



## NEW INDICATORS TO MEASURE PORT PERFORMANCE

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### ABSTRACT

Throughput volume is the most widely used performance indicators in the port industry, but does not provide information on the (regional) economic impact of the port and the attractiveness of the port as a location for port-related industries. Therefore, port-related employment and value added are also used as port performance indicators (PPIs). Due to the ongoing commercialization of port authorities (PAs) and the increasing pressure of stakeholders on PAs, new PPIs are developed. Such new indicators do not only satisfy the port authority's need for insight in port performance, but are also relevant for stakeholders with socio-economic interests in a port.

In this paper we present a number of potential new PPIs. These PPIs are related to three 'port products'. Besides an overview of currently used PPIs, we analyse performance indicators in other relevant economic and spatial entities like airports, regional economies and business parks. The result is an overview of new port performance indicators whose introduction may be useful for the port industry.

**Keywords:** Port performance indicators, performance measuring, port products

### INTRODUCTION

The general trend towards more and more advanced performance measurement is also visible in the port industry. However, developing appropriate PPIs is not

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straightforward. The performance of *terminals* is analysed frequently. In some cases the term port performance is used even though terminal performance is measured. Such studies are relevant, since terminals are the most essential function of ports. However, ports and terminals can no longer be regarded as stand alone facilities (see for instance Cullinane et al, 2004), UNCTAD, in a classic monograph on port performance indicators (UNCTAD, 1976) discusses PPIs such as berth occupancy, revenue per ton of cargo, and capital equipment expenditure per ton of cargo. These PPIs also focus on the productivity of terminals. Performance measurement of *ports* is more complicated. This is explained by the fact that the port is a cluster of economic activities (De Langen, 2004) where a large number of firms provide products and services and together create different port products.

The most widely used PPI is throughput volume. Ports are ranked according to the volume of cargo that is handled. These cargo volumes figure prominently in media and on websites of port authorities. Growth of throughput is regarded as evidence of the performance of ports. Even though the use of volumes as performance indicator is widespread, there are at least three limitations of throughput as PPI:

- Adding up throughput volumes of different commodities to one aggregated throughput figure limits the value of a comparison between ports. E.g. one ton of crude oil is very different from one ton of fruit juice.
- Throughput volumes do not tell much about the economic impact of a port.
- Growth of throughput volumes is mainly explained by international trade flows, and not by the performance of a port.

A second PPI, that is used in a number of ports, for instance in the Netherlands and Belgium, is the *value added* generated in seaports. This PPI is relevant for assessing the economic importance of the port but does not say anything about the efficiency of the port.

Table 1: Introduction of PPIs in the port of Rotterdam

Year – period	Indicators
Beginning 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	Establishments of (new) companies in port area

Sources: Port of Rotterdam (2006), Rabobank (2003), ECORYS-NEI (2003), Rebel Group/Buck (2005)

The increasing integration of ports in logistics chains has also led to attention for PPIs to assess this integration (Bichou and Gray, 2004). These PPIs are specifically focused on supply chain integration and not included in this overview of port performance indicators at a more general level. Due to the commer-



cialization of (some) port authorities and the increasing pressure from stakeholders on port development, new PPIs are introduced in the port industry. Table 1 shows the emergence of new PPIs in the port of Rotterdam in the last decades.

Table 1 shows the recent introduction of new PPIs<sup>3</sup>. Further progress with respect to PPIs is to be expected. Therefore, this paper identifies and evaluates possible new PPIs. First, an analysis of currently used PPIs is made. Second, a distinction is made between different 'port products'. Third, performance indicators used in other relevant economic entities like airports, regional economies and business parks are discussed. We finalize the paper with conclusions on new port performance indicators.

### CLASSIFYING PORT PERFORMANCE INDICATORS

Performance indicators (PIs) have mainly three functions: they provide management information for organizations, they serve to compare performance (of organizations and other units, such as countries) and they are used to communicate with relevant stakeholders. Publicly owned organizations increasingly use performance indicators to ensure public expenditure is managed effectively and the results of public investments can be measured.

