Conceptual approach for measuring the process quality of intermodal hinterland terminals

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1 ABSTRACT

The aim of this study is to develop an intelligent and integrated performance indicator concept that preserves all interests of both shippers and service providers, in intermodal transport. The findings of the study will have a lasting long-term effect on deflection of goods traffic and enable a better comparability of hinterland terminal performance. The focus will be on developing a set of interoperable und intermodal performance indicators to strengthen transparency in documentation and identification of hinterland terminal performance. The results of this study will substantially contribute to detect potentials in the deflection of traffic and minimization of the risk of bad investments and stranded costs when planning and (re)building the infrastructure and capacity of hinterland terminals.

Keywords: performance indicators, classification, standardization, hinterland terminals

2 INTRODUCTION

Increasing goods flow and continuous changes, force hinterland terminal operators to rethink their strategies and roles within the supply chain. Modern goods traffic allows for a variety of potential alternatives in transportation by road and rail, by water and by air. Interoperability and modal spanning concepts have become key factors in nowadays transport that are essential to meet customers' needs. The unequal share of transportation modes in overall transportation, constant growth of traffic volume and lacking transparency tackle politics and logistics and represent future challenges. In order to maintain a competitive position in international markets, decision makers must understand the parameters that determine hinterland terminal efficiency, establishing comparisons among local and national terminal locations. (RAMOS RIOS, GASTAUD MAÇADA 2006). Major hinterland terminal infrastructure has already reached its capacity limits and predictions show that most of the European countries will not be able to accommodate future transhipment demand (KLOTZ 2007).

In Austria, hinterland terminals are a fundamental link in supply chains that allow the frictionless turnover of goods between different modes of transport. The effectiveness and efficiency of these intermodal hubs substantially contributes to the overall competitiveness and attractiveness of an industrial area. The efficiency and performance of intermodal hubs affects to a large extent the economic well-being of the country. The risk of bad investments and stranded costs when planning and (re)building the infrastructure, has to be minimized. Intermodal services and quality of existing hinterland terminals do not keep up with the transhipment capacity needed in the next decade. In order to cope with future transport volume it is necessary to strengthen interoperability between different modes of transport. Therefore sound decisions are needed to guarantee effective and efficient operations and services in hinterland terminals. In fact comprehensive utilization analysis and detailed terminal infrastructure planning is becoming necessary to ensure an efficient hinterland terminal operation.

Parties involved do consider seriously alternatives in transport but often do not take into consideration innovative solutions to intermodal supply because of lacking transparency and prevalent complexity. In practice, performance indicators are defined on location or on company level, which results in a vast number of taxonomies. In fact the transport sector and especially hinterland terminals suffer from the diversity of conventions which leads to virtually no comparability of the performance. As a consequence the evaluation of hinterland terminals has to be done carefully. By understanding the reasons and factors that determine the performance of intermodal hubs it is possible to enable equal comparison and a comprehensive overview of the performance of alternative transport modes which improves the effective and sustainable utilization of existing hinterland terminals.

To provide a profound basis for the evaluation of existing infrastructure and assessing future needs, a standard for categorization and performance measurement for better comparability is needed. A detailed classification scheme and a standardized set of performance indicators will provide information on effectiveness and assist decision makers to make well-informed decisions. It is necessary to implement an integrated concept that allows for a performance comparison of all Austrian hinterland terminals. More over, it will be possible to all parties to have a detailed overview of the performance and effective utilization of particular locations. The results of this study are understood as preliminary work for creating a standard for categorization and measurement of hinterland terminals in Austria, that allows integrative performance comparability of different locations at national level.

We want to focus on a conceptual approach for measuring the process quality of Austrian hinterland terminals because the measurement of performance is not only a powerful tool for hinterland terminal operators, but also constitutes a most important input for informing regional and national authorities and hinterland terminal operators (CULLINANE et al. 2005). In fact, improving the performance of a hinterland terminal system improves Austria's international market access. As a consequence, efficient hinterland connection raises the productivity and profitability and leads to increased trade and higher levels output, income and employment (PARK, DE 2004).

The paper is organized as follows. In the next section we want give a thorough literature review that reveals that there is still a lack of theoretical basis for performance measurement in the domain of hinterland terminals. The following section concentrates on the methodology we applied and the one thereafter on the basic concept of our approach. In the last section we want to summarize our findings and draw conclusions on the underlying domain.

