, his study only focuses on productivity benchmark. This aspect of Rankine’s study confirms the theory of Pallis & Vitsounis (2008) stating that studies only focus on internal operations; they do not consider all the stakeholders of a port and neglect the external data.

Rankine (2003) provided industry standards for some of the indicators he considered as important. This is an important step towards making port benchmark consistent as no industry standards existed before. Even if the standards suggested by Drewry (2002) are global and do not take into account local considerations, these remain significant and present a good basis for benchmark. Adaptations to local, regional and port-specific conditions need to be undertaken in order to achieve great and useful results.

3. Hong Kong benchmark

The Hong Kongese marine department, in its document "*Port benchmark for assessing Hong Kong's maritime services and associated costs with other major international ports*", performed a port benchmark in order to position itself in terms of costs, productivity and level of service provided in comparison with the top 20 ports around the world (HKMD, 2006). This study presents two particularities; first it considers port charges that neither past port benchmark considered nor port performance indicators literature, and the fact that it focuses on the level of service provided which is one step towards considering external data as suggested by Pallis & Vitsounis (2008).

This port benchmark was realised through an extensive literature survey combined with publicly accessed data regarding port charges, container throughout (TEUs), characteristics of container terminals and port procedures and formalities. Interviews with shipping lines and agencies have also been done to have a better understanding of the port performance as seen by its users.

In terms of container terminal benchmark, one can divide the performance indicators used by HKMD into two categories: the first would be capacity and throughput related, however the second would be productivity measures.

The first measure that was considered is the total throughput. This approach is considered to be the most traditional benchmark approach. Another alternative has been used by HKMD (2006); it considers the growth of container throughput. Even though this metric is more significant than the total throughput, it is yet not perfect. Indeed, it does not reflect the port performance, but combines many factors such as the port authority endeavours to expand, the economic activity of the region, the attractiveness of the neighbouring ports and their performances, and the age or maturity of the port since newly developed ones tend to achieve greater growth. A detailed comparison is provided in appendix F.

Hong Kong port is considered to be a container terminal. Indeed, 74% of its operations are containerised cargo (in terms of weight). As a container terminal is characterised by its number of berths, quay length, maximum alongside depth, total terminal area and total storage capacity, HKMD used these factors as the basis for their benchmark. The aforementioned measures are mainly infrastructural, they don't assess how well a port is performing or how efficient and effective its operations are. Conversely, they just give a picture on the capacity of a port. These indicators can be useful when comparing market shares or to assess an expansion plan, however one cannot use them to compare ports. Table 7 summarises the range for each indicator among the top 20 ports around the world. A detailed comparison between ports in each of the measures is provided in appendix F.

Table 7: Capacity benchmark for the top 20 major container terminal (HKMD, 2006)

Measure	Max (location)	Min (location)
Number of berths	46 (Antwerp)	6 (Tanjung Pelepas)
Total quay length	12.120 Km (Antwerp)	2.138 Km (Ningbo)
Maximum alongside depth	17.6 m (Qingdao)	14.2 m (Shanghai)
Total terminal area	6161 TSM[5] (Los Angeles)	757 TSM (Ningbo)
Total storage capacity	204 Thousand TEU (Hong Kong)	0 Thousand TEU (Ningbo)

In terms of productivity measures, the HKMD benchmark used the following metrics: Productivity per meter quay length, Storage capacity per terminal area and crane productivity. These indicators are more powerful than the one presented earlier as they offer an overview on how well or bad a port is performing independent from its size or the total throughput it handles. These measures have numerous limitations, however they remain more comprehensive than the previous ones. For instance, crane productivity depends on the technology used, the layout of the terminal as well as the type of ships (HKMD, 2006). In the same vein, productivity per area have been criticised as mentioned in previous chapters (Mongelluzzo, 2010). Finally storage capacity per terminal area depends on the stacking technique used and is thus different from one port to another, therefore limiting the ability to compare ports.

Productivity per meter quay length (or per area) is generally used for the ease of data collection; total throughput and total area or quay length are information that is, most of the time, available on ports' websites. Crane productivity, however, is more difficult to obtain and is not generally published. Table 8 summarises the range for each indicator among the top 20 ports around the world. A detailed comparison between ports in each of the measures is provided in appendix G.

[5] TSM = Thousand Square Meter

Table 8: Productivity benchmark for the top 20 major container terminal (HKMD, 2006)

Measure	Maximum (location)	Minimum (location)
Productivity per meter quay length	2866 TEU per meter (Shanghai)	488 TEU per meter (New York)
Storage capacity/terminal area	128 TEU per TSM (Qingdao)	0 TEU per TSM (Ningbo)
Crane productivity	40 moves per hour (Tokyo)	23 move per hour (Busan)

The HKMD benchmark did not solely focus on productivity in ports, but it also considered the financial aspect. More precisely, the study analysed the different port charges; these are harbour and light dues, pilotage, towage, mooring/unmooring and ancillary charges. Port related literature employs financial metrics, but in contrast with this study they focus on profitability. For this reason, the HKMD benchmark is considered as a unique and one of a kind.

Harbour and light dues are general port charges applied by port authorities for using the port. They are generally proportional to the vessel's tonnage and are not related to any specific port service. Pilotage charges are costs incurred following a pilotage service. These are usually determined on the basis of the ship's size and the distance under pilotage. Apart from harbour and light dues, pilotage charges, towage and mooring/unmooring, another category of charges exists known as ancillary charges. These include charges such as port clearance, port entry fee, maritime welfare, harbour cleaning and maintenance fees, VTS users fee, etc. Different ports use different charges, so ancillary charges are different among ports. Thus comparing these charges is not a rational practice, however it remains indicative. Table 9 summarises the range for each indicator among the top 20 ports around the world. A detailed comparison between ports in each of the measures is provided in appendix H.

Table 9: Port charges benchmark for the top 20 major container terminal (HKMD, 2006)

Measure	Maximum (location)	Minimum (location)
Harbour and light dues	$ 23800 (Antwerp)	$ 1238 (Port Klang)
Pilotage charges	$ 16600 (Antwerp)	$ 621 (Singapore)
Towage charges	$ 8181 (Rotterdam)	$ 1173 (Singapore)
Mooring/unmooring	$ 2500 (Antwerp)	$ 53 (Ningbo)
Ancillary charges	$ 6255 (Busan)	$ 12.5 (Hong Kong)
Total charges	$ 51461 (Antwerp)	$ 4876 (Dubai)

In addition to the port charges and terminal productivity, the HKMD benchmark took into consideration the services provided to visiting ships and port formality procedures within ports. While quantitative comparisons are not practicable on these criteria, these areas are covered by empirical analysis.

A panel of services is offered to vessels in order to ensure safe and efficient operations, and to protect the environment. Ports traditionally offer navigation services as well as bunkering, fresh water and garbage collection. However, modern ports offer more sophisticated services such as Vessel Traffic Services (VTS), Differential Global Positioning System (DGPS) and waste reception services.

The VTS service helps "*monitor and provide navigational advices to vessels, particularly within confined and busy waterways*" (HKMD, 2006). DGPS is an improved and more accurate version of the civilian GPS. Waste reception facilities allow discharging chemical waste accumulated in the vessel while ensuring environment protection.

Most of the aforementioned services are offered by most of the top 20 ports worldwide. Only a few exceptions in one or two services can be noticed. A detailed comparison between ports in each of these services is provided in appendix I.

Another dimension of port performance that has not attracted the interest of port literature, but which is an essential component of port efficiency is port formality procedures. These include inappropriate formalities, unclear rules, pre-arrival notification requirements, number of port required and port formality processing time. In the HKMD benchmark, this data was collected from shipping companies.

Most ports require 24 hours notification prior to ship arrival. Singapore and US ports present exceptions; whilst the former requires only 12-hour notice, the latter asks for 96 hours for security purposes.

The number of documents required by port authorities varies depending on the port. Amongst twelve of the top 20 ports for which relevant data was collected, the number of documents asked for range from four to seventeen. These documents can be the crew list, maritime declaration of heath, vaccination list, arrival declaration of dutiable stores, cargo manifest and general declaration, etc.

The port processing time times for formalities varies from one to seven hours. Two thirds of the world top 20 ports achieve formality procedures in less than two hours.