For ports, a distinction in three types of performance indicators is relevant. *Output indicators* show the relevant output. For instance, the most important output indicator for firms is profitability, while for countries GDP per capita is the main output indicator. These output indicators are important, but do not provide insights in how a certain performance is achieved. *Upgrading indicators* provide additional insight in factors that influence the long term development of the port. The term upgrading is derived from the global commodity chain literature (Gereffi, 1999) and encompasses developments that strengthen the position of a port in commodity chains. *License to operate indicators* are increasingly required to report to stakeholders, such as residents and environmental groups, on the social and environmental performance of the port.

As ports have developed into clusters of economic activities, where cargo handling, logistics and port related manufacturing takes place, a distinction can be made between three different (but complementary) *port products*.

- 1 The *cargo transfer product* product. This product consists of the loading and unloading of ships. The most important users of this product are the shipping lines.

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<sup>3</sup> These PPIs are collected by Port of Rotterdam, a large bank in Rotterdam and the National Ports Council.

- 2 The *logistics product*. This product consists of storage and value adding activities, including re-packing, labelling and quality inspection. The most important users of this product are the logistics service providers and importing and exporting companies. Both can decide to locate logistics facilities in seaports.
- 3 The *port manufacturing product*. This product consists of the provision of space and conditions for investments in manufacturing facilities. The most important users of this product are (multinational) manufacturing companies that invest in manufacturing plants in the port area.

The cargo transfer product is the backbone of the port: the port only functions if it is an efficient node in transport networks. This product consists of terminal handling, towage, pilotage, customs, and other activities required to enable the transfer of goods from seagoing ships to other transport modes (or vice versa). The cargo transfer product is not the only product: many ports develop logistics zones in the vicinity of the port in order to attract logistics facilities. Examples include Rotterdam, Barcelona, Shanghai and Busan. This logistics product is a different product, with different port users and different competitors. Ports not only face competition from other ports, but also from other inland nodes (Van Klink, 1998). The third product, port manufacturing, is relevant for ports that aim to attract manufacturing activities. Because of the presence of a variety of raw materials in ports and the quality of transport infrastructure, some ports have developed in substantial centres of manufacturing, for instance for petro-chemical activities. Examples of ports with much manufacturing activities include Houston, Antwerp and Marseille. These ports provide locations and conditions for manufacturing activities. This port manufacturing is a third port product, also with different port users and competitors.

These three port products are complementary, but highly different: the port users and their selection criteria differ substantially. The competitive position of ports for these three products generally also differs substantially. For instance, Gioia Tauro has an attractive cargo transfer product, but a less attractive logistics and manufacturing product while Antwerp has an attractive logistics and manufacturing product.

Table 2 summarizes the most important characteristics of these three port products. These three port products all consist of activities of a large number of firms and organizations such as the port authority and customs.

The two distinctions discussed above –between three types of performance indicators and three different port products- is used to categorize PPIs and to enable a more precise analysis of potential new PPIs. Specific PPIs for the three port products are better than PPIs for the port as a whole, because of the large differences between these port products. For instance, it is not very useful to compare the value added generated between ports with completely different positions in each of the port products. PPIs for specific port products provide more detailed and insightful for management information and allow for better comparison between ports.



Table 2: Important characteristics of the three different port products

<b>Characteristic</b>	<b>Cargo transfer Product</b>	<b>Logistics product</b>	<b>Manufacturing product</b>
<b>Most relevant firms for the provision of this product</b>	Terminal operating companies, towage, pilotage and bunkering firms	Logistics service providers, transport firms, forwarders	Port authority (landlord), utility providers for manufacturing (water, heat, energy)
<b>Competition</b>	Other ports in the proximity	Other logistics zones, either in ports or in inland distribution centres	Other 'sites' for manufacturing activities
<b>Relation with other port products</b>	A better cargo transfer product improves attractiveness of both other products	A better logistics product, increases demand for cargo transfer product and improves attractiveness of manufacturing product.	A better manufacturing product increases demand for both other port products
<b>Performance indicators</b>	Throughput volume, ship waiting time	Value added in logistics, m <sup>2</sup> logistics space	Value added and investment level in port related manufacturing

However, some licence to operate indicators, can best be developed for the port as a whole, because the port is perceived by its stakeholders as one economic complex.