3 REVIEW OF LITERATURE

In the domain of open sea ports, performance evaluation and benchmarking are a commonly accepted method to identify and adopt best practices as a means to improve the performance and increase productivity. These methods are particularly valuable when no standard is available to define efficient and effective performance (PARK, DE 2004). In a more traditional context TONGZON and HENG (2005) discuss the eight key determinants of port competitiveness and adduce terminal operation efficiency, cargo handling charges, reliability, selection preferences of carriers and shippers, the depth of navigation channel, adaptability to the changing market environment, landside accessibility and product differentiation. CULLINANE et al. (2006) list a thorough overview of work done on the optimization of the operational productivity in container terminals. Traditionally, the performance of ports has been evaluated by measuring a single factor or by comparing actual with optimum throughput over a specific time period (CULLINANE et al. 2005). TONGZON and HENG (2005) postulate that the efficiency of inland transport has become a critical factor of port's potential future as well as of their overall growth prospects. The quality of hinterland connectivity and the accessibility of port facilities are already an important indicator for port evaluation and further a requirement for port users' port selection (TONGZON, HENG, 2005). In fact hinterland terminal performance measurement has become a point of interest in integrated logistics chains.

In recent years more holistic approaches like the data envelopment analysis (DEA) and the stochastic frontier analysis (SFA) were applied on container port and container terminal efficiency and productivity. DEA is the most prominent approach in literature to measure port and container terminal efficiency. (WANG, CULLINANE 2006) studied 104 European container terminals by utilizing DEA CCR and DEA BCC. They state that the primary finding of their paper is the significant inefficiency that generally pervades most of the terminals under study. They also mention that it is extremely important to note that although the results derived from DEA provide important information on 'theoretically' optimum production, such results should be always interpreted with a fair degree of caution in practice; especially with respect to applications to the port industry. The optimal production achievable in one port is not necessarily achievable for another port. (PARK, DE 2004) utilized a four stage DEA to measure productivity, profitability, marketability and overall efficiency of 11 Korean ports. They changed input and output in each stage and concluded that improvement of marketability (input: revenue, output: customer satisfaction) of all Korean ports is necessary. (RAMOS RIOS, GASTAUD MAÇADA 2006) studied Brazilian, Argentinean and Uruguayan container terminals with DEA BCC. They applied typical input variables like number of cranes, number of berths, number of employees, terminal area and amount of yard equipment to analyze the influence on total TEUs (twenty-feet equivalent) handled. (PESTANA BARROS, ATHANASSIOU 2004) applied the DEA CCR and DEA BCC to seaports in Greece and Portugal. They postulate that privatization will allow seaports under study to improve their productivity, because privatization and competition has proven to be the best procedure for efficiency improvement. Furthermore the pattern of ownership, structural rigidities to the labor market, unequal access to information, time lags in acquiring new technology and organizational factors associated with human capital have significant influence. (TONGZON 2001) used the DEA CCR to empirically test the influencing factors on port performance and efficiency of four Australian and 12 other international ports. His findings showed that a port's efficiency level has no clear relationship with its size and its function. (CULLINANE et al. 2006) applied DEA BCC and DEA CCR to 57 container terminals ranked in the top 30 in 2001. In their findings they argue that gateway terminals appear to exhibit lower levels of technical and scale efficiency than ports that specialize in transhipment. Further they compare the efficiency of land use and point out that city ports, where land is at a premium, are invariably more efficient than where this is less a constraint. Further CULLINANE et al. (2001) mention that utilizing panel data approaches are a better way to analyze the efficiency levels of ports in a dynamic context. (PESTANA BARROS 2006) studied 24 main Italian ports. They note that large seaports, with higher book value of assets, tend to have higher efficiency; an effect explained by the economies of scale. Another point to mention is that containerized seaports reached higher efficiency scores as a result of the technological advantage and the standardization of the container. He suggests that Italy should concentrate on efficient ports and close inefficient ones to gain advantage of economies of scale. CULLINANE et al. (2006) also mention that high levels of technological efficiency are associated with scale, private sector participation. CULLINANE et al. (2005) postulate that appropriate variable definition of input and output factors is a crucial element of meaningful applications in the area of DEA. WANG and CULLINANE (2006) point out that an important area deserving of further study is the analysis of the relationship between DEA efficiency estimates and more widely used industry data and indicators. CULLINANE et al. (2006) conclude that input and output variables should reflect the objective and the process of container port production as accurate as possible.

Further work on the efficiency measurement of ports and container terminals by applying different models and methods was done by COTO- MILLÁN et al. (2000); CULLINANE et al. (2002); CULLINANE et al. (2005), SONG and YEO (2004), TONGZON (1995) and TONGZON and HENG (2005). CULLINANE et al. (2002) concluded that privatization should have some relation with the improvement in efficiency. They argue that ports with larger throughput seem to have certain performance advantage over smaller competitors. COTO- MILLÁN et al. (2000) found that the type of organization has a significant effect on efficiency and they showed that port size is not significant when trying to explain economic efficiency.

LE GRIFFIN (2008) points out that comparisons of productivity between major container ports and terminals are usually made at a high level of aggregation Most studies are based on publicly available data, such as facility characteristics and physical resources and annual throughput demand. On of the main challenges to terminal operations and port authorities is how to improve productivity to accommodate a large portion of the anticipated increase in container traffic (LE-GRIFFIN, MURPHY 2006).