The HKMD benchmark is a successful example to follow; it is a comprehensive benchmarking approach. It includes a financial (port charges) viewpoint, an efficiency and productivity perspective as well as an investigation of the level of service provided. Two of the three factors examined are of prime interest for port users. This study is thus in line with Pallis & Vitsounis (2008) work encouraging external data. Even though it is not completely followed, and even if the approach lacks external focus, it is a valuable first step.

On the other hand the HKMD benchmark lacks some important points that are worth being considered. It did not follow a holistic stakeholder perspective as highlighted by the PRISM performance framework (Neely, 2002); in terms of financial indicators, it only took into consideration port charges and ignored profitability metrics. Environmental measures, as well, were ignored.

4. Implementation issues

Implementing a benchmarking initiative can be extremely beneficial to a company. Xerox case is a great example that illustrates how a company that was in a decreasing curve managed to improve quality, reduce costs, improve service delivery level and regain market shares (Neela, 2002). However, benchmarking is not exempt from obstacles. The most popular challenges that can be encountered in the implementation of a benchmarking methodology are data collection, difficulties to define objectives due to the large number of stakeholders and their competing interests (Ward, 2005), and finally resistance to change (Watson, 1971).

A large amount of data relative to seaports is available for public use; information can be found in ports websites, annual reports (when ports are publicly traded), from international and regional organisations, and port users and port authorities (Rankine, 2003 and Freiling & Huth, 2005). Nevertheless, most of the publicly accessible data is of little importance; it does not allow a thorough analysis or the assessment of efficiency and productivity. Benchmarking requires access to important and critical figures. This kind of data can be reached through alliances and cooperative relationships between ports. Organisations with cross-functional roles can also facilitate the collection of data (Bichou, 2007). Finally, the creation of a global benchmark initiative can also be a catalyst for a more widespread data sharing and thus facilitates global port benchmark.

Maritime ports are generally characterised by a multi-stakeholder environment; they have numerous stakeholders from different natures (Tongzon et al., 2009). This multiplicity and diversity among stakeholders results in a wide range of objectives; these may sometimes be competing.

In these circumstances, satisfying all the stakeholders at a time becomes unachievable. In this regard, having a system thinking and optimising the whole system instead of optimising each of its processes is essential. Bichou's (2007) Logistics and Supply Chain Management perspective proves successful in this regard. The object of the benchmark should be the improvement of the whole system instead of thinking about the interests of individual stakeholders.

Another challenge that can be encountered in any project in general, and for benchmark in particular is the resistance to change. As Deming says "*In my experience, people can face almost any problem except the problems of people*". Generally employee fear change; they prefer the status quo and they are unwilling to change their habits. Resistance to change results from social or cultural factors, personality traits, fear of the unknown and expectations of loss. In order to solve this difficulty, it is important to involve the employees in the diagnostic effort to understand the issue and feel its importance (Watson, 1971). Another solution is education and training. In this context, the ten-pillar ideal learning organisation model can be applied (Philips, 2003).

Conclusion

This project, through a literature review, studied the various performance indicators and metrics used by academics and practitioners. Research reveals that there is not a standard practice that has been agreed among ports, international institutions, and academics and expert in the field of maritime ports about what measures should be used and how to calculate them. Many authors analysed port performance indicators and port efficiency, but common conclusions have never been reached and the field remains characterised by a large consistency.

This paper addressed port performance indicators from different sources and diverse origins. It covered research papers and academics works, international organisations' conferences and publications such as the UNCTAD and the World Bank, professionals' viewpoints and publications like Drewry publications and the Journal of Commerce. This wide use of data confirms the inconsistency observed in the port industry in terms of performance measurement metrics.

Given the lack of clear performance measurement frameworks in the port industry, this paper attempts to fill this gap. Bichou's (2007) work was presented; in contrast with the traditional fragmented methodologies, it conceptualises ports from a logistics and SCM standpoint. The importance of externally generated data was also stressed in this paper (Pallis & Vitsounis, 2008).

Another attempt to further improve the port performance measurement practices was designed by the author; it is an adaptation of the Prism performance framework to the seaport industry. This framework has been judged appropriate given the complex stakeholder environment that surrounds the port industry.

This paper also presents and analyses a couple of benchmarks performed in practice. The first benchmark is a very interesting initiative by Rankine

(2003); it gives industry standards to help ports compare their performance. It has the specificity to be the first project in its kind. The second example is a benchmarking initiative performed by Hong Kong port that focuses on costs, productivity and service s provided.

This paper reviewed the existing literature regarding port performance measurement and attempted to fill the identified gaps, however it also comes with some limitations. This study focuses mainly on container terminals. These experienced a consistent growth since their introduction and became the most important type of cargo traded. Even though many of the performance indicators mentioned in this paper can be used in different types of terminals, the study is meant to address primarily container terminals.

Another limitation for this paper lays in the fact that it gives a partial view for benchmarking; it only considers performance measurement and comparison with competitors, and ignores the identification of best practices to benchmark against.

The adaptation of the Prism performance framework, even though judged appropriate and accompanied with numerous potential benefits, has its limitations. It is only an illustrative attempt to develop a port performance measurement framework and improve port management practices. It is not intended to be a conclusive result; it still needs testing and validation from both academics and practitioners.

One more limitation for this paper, and for port benchmark in general, is the fact that it does not consider process benchmarking; it is the benchmark of ports against best practices in different industry sectors. One reason why this type of benchmark has not been considered is that this work only focuses on the performance measurement and comparison as mentioned earlier. Another reason is that this practice has never been observed in the port industry (Bichou, 2007); Ports have only been compared to ports. Ports operations, such as warehousing, have never been compared to similar operations in other industries. More research should be done in this direction.

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Appendices

Appendix A: Ship's time in port

Appendix B: Individual metrics used in the literature

Appendix C: Detailed strategy of port Everglades (2009)