#### PORT PERFORMANCE INDICATORS USED IN LEADING PORTS

In table 3, 4, and 5 PPIs presented in the annual reports of a number of leading port authorities are classified into the three different port products and the three different types of PPIs. PPIs that are relevant for the port as a whole are given in table 6. For this research, annual reports of over 30 ports were collected, and the PPIs presented in these annual reports were listed<sup>4</sup>. Not all ports present 'new PPIs', the ports that report 'new' PPIs are given in the tables. Most annual ports report throughput (for various commodities), turnover, profits and some other financial indicators.

<sup>4</sup> Sources: Port of Vancouver (2005), Port of Dampier (2005) Ports Corporation of Queensland (2005), Port of Long Beach (2004), Port of Tacoma (2005), Port of Valencia (2003), Port of Stockholm (2004) and Port of Antwerp (2004). These ports are located in densely populated areas with organized stakeholders. This explains why new PPIs emerge in these ports.

These are not given as they are standard. The financial indicators do not demonstrate the performance of the port, but of the *port authority*.

Most of the PPIs in the following tables are not updated annually and also not reported for consecutive years. More importantly, international comparison of PPIs is hardly possible because of the lack of uniform definitions and methods of data collection.

Table 3: PPIs for the cargo transfer product

Type of PI	PPI	Example of port that collects this PPI
Output indicators	Throughput volumes Value added of port Investment level in port Market shares in hinterland regions	Virtually all ports Belgian & Dutch ports Antwerp Long Beach
Upgrading indicators	Number of 'first port of call' services Value of goods passing through the port EDI use in port	Halifax Most ports in US Antwerp
License to operate indicators	Modal split hinterland traffic Index of port dues at 'real prices' Custom revenues from port	Rotterdam Dampier Long Beach

Source: Annual Reports port authorities

An interesting 'license to operate indicator' is the index of port dues at real prices. This shows whether the port dues rise or fall in real terms. This indicator shows whether or not port costs decline in relative terms over time. For large numbers of port users, especially consumers, this indicator is relevant.

Table 4: PPIs for the port logistics product

Type of PI	PPI	Example of port that collects this PPI
Output indicators	Warehouse area (m <sup>2</sup> )	Antwerp and Rotterdam
Upgrading indicators	Time to major consumer markets	New Orleans
License to operate indicators	No indicators found	—

Not many ports collect PPIs for the logistics products, even though most ports increasingly recognise their role in logistics chain. Both Rotterdam and Antwerp collect data on the warehouse space in the port area. This shows the supply of logistics services in the port.



Table 5: PPIs for the port manufacturing product

Type of PI	PPI	Example of port that collects this PPI
Output indicators	Value added in port related manufacturing Investments in port manufacturing	Dutch & Belgian ports Dutch ports
Upgrading indicators	Number of major chemicals available in port (compared to other major chemical manufacturing sites –mostly ports)	Antwerp
License to operate indicators	Emissions of greenhouse gasses	Rotterdam

The use of indicators for the port manufacturing product is limited to those ports that have developed into large manufacturing sites, such as Rotterdam and Antwerp. Investment in port manufacturing is the most relevant output indicator.

Table 6: PPIs for the port as a whole

Type of PI	PPI	Example of port that collects this PPI
Output indicators	Value added of port Investment level in port	Belgian & Dutch ports Antwerp
Upgrading indicators	Certification of management programmes Average wage port industries compared to regional economy	Stockholm Tacoma
License to operate indicators	Number of environmental accidents Water quality in port Employment in port region Economic impact of a port	Queensland Valencia Long Beach Most large ports

Most licence to operate indicators are developed for the port as a whole and not related to specific port products. Examples of such indicators include the number of environmental accidents, the water quality in the port and the employment in the port region. The most widely used indicator in this respect is the economic impact of a port (see Hall, 2004, for a recent critical analysis of economic impact studies).