There is also extensive literature on performance indicators and performance measurement systems which allow an overall insight. GRONALT and POSSET (2007) and JIN et al. (2001) give a comprehensive overview of the definition and selection of performance indicators. GUNASEKARAN and BULENT (2007) give a comprehensive overview of performance measures and metrics in logistics. They define performance measurement as a process of transparent editing of data to draw attention on cause-effect chains. KELLER and HELLINGRATH (2007) highlight the problem of diversity of indicator definition in practice and theory. In fact, it is virtually impossible to compare indicators of different areas of application or even within the same industry. LOBO and ZAIRI (1999) emphasize the comprehensive function of commonly accepted performance indicators and their clarifying function. Performance indicators give information on the degree of contribution of single actions and make the output and impact measurable. Depending on the sector, performance indicators are related to finance, quality and satisfaction. SHAHIN and MAHBOD (2007) recommend their so called smart criteria (specific, measurable, attainable, realistic, and time-sensitive) for defining and selecting appropriate performance indicators. RIGO et al. (2007) focused in their work on the performance comparability of road transportation and inland navigation. They used multi criteria decision analysis to work out a single performance indicator that allows for comparing the sustainability of these two means of transportation. A further, more common, approach is done by NEELY et al. (2005). They deal with the definition of performance indicators and performance measurement systems. The authors point out that most measures found in the literature can be aggregated in the areas of quality, time, flexibility and costs. Further they lay attention on the two major directions of performance measurement systems; balanced score card bay Norton and Kaplan and the supply chain operations reference model by the supply-chain-council. Further work on the classification of performance indicators and performance measurement systems is done by BEAMON (1999), DE TONI and TONICHA (2001), GUNASEKARAN et al. (2001), and RADNOR and BARNES (2007).

A common conclusion drawn in the literature is that a uniform system for evaluating the productivity of container terminals would require the disclosure of a substantial amount of data. Experience showed that needed data for analysis is not accessible it is related to data which terminal operators generally consider to be proprietary in nature (LE-GRIFFIN, MURPHY 2006). WANG and CULLINANE (2006) state that the problem of obtaining data on each of the variables across large samples is likely to prove virtually insurmountable. As a consequence comparisons of productivity between major container ports and terminals are usually made at a high level of aggregation, excluding major influencing factors (LE-GRIFFIN, MURPHY 2006). Quite often efficiency and productivity analysis of container ports and container terminals are based on financial reports and the containerization international yearbook because of data unavailability. WANG and CULLINANE (2006) postulate that the ambition is to develop suitable metrics and to collect data on the determinants of port efficiency. There is a need for commonly accepted and accessible data and measures for the future. The data has to be included within models to measure the direct quantitative influence over estimates derived to have a more profound basis for comparison (WANG, CULLINANE 2006). The analysis of the performance of container terminals is of great importance for the survival and competitiveness of the industry (CULLINANE et al. 2006). Container terminals no longer enjoy monopoly and they are not only concerned with whether they can handle cargo, but also whether they can successfully compete for it (CULLINANE et al. 2006).

Parallel to the literature review we analyzed the state-of-the art of organizations that already apply performance indicators in the transportation sector. Worth mentioning in this context are organizations like the International Navigation Association (PIANC), the world road association (PIARC), Airports Council International (ACI) and the Organization for Economic Co-Operation and Development (OECD). A committee including Germanischer Lloyd Certification (GLC) and the Global Institute for Logistics (GIL) launched the Container Terminal Quality Indicator (CTQI) which is a benchmarking certification scheme for auditing global container terminal operation. They defined four areas (internal- and external factors, management system and performance evaluation) plus 70 container terminal performance measures to evaluate the quality of open sea container terminals. CTQI is intended to be a global standard for measuring container terminal efficiency. GLC and GIL want to increase productivity and reliability of the terminals in order to increase supply chain efficiency.

The review of the literature and the state-of-the art of performance indicators applied by organizations in practice built the basis for our study. We evaluated in relation to available performance indicators in port and container industry, performance measurement in general and approaches to performance measurement system. Especially in the field of efficiency and productivity measurement a lot of work is done. Data envelopment analysis and stochastic frontier analysis are widely used for comparison of ports and container terminals. We did not focus on the methods but on the utilized inputs and outputs and the drawn conclusions. This gave us a deep understanding on commonly agreed standards for comparison and factors to be considered when analyzing intermodal infrastructure. Most of the literature, except WANG and CULLINANE (2006) who also included hinterland terminals in their study, is focused on open sea ports and container terminals. We also had a focus on performance indicators and related theory in logistics and other areas of transportation to work out the state-of-the art in performance measurement.

4 METHODOLOGY AND DATA

The main challenges for the contemporary container port industry arise from the complicated nature of its operations as a consequence of the number of different agents involved in importing and exporting containers and the complex operational interactions between the different service processes taking place at a container terminal (CULLINANE et al. 2006).