Appendix D: Benchmarking types

Appendix E: Berth productivity in some of the major European ports

Appendix F: Hong Kong container terminal capacity benchmark

Appendix G: Hong Kong container terminal productivity benchmark

Appendix H: Hong Kong port charges benchmark

Appendix I: Hong Kong port services benchmark

Appendix A: Ship's time in port

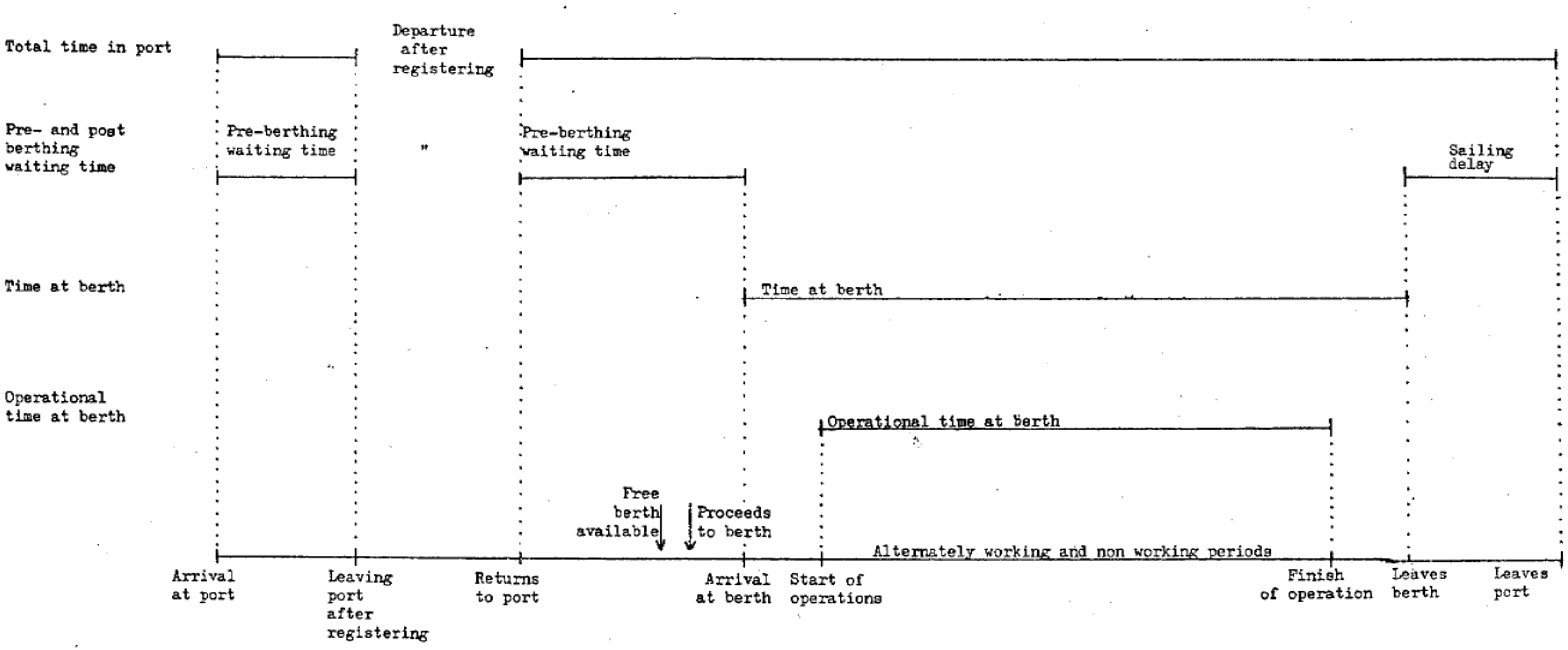

Figure A-1: Ship's time in ports

Appendix B: Individual metrics used in the literature

Table B-1: Individual metrics used in the literature

Category	Metric
Financial	Return On Investment
	Return On Asset
	Capital structure
	Short term liquidity
	Ancillary revenue as % of gross revenue
	Average days account receivable
	Capital expenditure as % of gross revenue
	Debt: equity ratio
	Growth in profit (before taxes)
	Port related profit as % of port related revenue
	Terminal charges as % of gross revenue
	Yield % on shares (if publicly traded)
	Average revenue per TEU
	Harbour and light dues
	Pilotage charges
	Towage charges
	Mooring/unmooring charges
	Ancillary port charges
	Total port charges
Capacity	Labour related
	Number of berths
	Number of cranes
	Terminal area
	Total quay length
Throughput	Total cargo handled
	Growth in TEU throughput
	Container throughout
	Number of passenger

Category	Metric
Stay time	Total turn-around time
	Average turn-around time
	Total turn-around time per cargo tonnage
	Total turn-around time per cargo composition
	Ship's waiting time for a berth
	Ship's waiting time at berth
	Hours of equipment downtime per month
	Average yard dwell time
	Departure cut-off time
Productivity	Crane throughput per machine hour
	Crane density
	Lifts per crane hour
	Berth throughput per square meter capacity
	TEU per acre
	Container port throughput (TEU/meter of quay/year)
	Gang output per hour
	Employee per tonne handled
Environmental performance	Carbon footprint
	Waste management and water consumption
	Environmental management systems
Other	Customer complaints per month
	Employee turnover rate
	Invoice accuracy (%)
	Overall customer satisfaction
	Stakeholder satisfaction
	Intermodal connectivity
	Maritime connectivity
	Hinterland related metrics

Appendix C: Detailed strategy of port Everglades (2009)

Table C-1: Strategy of port Everglades

1. Economic development	
1.1: Infrastructure development	1.1.1: Short-term infrastructure improvements
	1.1.2: Infrastructure maintenance
	1.1.3: Multi-purpose terminals
	1.1.4: Interconnected land uses
	1.1.5: Intermodal facilities
	1.1.6: Foreign-Trade Zone
	1.1.7: Future development
1.2: Cargo and cruise industry expansion	1.2.1: Marketing plans
	1.2.2: Marketing activities
	1.2.3: Private businesses
1.3: Land use compatibility and development regulation	1.3.1: On-port land uses
	1.3.2: Development consistency
	1.3.3: Consistency with County and municipal plans and regulations
	1.3.4: Land use amendments
	1.3.5: Historical and archeological resources

2. Transportation system efficiencies	
2.1: Deepwater access	2.1.1: Maintenance dredging
	2.1.2: New deepening and widening
	2.1.3: Disposal site development
	2.1.4: Dredge material management
	2.1.5: Hydrographic surveys
	2.1.6: Sand for beach renourishment
	2.1.7: Consistency with the State and Broward County *Comprehensive Plans*
2.2: On-port road and rail network	2.2.1: On-Port road improvements
	2.2.2: On-Port rail improvements
	2.2.3: Service and emergency vehicles
	2.2.4: Traffic monitoring
2.3: Off-port access and connectivity	2.3.1: Vehicular access
	2.3.2: Rail service and connectivity
	2.3.3: Sunport Intermodal Center and Automated People Mover
2.4:Transportation agency coordination	2.4.1: MPO Transportation Improvement Program
	2.4.2: FDOT District 4 Annual Work Program
	2.4.3: Broward County Capital Plan
	2.4.4: Florida Seaport Transportation and Economic Development Program

3. Environmental stewardship and sustainability	
3.1: Natural resource preservation and protection	3.1.1: Cumulative impacts on coastal resources
	3.1.2: Habitat inventory and protective policies
	3.1.3: Manatee habitat
	3.1.4: Mitigation plans
	3.1.5: Portwide best management practices
3.2: Estuarine quality	3.2.1: Estuarine system protection
	3.2.2: Avoidance and minimization of water-quality degradation
	3.2.3: Water quality monitoring
	3.2.4: Drainage facilities
	3.2.5: Tidal flushing and circulation
	3.2.6: Compliance with agency requirements
3.3: Water-dependent uses	3.3.1: Shoreline land uses
	3.3.2: Water access
	3.3.3: Facility redevelopment
3.4: Beaches and dunes	3.4.1: Coastal Construction Control Line
	3.4.2: Sand bypass system

3.5: Coastal High Hazard Areas	3.5.1: Coastal High Hazard Area designation
	3.5.2: Use of public funds
	3.5.3: Residential development
3.6: Plan implementation	3.6.1: Agency and stakeholder cooperation
	3.6.2: Interagency agreements
3.7: Sustainability	3.7.1: Energy-efficient vehicles and buildings
	3.7.2: Sustainable operations
	3.7.3: Climate change

4. Safety and security	
4.1: Protection from natural hazards	4.1.1: Flood Zone compliance
	4.1.2: Building code compliance
4.2: Hurricane-preparedness	4.2.1: Hurricane evacuation times
	4.2.2: Evacuation rotes
	4.2.3: Agency coordination
	4.2.4: Hurricane simulation exercise
4.3: Hazardous materials	4.3.1: Hazardous spill cleanup
	4.3.2: Oil spill contingency planning
	4.3.3: Timely information to public

4.4: Safe operating environment	4.4.1: Safety and health measures
	4.4.2: Compliance with health and safety standards
4.5: Port security	4.5.1: Port security plan
	4.5.2: Agency coordination
	4.5.3: Public access and traffic checkpoints
	4.5.4: Dockside control
	4.5.5: New technologies
4.6: Emergency management	4.6.1: Emergency management plan
	4.6.2: Emergency management coordination
4.7: Post-disaster redevelopment	4.7.1: Post-disaster redevelopment planning
	4.7.2: Post-disaster priorities

5. Intergovernmental coordination	
5.1: Coordination with other Broward County departments	5.1.1: Compatibility with Broward County's *Comprehensive Plan*
	5.1.2: Airport-Seaport coordination
	5.1.3: Infrastructure and utility capacity
5.2: Community, agency, and stakeholder coordination	5.2.1: Local communities
	5.2.2: Regional, state, and federal agencies
	5.2.3: Local and regional maritime, commercial, and industrial interests

6. Financial stability	
6.1: Budgetary process	6.1.1: Port revenues
	6.1.2: Business decision criteria
	6.1.3: Expense control benchmarks
6.2: Capital Improvement Plan	6.2.1: Annual 5-Year CIP updates
	6.2.2: 10- and 20-Year Vision Plans
6.3: Funding opportunities	6.3.1: Legislative and agency awareness
	6.3.2: State and federal grants
	6.3.3: Public/private partnerships and other funding
	6.3.4: Borrowing power

Appendix D: Benchmarking types

Strategic Benchmarking: Aimed at improving a company's overall performance by studying the long-term strategies and approaches that helped the 'best practice' companies to succeed. It involves examining the core competencies, product/service development and innovation strategies of such companies.

Competitive Benchmarking or Performance Benchmarking: Used by companies to compare their positions with respect to the performance characteristics of their key products and services. Competitive benchmarking involves companies from the same sector.

Process Benchmarking: Used by companies to improve specific key processes and operations with the help of best practice organizations involved in performing similar work or offering similar services.