This overview shows that a large number of PPIs is in use. However, different ports use different PPIs, and more importantly, there is no uniform method to calculate the indicators. This is a major weakness of current performance measurement practices in seaports.

## NEW PORT PERFORMANCE INDICATORS

The preceding section showed that various PPIs are used, but not always in a uniform way. This section explores PPIs that are used in other environments and that may also be useful for the port industry. An analysis was made of performance indicators for airports, clusters, industrial parks and regions. Performance indicators may also be introduced to the port industry.

Airports are similar to seaports because they are nodes in international transport networks (O-Kelly, 1998). Performance measurement at airports is advanced compared to seaports (see Francis et al, 2002, and Oum and Yu, 2004). Consequently, performance indicators used in airports are analysed. Airports measure environmental performance, including perceived risk of incidents, and safety, measured by the number of accidents. Airports also measure customer service indicators, for passengers, airlines and cargo owners are recognized as customers. A discussion of customer service measures is available in Doganis and Graham (1987). Indicators like variability in service times and average time to deliver cargo from airplane to cargo terminal could be useful in the port industry.

Clusters are similar to seaports because ports can be considered as specific examples of clusters (De Langen, 2004). Studies on performance of clusters (Porter, 2003) have used indicators like number of patents, that may also be introduced in the port industry.

Industrial parks and business parks are similar to ports because ports are also areas with large numbers of complementary and interrelated firms. Ports can be considered as special cases of industrial parks, aimed at attracting companies that require land with deep-water access (see for a recent article on industrial parks Eilering and Vermeulen, 2004). The economic performance of industrial and business parks (incl. shopping areas) is mainly measured by (real estate) developers and banks. Relevant indicators include expenditures per visitor, land price, and rental prices. These indicators are not used as performance indicator in ports, but could be valuable.

Finally, performance measurement of ports may be able to use performance indicators used for regions, because port regions are in many cases mainly specialized in port related activities. The most used indicator for regional economic performance is gross regional product. Other indicators include average wage level (Porter, 2003) and a number of indicators related to "living attractiveness" and "investment climate". These indicators could be useful to extend port performance measurement. Studies on location decisions of port related activities, such as Oum and Park (2004) for distribution centres, provide relevant insights for ports aiming to attract such industries.

Table 7, 8, 9 and 10 show relevant new indicators that are derived from this analysis. Some further explanation is given below the tables.



Table 7: New PPIs for the cargo transfer product

Port product	Type of PI	New PPI
Cargo transfer	Output	Ship turn around time Connectivity index
	Upgrading	Throughput per square meter
	License to operate	Consumer benefits from lower transport costs

Even though *ship turnaround time* is already discussed in academic literature for more than 30 years (see Heaver and Studer, 1972), no port systematically reports the ship turnaround times. This turnaround time includes the time spend with entering the port, loading, unloading and departing. Even though this is clearly relevant for shipping lines, ports do not report turnaround time in annual reports or other publications.

A *connectivity index* can be used to quantify how well a port is connected to overseas destinations. Such a connectivity index is used for airports (Button and Stough, 2000) but does not exist for seaports. The most practical approach would be to develop an index for both overseas accessibility and hinterland accessibility. The index can be calculated based on the quality of connections (in terms of frequency and transit time) to a large number of ports and intermodal terminals in the hinterland.

A good upgrading indicator would be the average throughput per square meter. This indicator has been calculated in a number of cases, but is not reported structurally by ports. This indicator is used more frequently in the airline industry (see Park, 2004).

Table 8: New PPIs for the port logistics product

Port product	Type of PI	New PPI
Port logistics	Output	Percentage of goods to which value is added in port region
	Upgrading	Land price Value added (or employment) per square meter
	License to operate	-

The indicator ‘consumer benefits from lower transport costs’ can be estimated by calculating the additional costs when a ‘second best’ port would have to be used. These additional costs do not have to be incurred because of the presence of the

port. Thus, they can be regarded as the benefits of the presence of this port. Due to the competition between ports, it can be assumed that these benefits are passed on to the port users, and finally to the consumers in the hinterland served by the port. Even though some economic impact studies do argue along these lines, the benefits to consumers in the port hinterland are not presented explicitly.