In order to keep in mind the diversity and complexity of intermodal hinterland terminals, the set of analyzed locations has to be chosen carefully. Therefore this study is restricted to a selected set of major Austrian hinterland terminals. In Austria there are 16 terminals in total, offering different services to their customers, including 11 locations for unattended combined transport, two for rolling road and three offering both unattended combined transport and rolling road. In this study we choose a sample of eight representative hinterland terminals that span the scope of diversity of all Austrian terminals.

The findings of this study are a result of a long lasting cooperation with an Austrian hinterland terminal-operating company and an Austrian rail infrastructure operator. This ensures the integration of practice based data and know-how. To guarantee sustainability we based our work on a standardized cycle for classification and comparability (see Fig. 1) and applied the Delphi method (see LOO (2002), MULLEN (2003), HÄDER (2002)). The Delphi method was chosen because it exactly fits the needs of the addressees of our study. Because of the spatial extent of our study to hinterland terminals all over Austria it was not possible to organize a group discussion including all operational terminal managers. We also wanted to avoid that the opinion of individual managers might be influenced by group dynamic behavior. As a consequence individual interviews based on standardized questionnaires appeared to be best solution for us. In addition of the Delphi study we also applied the cycle guaranteeing the reflection of findings at all stages of the research.

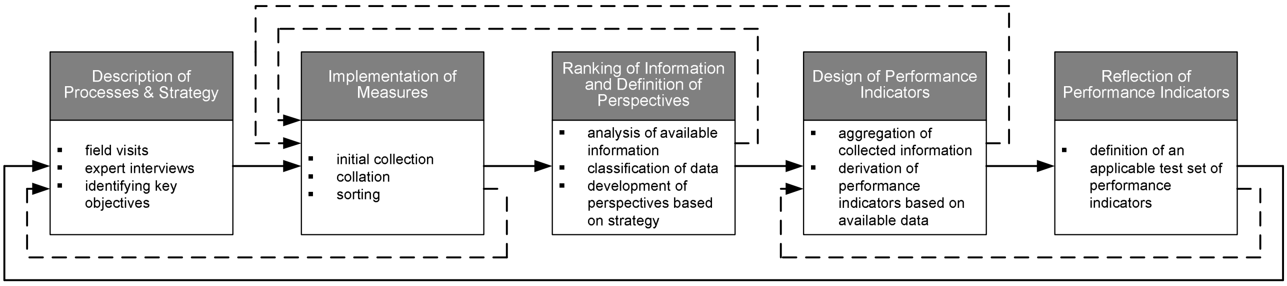

Fig 1: Standardized Cycle for classification and comparability

In a first step we made expert interviews with strategic managers to identify the key objectives of effective hinterland terminal operation from a strategic point of view. The expert interviews helped us to define and work out all areas that had to be considered for the design of the questionnaire applied for the first round of the Delphi interviews. We also did several field visits and expert interviews with operational terminal managers to develop standard processes depicting all relevant activities and parameters to incorporate operational aspects.

During our field visits we applied a first questionnaire to check the availability of generic data and collect available information on the performance of the terminals to define the gap between needed indicators and availability of data. By analyzing the records of the interviews and the field visits we defined a total set of 493 possible indicators. The total set consisted of 344 generic indicators and 149 aggregated indicators. In a next step we made a workshop with the strategic managers and defined a set of 200 potential generic indicators.

In a next step we established 14 measurement areas (see Fig. 2) and assigned each indicator to its corresponding area. The aggregated information was used to design the final questionnaire which was then sent again to the operational terminal managers who were intended to rate the information quality of each indicator on a scale from one (very poor) to six (very important). So we did some kind of a mixture of a deliberative poll (HÄDER 2002) and a Delphi study because we brought the operational terminal managers into touch with the subject before we sent them the questionnaire. First analysis of the results of the questionnaire showed that the areas of performance, utilization and throughput were ranked to be the most important measurement areas (see Fig. 2).

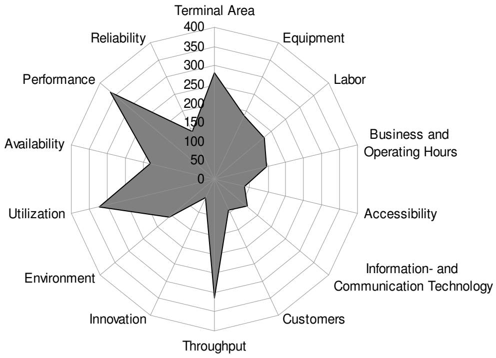

Fig. 2: Measurement areas

Additionally we did a second field visit to check the availability and validity of information, necessary to implement the indicators included in the questionnaire. Because of the manageable number of questionnaire addressees we had a response rate of 100 %. The returned questionnaires were analyzed and indicators were ranked according to their total rating. The result was then presented to the strategic managers again. In fact, the second round of the Delphi study has to be done with care. The analysis of the findings of the first round showed that the interviewees weighted the indicators according to their own experience. Managers of bimodal (rail and truck) hinterland terminals and managers of trimodal (rail, truck, ship) terminals prioritized the indicators differently. Further we became apparent that the weighting was dependent on the age of the terminal and the type of ownership structure. Managers of private and modern terminals had a distinct focus on environmental aspects, quality and reliability. The reason for this bias is a different perception of priorities and market pressure originated in the ownership structure and market position of the terminal. We also had to distinguish between operational and strategic perception of indicators. Therefore we had to stick to indicators that were not considered or ranked that high by operational managers because of their strategic importance. In a next step the new set of performance indicators will be used to design a new questionnaire for a second round of Delphi interviews. According to the Delphi method we will give anonymized information on the findings of the first round to the interviewees. The aim of the underlying Delphi study is to find consensus on applicable and meaningful perspectives and performance indicators.