Functional Benchmarking or Generic Benchmarking: Used by companies to improve their processes or activities by benchmarking with other companies from different business sectors or areas of activity but involved in similar functions or work processes.

Internal Benchmarking: This involves benchmarking against its own units or branches for instance, business units of the company situated at different locations. This allows easy access to information, even sensitive data, and also takes less time and resources than other types of benchmarking.

External Benchmarking: Used by companies to seek the help of organizations that succeeded on account of their practices. This kind of benchmarking provides an opportunity to learn from high-end performers.

International Benchmarking: Involves benchmarking against companies outside the country, as there are very few suitable benchmarking partners within the country.

Appendix E: Berth productivity in some of the major European ports

Table E-1: Berth productivity in some of the major European ports

Port	Bert productivity (TEU per annum per meter of quay)
Felixstowe	971
Rotterdam	884
Thames port	772
Southampton	663
Hamburg	622
Bremerhaven	604
Antwerp	412
Le Havre	252

Appendix F: Hong Kong container terminal capacity benchmark

Table F-1: Total throughput and throughput growth benchmark

Port	Throughput (Million TEU)	Growth 2001-2005 (%)
Singapore	23.19	48.93
Hong Kong	22.43	25.83
Shanghai	18.08	185.43
Shenzhen	16.2	219.12
Busan	11.84	46.67
Kaohsiung	9.47	25.59
Rotterdam	9.29	52.39
Hamburg	8.09	72.54
Dubai	7.62	117.6
Los Angeles	7.48	44.3
Long Beach	6.71	50.35
Antwerp	6.49	53.86
Qingdao	6.31	139.15
Port Klang	5.54	47.36
Ningbo	5.21	180.11 (2002-2005)
Tianjin	4.8	138.81
New York	4.8	44.74
Tanjung Pelepas	4.17	103.51
Laem Chabang	3.77	63.03
Tokyo	3.7	45.91