A relevant output indicator for the port logistics product is the percentage of goods to which value is added in the port area. This indicator shows to what extent the port is a logistics location. Such an indicator would be especially relevant for containerised commodities.

A relevant upgrading indicator is the price of warehouse space. This price reflects the willingness to pay for a location in the port. Thus, higher prices reflect upgrading of the product<sup>5</sup>. These prices are collected by logistics consultants, such as Cushman and Wakefield, but not reported by port authorities.

A second relevant upgrading indicator is the value added per square meter. Such an indicator demonstrates the value of the logistics services provided in a warehousing area.

Table 9: New PPIs for the port manufacturing product

Port product	Type of PI	New PPI
Port manufacturing	Output	Investment level manufacturing sites
	Upgrading	Productivity port industries Wage level port manufacturing industries
	License to operate	-

Most ports do not report any PPIs for the port manufacturing product. The most relevant output indicator is the investment level in manufacturing facilities. This indicator shows whether port manufacturing is expanding or declining. There are two relevant upgrading indicators. First the productivity of the industries. A proxy to measure productivity would be the value added per employee. Second, the wage level in port manufacturing is relevant. Relatively high wages indicate a highly qualified workforce and can be expected to lead to high productivity.

For the port as a whole, a number of performance indicators can be developed that are used to analyse the performance of regions (see e.g. Porter, 2003 and Wenekers & Thurik, 1999). New establishments (either start-ups or branch offices) are

<sup>5</sup> This argument is only valid when one assumes that the market for land is relatively free. In such cases, firms can choose locations and the price level in attractive locations will rise. In the case the land market is heavily regulated, a high price cannot be associated with the quality of the location.



Table 10: New PPIs for the port as a whole

Port product	Type of PI	New PPI
Port as a whole	Output	-
	Upgrading	New establishments Number of patents Education levels employees Wage level port industries
	License to operate	Housing prices in vicinity of port

a good indicator of the attractiveness of the port for new companies. Special attention could be given to ‘knowledge intensive’ start-ups, since these are especially relevant for upgrading processes. An indicator could use data from company registers to assess how many new firms are established. The number of port related patents registered by companies operating in the port could be a second upgrading indicator. However, the number of patents in the port industry (even when broadly defined) is rather limited. A third upgrading indicator that could be developed for ports is the education level of employees. This indicator also provides information on the presence or absence of upgrading processes. The final potential new PPI is the wage level earned in the port. This could also show upgrading, especially if there is no reason to assume employees in the port area can extract economic rents (Goss, 1999).

The prices of houses in the vicinity of the port could be a good licence to operate-indicator. When these prices rise, relative to the national or regional average, this indicates that the negative effects of the port are rather limited, or are offset by the positive effects of the port (e.g. living close to the waterfront).

## CONCLUSIONS

In this paper an analysis was made of Port Performance Indicators (PPIs) in the port industry. The use of such indicators is useful, to measure whether the development of the port is satisfactory or not, to compare ports and learn where performance can be improved and to communicate the performance of the port to a wide range of stakeholders. Because of the complexity of seaports, and the fact there the ‘port’ consists of large numbers of different firms, so far, most ports hardly collect PPIs in a structured way. However, due to commercialization of the port authority and the increased pressure from stakeholders on port performance, the introduction of new PPIs can be expected. The case of Rotterdam shows that new indicators were developed over the last years.

The distinction between the cargo transfer, port logistics and port manufacturing product is relevant. For each port product, PPIs differ substantially. Depending on their structure, different PPIs are relevant for different ports.

In this paper, a couple of potentially useful new PPIs were discussed, based on an overview of annual reports of leading port authorities and an analysis of performance measurement of units that are similar to ports, such as airports and clusters.

The introduction of new PPIs may lead to new academic research. While the current research mostly focuses on throughput volumes, new research opportunities for instance an analysis of the performance of ports in logistics chains and an analysis of conditions that explain the efficiency of land use in ports, may become viable once new PPIs are introduced.

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