The application of the Delphi method takes much more time than group discussions and expert interviews. In fact we yet have not reached the last stage of the standardized cycle for classification and comparability (see Fig. 1). We actually work on the design of the questionnaire for the second round of Delphi interviews. Depending on the degree of consensus of the second round we will be able to define a first test set of performance indicators which will be evaluated in practice. The aim of the fifth stage is to define the level of applicability and expressiveness of the defined set of indicators. Our cycle is designed in such a way that it allows drawing conclusions on the underlying processes. Actually the processes are based on the findings of our field visits which does not necessarily mean that these processes are based on best practice. As a consequence it might be possible that we will have to adapt the processes. Further empirical evidence might show that the test set is not appropriate to measure the performance of the underlying system adequately.

The standardized cycle for classification and comparison allows considering both internal and external factors that influence the performance of hinterland terminals. By analyzing the underlying processes, internal and external infrastructure and economic environment of a terminal location it is possible to consider a more meaningful set of indicators. Further the Delphi method provides access to much more multifaceted knowledge and points out differences in perception of different players. The consideration of feedback loops within the cycle allows all participants to gain access to broader knowledge and therefore guarantees a sound basis for consensus. The result will be a complete and commonly accepted set of indicators.

5 DEFINITION OF PERSPECTIVES AND INDICATORS

In fact it was not possible to maintain 200 potential indicators. So we decided to focus on the top five of each measurement area and worked out a total of four perspectives to organize the final set of indicators. The 14 measurement areas contain indicators related to terminals area, equipment, labor, business and operating hours, accessibility, information and communication technology, customers, throughput, innovation, environment, utilization, availability, performance and reliability. Each of the indicators was assigned to exactly one area to structure the questionnaire and facilitate the work for the interviewees. Within the measurement areas we aggregated indicators corresponding to the nature of associated information content. In a next step we assigned the measurement areas to a location quality, location accessibility, location performance and an environmental performance perspective. We composed the perspectives in such a way that individual indicators can be part of several perspectives. After having defined the perspectives the delicate linking of generic indicators has to be done.

An example for the linking is the truck turn time which requires consideration of the above mentioned factors. In absence of advanced technology, increased storage density achieved by stacking containers in several tiers will often reduce the operational accessibility to a specific container, and as a result increase the retrieval time (LE-GRIFFIN 2008). Another example is the ground space utilization of a hinterland terminal. The degree of ground space utilization depends on the size of the container yard, age and type of equipment, availability of man power and laws and regulations on safety. High stacking strategy can be therefore a result of limited terminal space due to limited expansion space, high land costs or restrictive environmental regulations. Terminals with high stacking density also implement advanced technology equipment. Advanced technology equipment requires skilled labor and skilled labor is more expensive. Keeping in mind the complexity of the above mentioned examples, the linking of the indicators has to be done with care. Otherwise the comparison of these indicators can lead to misplaced efforts to improve the performance of a hinterland terminal. During our investigation all interviewees reinforced that there is a need for complex performance indicators to overcome the lack of information of generic indicators.

Additionally to the complexity of performance indicators in the domain of container terminals it is important to bear in mind the diversity of different terminals. Therefore we decided to establish a classification scheme that allows and facilitates the categorization of hinterland terminals and further on the interpretation of performance indicators. Based on the collected data we developed an appropriate scheme, considering the special nature of hinterland terminals. We decided to base our concept on existing approaches, found in the literature (BICHOU, GRAY 2005), and customized them to the underlying domain. The new scheme is intended to allow for a detailed classification which will be used to guarantee impartial comparison of hinterland terminal performance indicators (see Fig. 3).