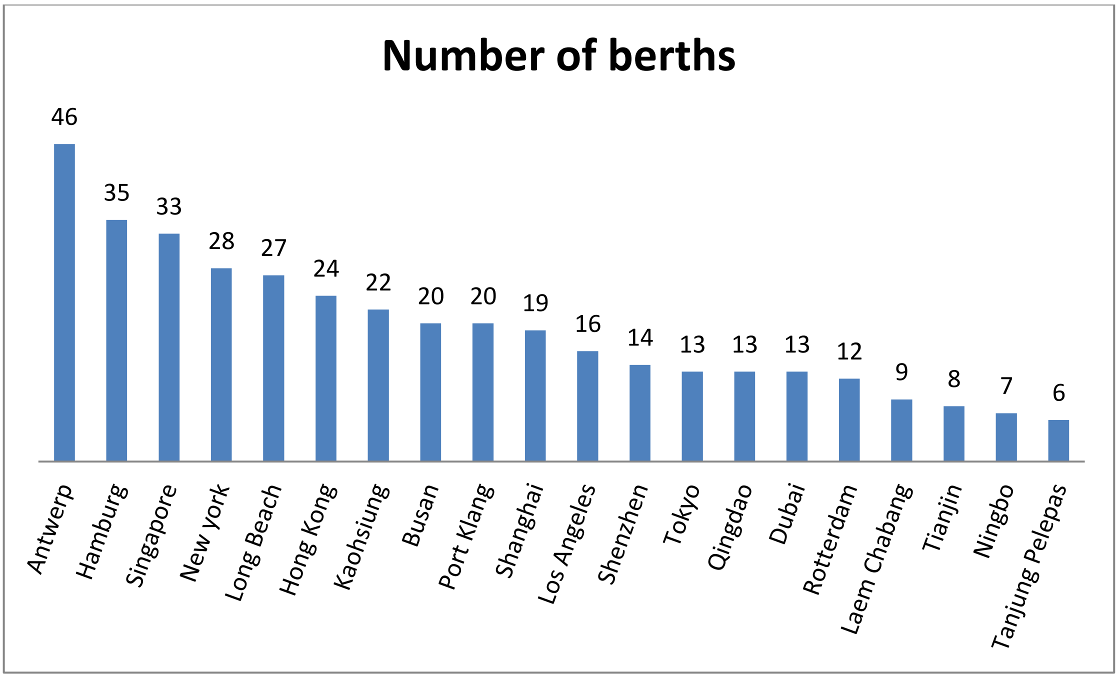

Figure F-1: Number of berths benchmark

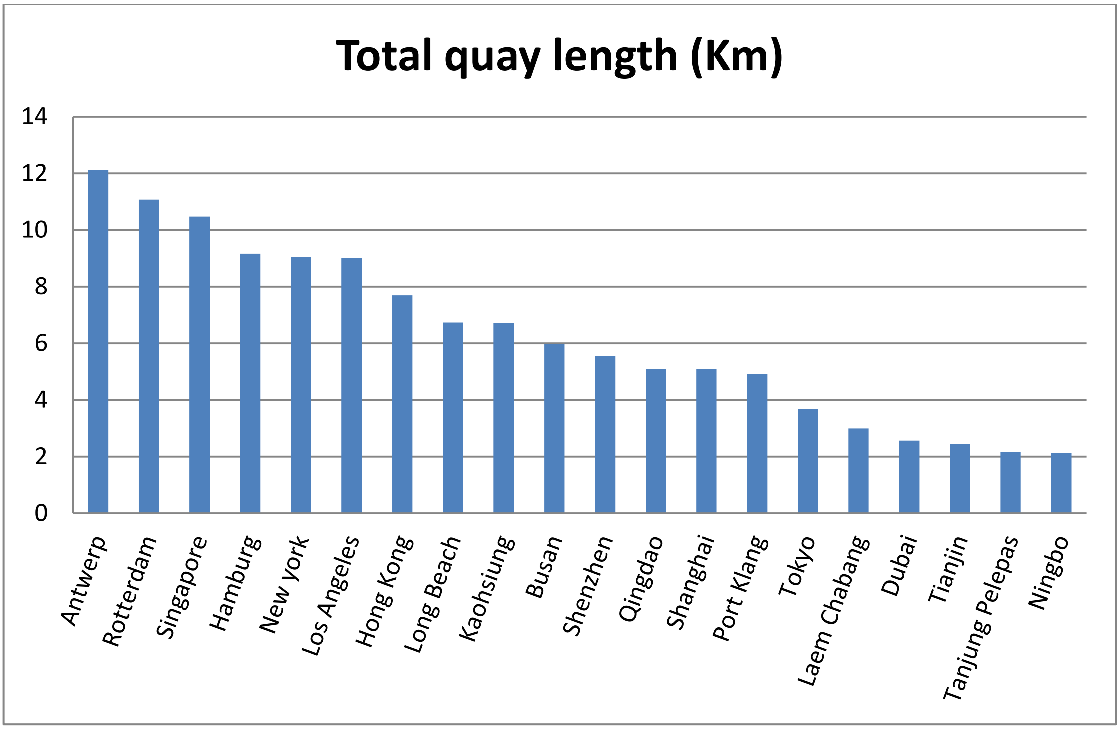

Figure F-2: Total Quay length benchmark

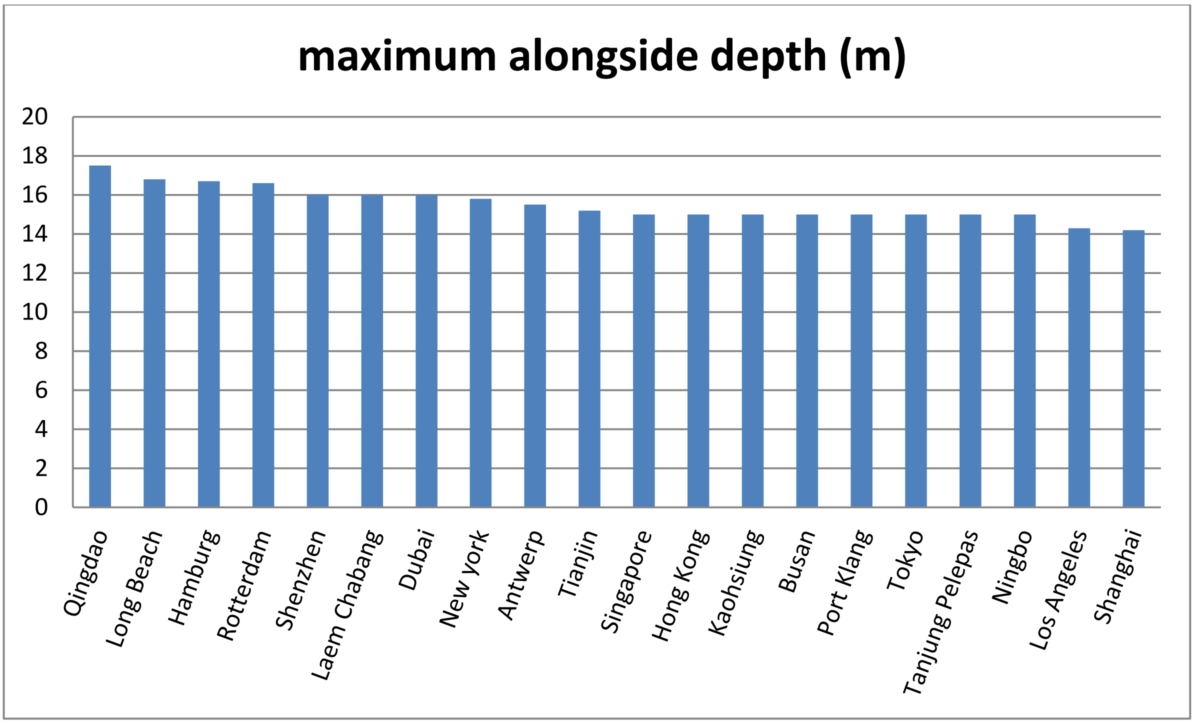

Figure F-3: Maximum alongside depth benchmark

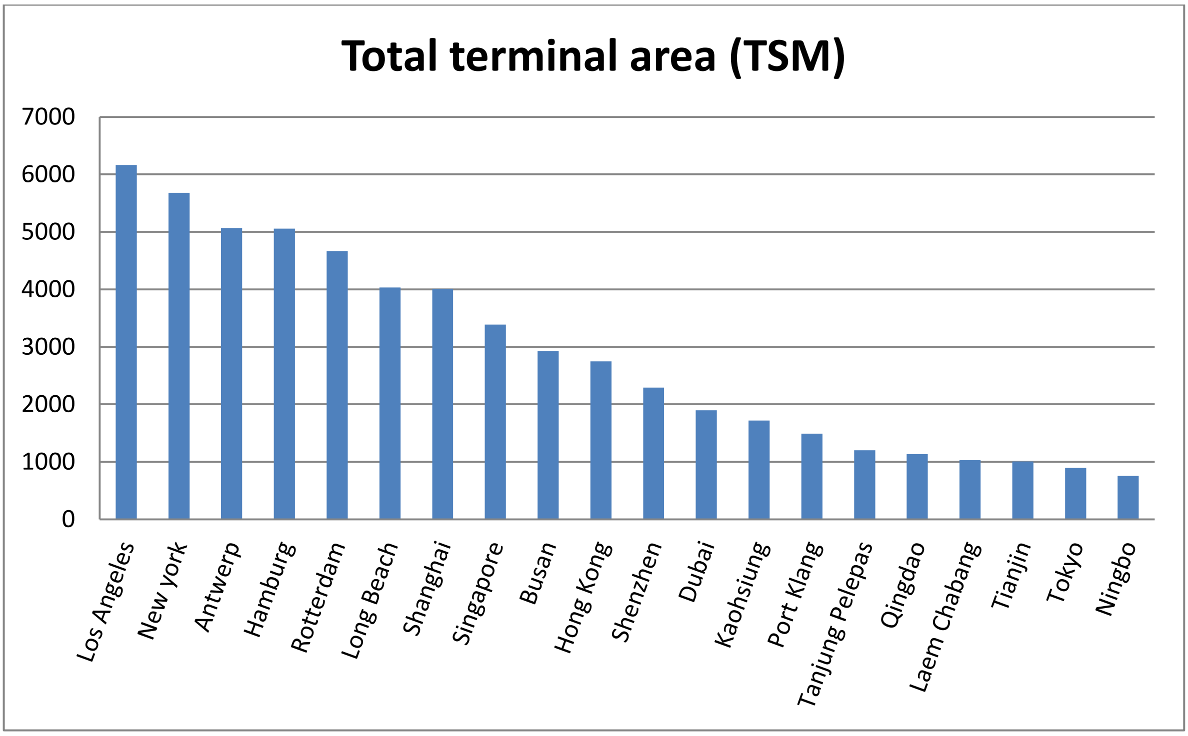

Figure F-4: Total terminal area benchmark

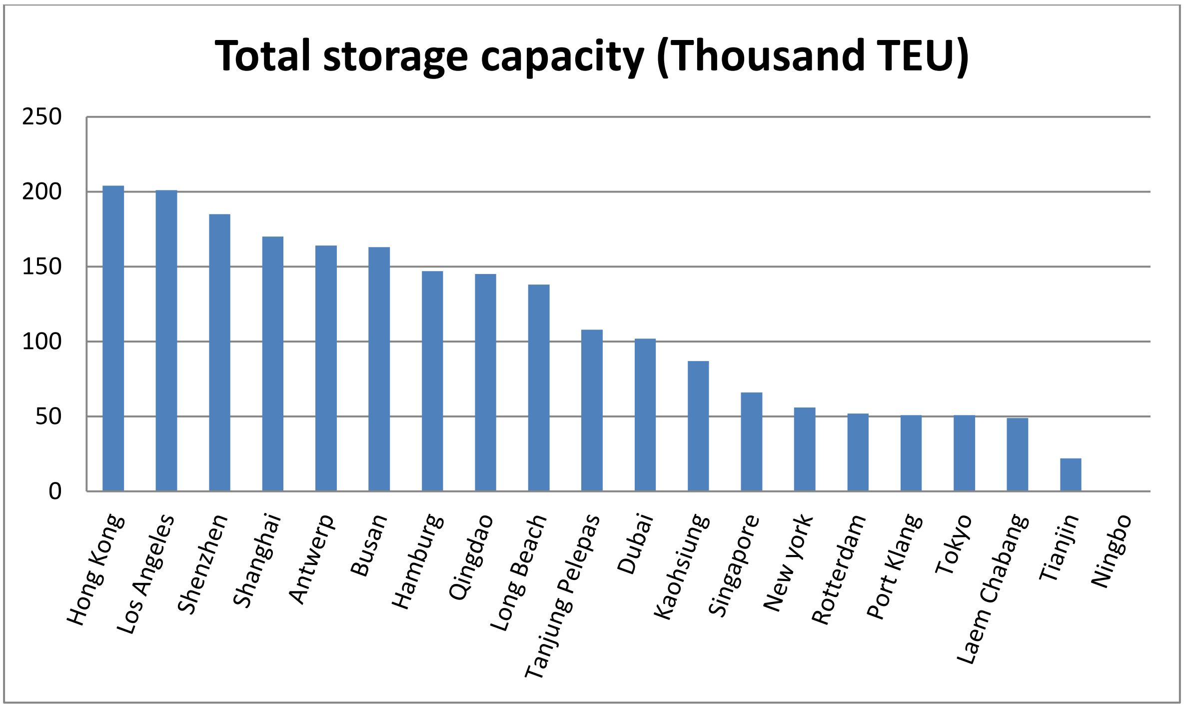

Figure F-5: Total storage capacity benchmark

Appendix G: Hong Kong container terminal productivity benchmark