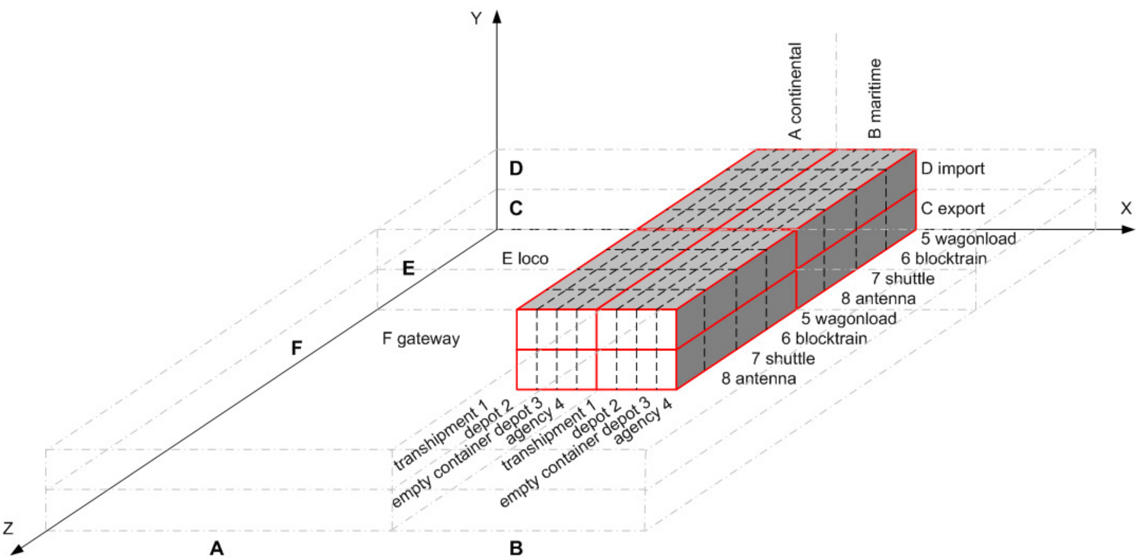

Fig. 3 Classification of hinterland terminal by function and operation

In a first step the hinterland terminal has to be classified on the X axis according to its area of operation. Further we distinguish on the Y axis between the logistics function and on the Z axis between the area of transportation of the terminal.

According to the area of operation on the X axis we separate continental terminals (A) that have their main focus on hinterland transportation and maritime terminals (B). Continental transport is characterized by the diversity of load units, also including semi trailers, swap bodies and continental load units. In maritime terminals the majority of handled load units are standard 20 feet and 40 feet containers.

The Y axis is subdivided into export terminals (C) and import terminals (D). Export terminals are sources that remove goods from a region. There are more containers leaving the terminal than container going to the terminal. Export hinterland terminals always have a lack of empty containers. Import terminals are sunks that supply a region with goods. There are more containers going to the terminal than containers that leave the terminal. Such locations always have a surplus of empty containers.

The Z axis considers loco traffic (E) and gateway traffic (F) terminals. Loco traffic means that the terminal acts as a regional distribution center where most of the load units are delivered by truck and further transport is done by railway or the other way round. On the other hand a gateway terminal acts as a transhipment node for trains. The majority of load units is transhiped between trains, coming from different origins and going to different destinations, directly. Trains enter the terminal, exchange load units and leave the terminal. The sequence and combination of the trains stays the same.

Within the subcategories of X axis we consider the services offered by the terminal. Transhipment (1) is the lifting of load units directly from one means of transport to another or lifting combined with temporary storage (up to three days) for further transport by a different means of transport to another destination. Normally intermediate storage less than three days is free. If the load units stay longer the customer is intended to pay a storage fee. The reasons for transhipment are the change of means of transport or the combination of several shipments to a single shipment. Sometimes transhipment also includes the checking of containers. If a load unit is damaged either the terminal informs the customer to make a bid for repair or the customer has agreements that the terminal is allowed to repair the load unit. Depot (2) means that the terminal acts as an interim storage facility or safety stock of a customer. This means that load units are typically stored longer than three days and that the customer has to pay a storage fee. If a terminal offers empty container depot (3) service it acts as storage for empty load units of one or several customers. The shipper bundle their empty load units in one or several location and access them when needed. Empty container depots often include services like repair and cleaning depending on the type of agreement with the customer. Terminals with agency services (4) offer the procurement of carriers and compilation of waybills. In terminals which do not offer agency services the customers contact carriers or operators who organize their transport. In that case the carrier or operator is the customer or contact person of the terminal.

The Z axis is further subdivided into five subclasses wagonload (5), block train (6), shuttle train (7) and antenna (8). Wagonload means that small quantities are delivered up to a time schedule. Wagonload traffic is the bundling of single wagons or sets of wagons of a whole region in a shunting yard to a train. The reasembled trains have fixed time schedules and can either go to further shunting yards or directly to customers. Using wagonload traffic and reassembled trains allows to go to nearly every destination within the whole network. Within a terminal there is no difference between wagonload and block train traffic because the terminal always dispatches a set of wagons with a length of up to 650 meters. There is only a difference in the shunting yard. While a block train leaves the terminal without further shunting the wagonload traffic has to be reassembled according to the dedicated destinations of the load units. A block train is typically built with several sets of wagons having the same destination and which are assembled to a block train with a length of up to 650 meters. The total length of a block train depends on the number of loaded wagons. In the terminal of destination the train or the set of wagons are separated to be reassembled for the next destination. Block trains are characterized by the link, the load unit and the time schedule. Block trains are disassembled in the terminal of destination to be reassembled to new block trains which go on to further destinations. In contrast to shuttle trains, the wagons are shunted while the load units remain on the wagons. As a consequence there is no transsphipment. A shuttle train is a set of wagons that oscillates between two destinations. Shuttle trains vary in length, depending on the customers' needs, and are up to 650 meters. This type of traffic is dedicated to a link, which can include intermediate stops, between two terminals or stations. In contrast to block trains the focus of shuttle trains is on the set of wagons and the time schedule. Irrespectively of the number of transported load units the set of wagons and the sequence of wagons always stays the same. Due to the fact that the set of wagons always stays the same the load units have to be transshiped to other wagons or means of transportation. Antenna means that several trains coming from different terminals of origin, transporting load units having different destinations, meet at an intermediate terminal and go on to their dedicated destinations. Within the intermediate terminal particular sets of wagons are exchanged between trains while load units remain on the wagons.

The classification scheme is designed in such a way that it is possible to assign each hinterland container terminal to, except the subclasses on the z axis, exactly one category (see Fig. 3: red boxes are seen to be a category). The assignment is done by analyzing the traffic pattern and offered services in a terminal location.

To highlight the logic of the used classification scheme and the exting links between variables, we take the example of a terminal which can be classified as maritime (X), export (Y) and loco (Z).

Let's assume that this terminal further handles block trains and offers services like transshipment, depot and empty container depot. When evaluating the corresponding performance indicators a lot of aspects have to be considered:

- In hinterland terminals that serve open sea terminals the majority of handled load units are standard 20 and 40 feet containers.
- If it is a rise most of the containers will go from the hinterland terminal to the open sea terminal which means that there is a need for empty containers and so they might also offer empty container depot service.
- The handling of block trains has an impact on the loading and unloading and storage strategy of the terminal.
- The storage strategy of the terminal is determined by the type of equipment.
- The type of equipment further has an influence on the train- and truck turn time and the required man power.
- Advanced technology equipment requires skilled and more expensive labor.
- Additionally, a terminal that offers an empty container depot requires more man power and eventually more equipment.

The classification scheme is intended to facilitate the interpretation of performance indicators and to highlight cause and effect chains. By combining the performance indicator set and the classification scheme it will be possible to make more sensitive cross-terminal comparisons based on detailed information and comprehensible performance indicators.

6 SUMMARY AND CONCLUSION

Our approach shows that hinterland terminals have to be considered as complex infrastructure (GRONALT et al. 2007) that will need much more attention in the future. They are important hubs in modern logistic-networks that ensure efficient and frictionless intermodal (rail, truck, ship) container turnover which has to be planned and coordinated. Therefore it is necessary to establish a commonly accepted and meaningful set of performance indicators to quantify and simplify information in a manner that facilitates understanding for decision makers and regional and public authorities. The magnitude and diversity of interests and aims of stakeholders necessitate a standardized reporting, evaluation and analysis on hinterland terminal operation and performance.

LE-GRIFFIN (2008) highlights that obtaining reliable and consistent data presents a continuing challenge. The vision of a uniform system for evaluating the performance of hinterland terminals requires a comprehensive amount of terminal-level data. Most of the data is simply marketing data used in mirror finish brochures or it is considered to be proprietary in nature by terminal operators. Actually there is no public mechanism in Austria to report on hinterland terminal performance. As a consequence care should be taken when available indicators are used for cross-terminal evaluation. The interpretation of such figures has to be done very carefully because in the context of hinterland terminals. Here: the more does not always mean the better. In fact the performance of Intermodal infrastructure depends on its special and individual physical characteristics and operational practices.

During our study we found out that performance indicators have to be seen as very complex figures that have to be interpreted in context with the underlying physical and operational parameters that determine the overall performance of each terminal. Comparing the performance of hinterland terminals based on indicators without keeping in mind the special nature of the underlying infrastructure and operational practices can potentially lead to misinterpretation. The standardized cycle for classification and comparison and the classification scheme are a new approach in the domain of hinterland terminals. Standardized and structured expert interviews combined with a Delphi study build a basis for consensus. All indicators, areas and perspectives are based on the expertise of managers collected in interviews. As a result the findings of our study are built on a consensus. The combination of the standardized cycle and the classification scheme are intended to be a standard method for analyzing intermodal infrastructure.

Actually we are still working on the definition of the performance indicators to guarantee an applicable set which will be tested by the operational terminal managers in daily business. We also have to validate the acceptance and comprehensiveness of our classification in the next round of our Delphi interviews. The underlying approach for measuring the quality of processes of Intermodal infrastructure is still a concept but it is a first step in direction of a systematical process for collecting data on the performance of hinterland terminals. With our study we want to establish a framework that allows for impartial performance monitoring. Our comprehensive and comprehensible set of performance indicators will provide timely feedback and ensure action on time.