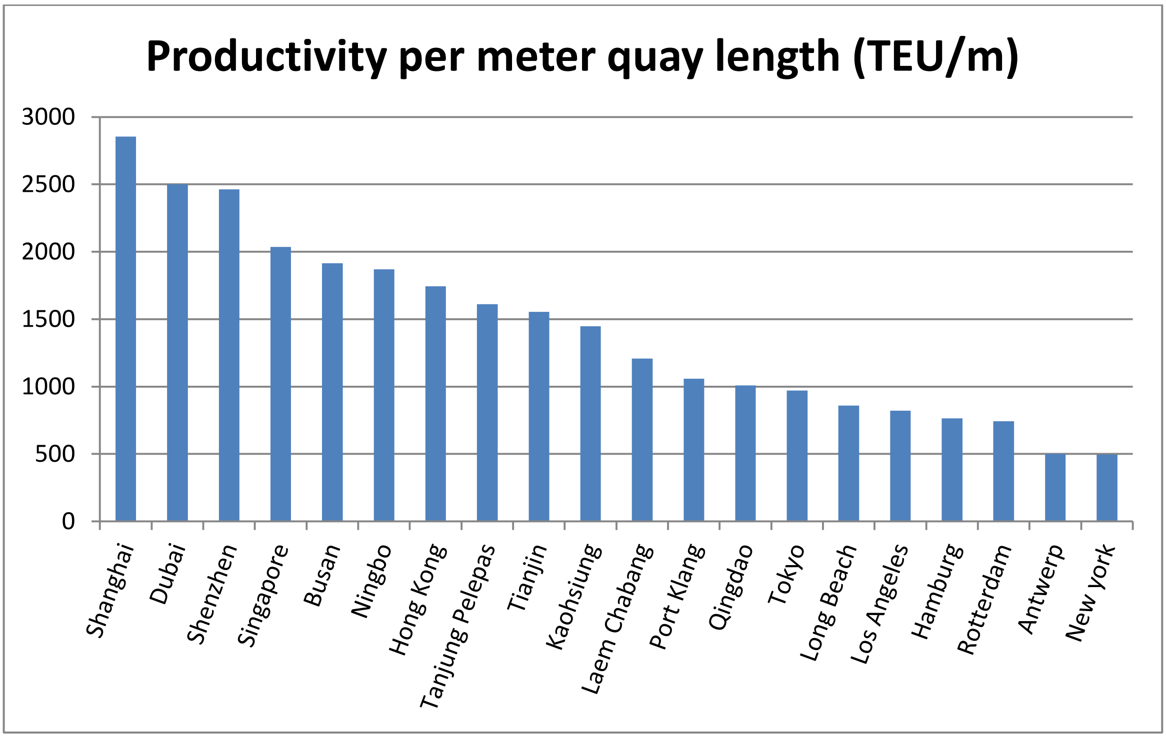

Figure G-1: Productivity per meter quay length benchmark

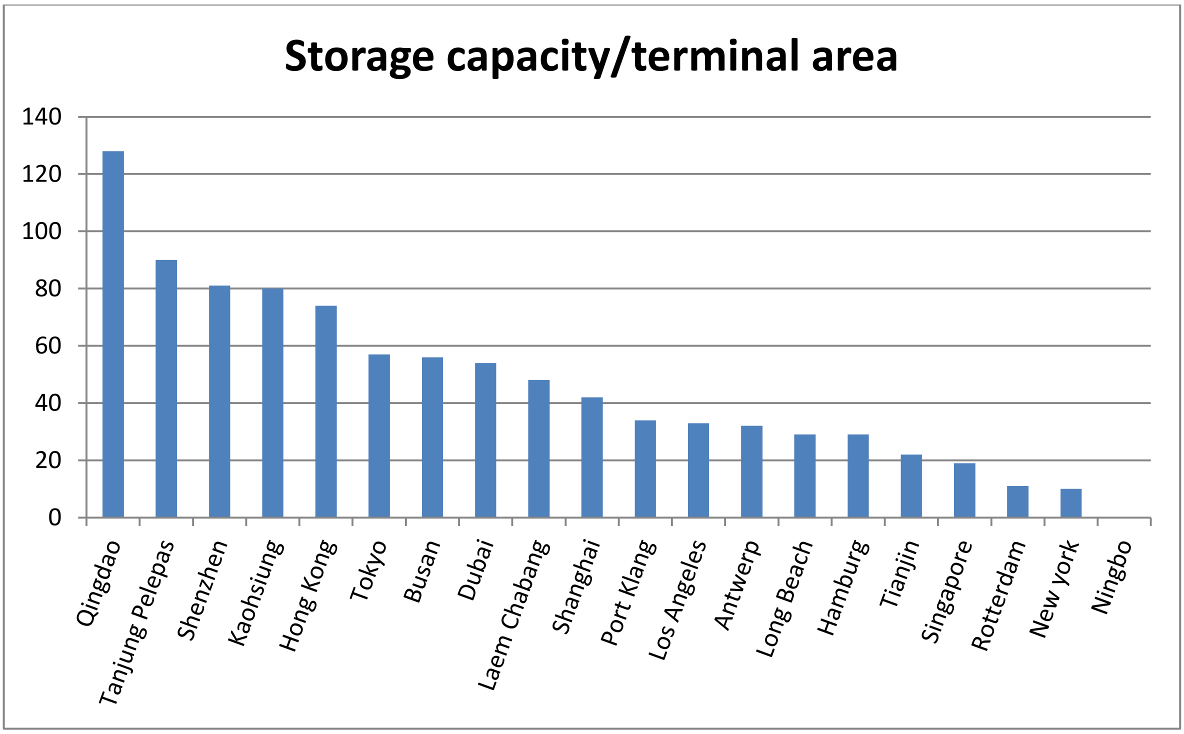

Figure G-2: Storage capacity/terminal area benchmark

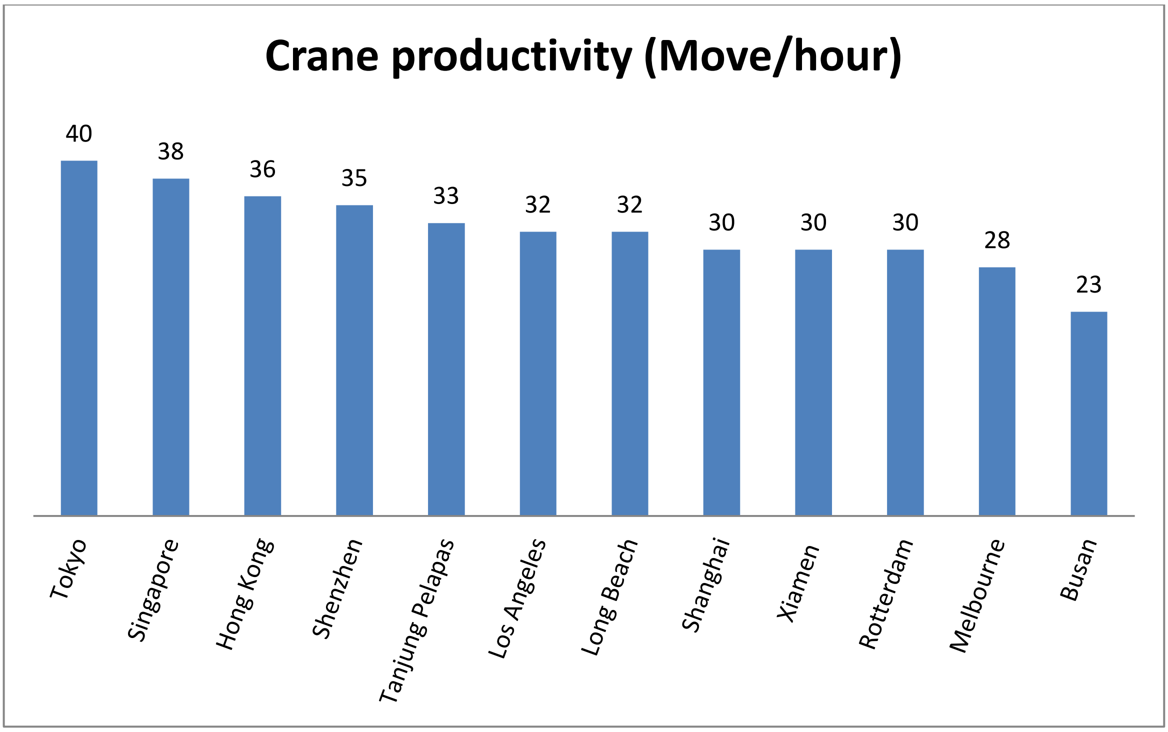

Figure G-3: Crane productivity benchmark

Appendix H: Hong Kong port charges benchmark

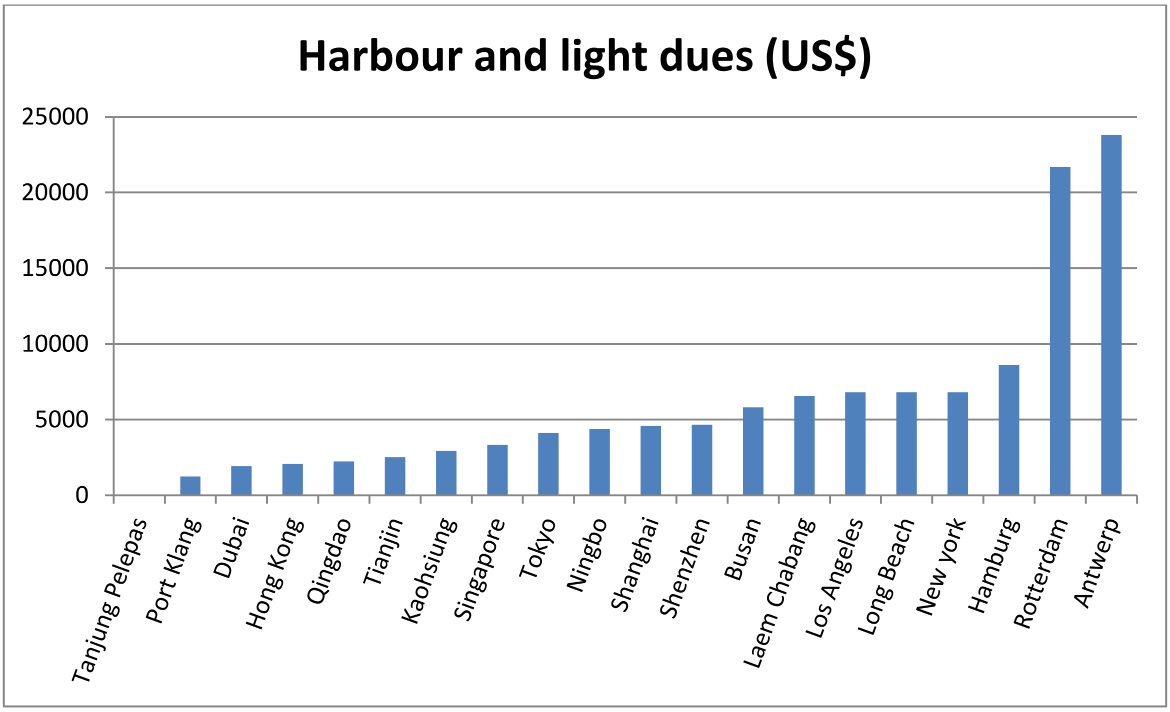

Figure H-1: Harbour and light dues benchmark

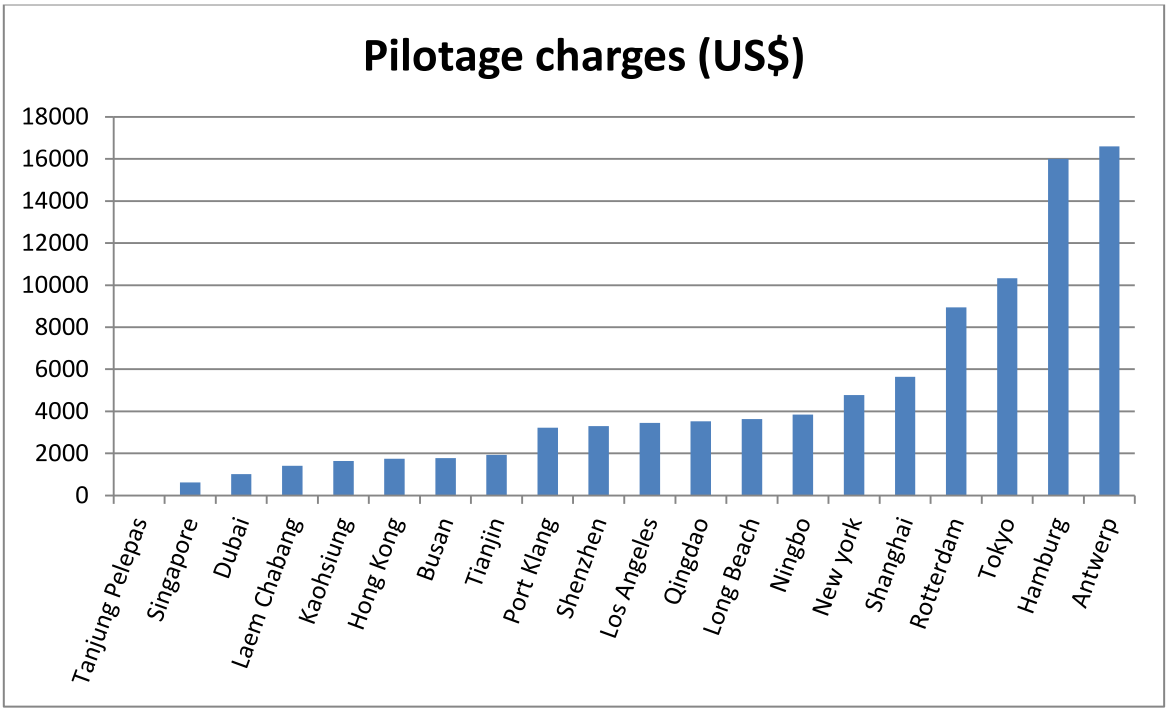

Figure H-2: Pilotage charges benchmark

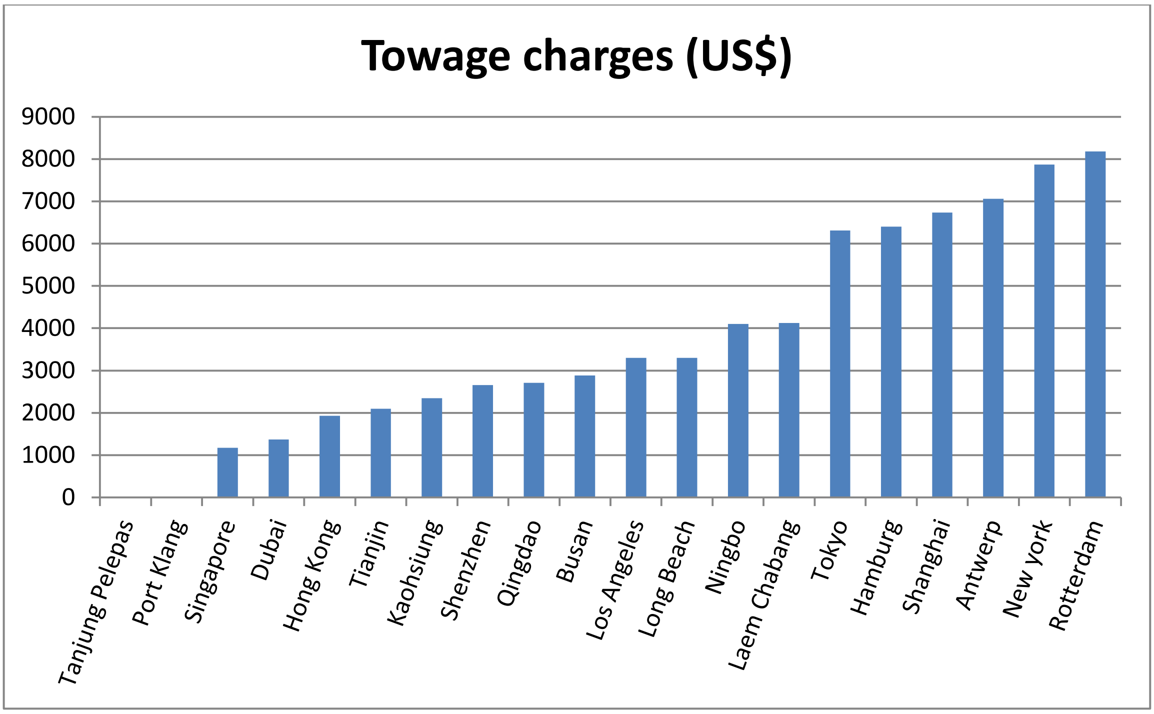

Figure H-3: Towage charges benchmark

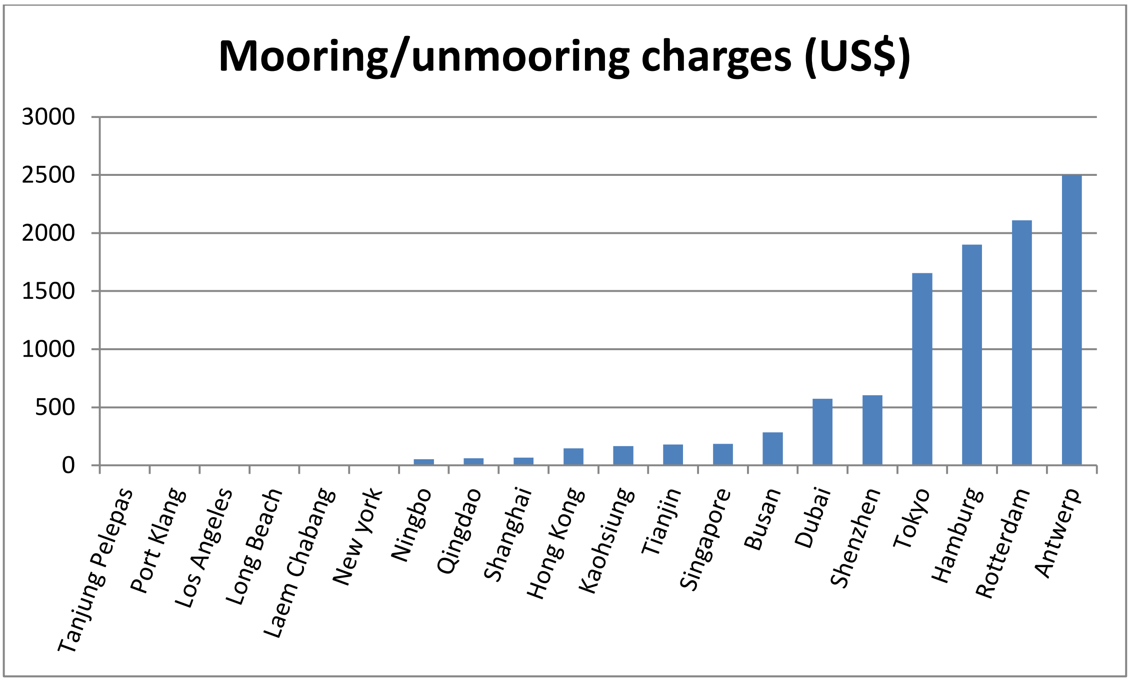

Figure H-4: Mooring/unmooring charges benchmark

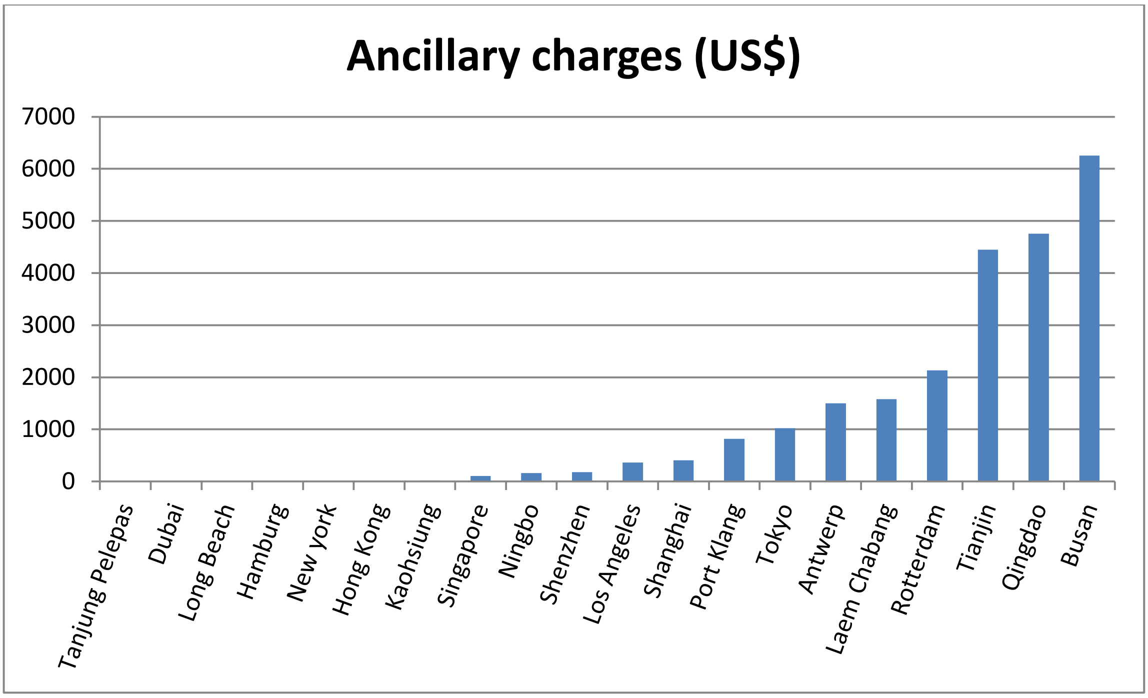

Figure H-5: Ancillary charges benchmark

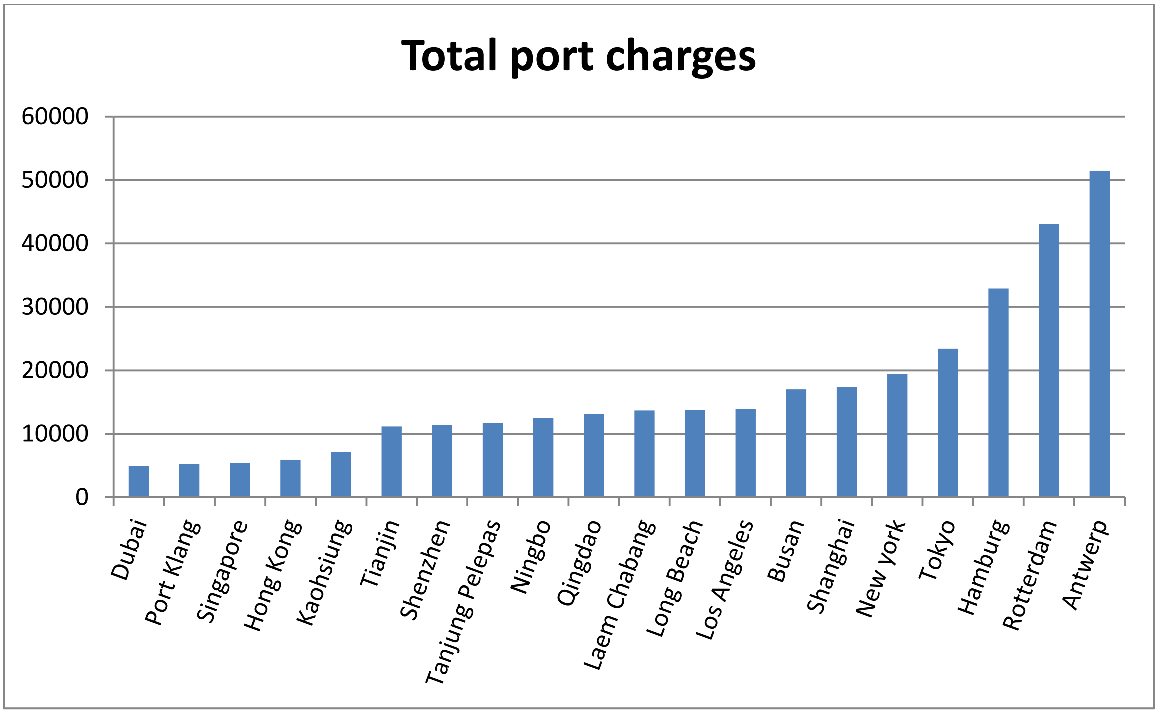

Figure H-6: Total port charges benchmark

Appendix I: Hong Kong port services benchmark

Table I-1: Port services benchmark

Port	VTS	AIS integration	DGPS	Waste reception facility
Hong Kong	Yes	Yes	Yes	Yes
Singapore	Yes	Yes	Yes	Yes
Shanghai	Yes	Yes	Yes	Yes
Busan	Yes	Yes	Yes	Yes
Rotterdam	Yes	Yes	Yes	Yes
Los Angeles	Yes	Yes	Yes	Yes
Hamburg	Yes	Yes	Yes	Yes
Antwerp	Yes	Yes	Yes	Yes
Port Klang	Yes	Yes	Yes	Yes
Qingdao	Yes	Yes	Yes	Yes
Tianjin	Yes	Yes	Yes	Yes
Tokyo	Yes	Yes	Yes	Yes
Long Beach	Yes	Yes	Yes	-
New York	Yes	Yes	Yes	-
Ningbo	Yes	-	Yes	Yes
Shenzhen	Yes	Yes	-	-
Dubai	Yes	Yes	-	-
Tanjung Pelepas	Yes	-	-	Yes
Kaohsiung	Yes	-	-	-
Laem Chabang	-	-	-	-