7 REFERENCES

BICHOU, K., GRAY, R.: A critical review of conventional terminology for classifying seaports, Transportation Research Part A, 39, 2005

COTO-MILLÁN, P., BAÑOS-PINO, J., RODRÍGUEZ-ÁLVAREZ, A.: Economic efficiency in Spanish ports: some empirical evidence, Maritime Policy and Management, Vol. 27, No. 2, 2000

CULLINANE, K., SONG, D.W., GRAY, R.: A stochastic frontier model of the efficiency of major container terminals in Asia: assessing the influence of administrative and ownership structures, Transportation Research Part A, 36, 2002

CULLINANE, K., SONG, D.W., WANG, T.F.: The application of mathematical programming approaches to estimating container port production efficiency, Journal of Productivity Analysis, 24, 2005

CULLINANE, K., WANG, T.F., SONG, D.W., JI, P.: The technical efficiency of container ports: comparing data envelopment analysis and stochastic frontier analysis, Transportation Research Part A, 40, 2006

DE TONI, A., TONICHA, S.: Performance measurement systems. Models, characteristics and measures. International Journal of Operations & Production Management, Vol. 21, No. 1/2, 2001

GRONALT, M., POSSET, M.: Performance Indicators for Inland Waterways, Unpublished Working Paper, PIANC working group 32, 2007

GRONALT, M., POSSET, M., BENNA, T.: Standardized Configuration in the Domain of Hinterland Container Terminals. In: Blecker, T., Edwards, K., Friedrich, G., Hvam, L., Salvador, F. (Eds.), Series on Business Informatics and Application Systems Innovative Processes and Products for Mass Customization 3, 105-120; GITO-Verlag, Berlin; 2007

GUNASEKARAN, A., BULENT, K.: Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications. International Journal of Production Research, Vol. 45, No. 12, 2007

GUNASEKARAN, A., PATEL, C., TIRTIROGLU, E.: Performance measures and metrics in a supply chain environment. International Journal of Operations & Production Management, Vol. 21, No. 1/2, 2001

HÄDER, M.: Delphi-Befragungen, Ein Arbeitsbuch, Westdeutscher Verlag, 1. Auflage, 2002.

JIN, M., WANG, H., WALDEN, C.T.: System measures for intermodal transportation with a case study and industrial application. A report submitted to the National Center for Intermodal Transportation: A partnership between the University of Denver and Mississippi State University, 2001

KELLER, M., HELLINGRATH, B.: Kennzahlenbasierte Wirtschaftlichkeitsbewertung in Produktions- und Logistiknetzwerken. In Otto, A., Obermeier, R. (Hrsg.): Logistikmanagement. Analyse, Bewertung und Gestaltung logistischer Systeme. Deutscher Universitäts-Verlag, 2007

KLOTZ, H.: Kombi-Kapazität kann Wachstum kaum fassen, Kombinierte Verkehr VDV-Workshop: Erste Ergebnisse der DIOMIS Studie, DVZ Deutsche Logistik Zeitung, DVV Media Group GmbH, Hamburg, 13.11.2007

LE-GRIFFIN, H.D.: Assessing container terminal productivity: Experiences at the port of Los Angeles and Long Beach, Technical Report, Department of Civil and Environmental Engineering, University of Southern California, 2008

LE-GRIFFIN, H.D., MURPHY, M.: Container terminal productivity: Experiences at the port of Los Angeles and Long Beach, Technical Report, Department of Civil Engineering, University of Southern California, 2006

LOBO, I., ZAIRI, M.: Competitive benchmarking in the air cargo industry:Part III. Benchmarking, Bradford, Vol. 6, Issue 4, 1999

LOO, R.: The Delphi method: a powerful tool for strategic management, Policing: An International Journal of Policiy Strategies & Management, Vol. 25, No. 4, 2002

MULLEN, P.M.: Delphi: myths and reality, Journal of Health Organizations and Management, Vol. 17, No. 1, 2003

NEELY, A., GREGORY, M., PLATTS, K.: Performance measurement system design. International Journal of Operations & Production Management, Vol 25, No. 12, 2005

OECD: Performance Indicators for the Road Sector. Organisation for Economic Co-Operation and Development, 2001.

PARK, R.K., DE, P.: An alternative approach to efficiency measurement of seaports, Maritime Economics & Logistics, 6, 2004

PESTANA BARROS, C.: A Benchmarking analysis of Italian seaports using data envelopment analysis, Maritime Economics & Logistics, 8, 2006

PESTANA BARROS, C., ATHANASSIOU, M.: Efficiency in European seaports with DEA: Evidence from Greece and Portugal, Maritime Economics & Logistics, 6, 2004

RAFELE, C.: Logistics service measurement: a framework, Journal of Manufacturing Management, Vol. 15, No. 3, 2004

RADNOR, Z.J., BARNES, D.: Historical analysis of performance management and management in operations management. International Journal of Productivity and Performance Management, Vol. 56, No. 5/6, 2007

RAMOS RIOS, L., GASTAUD MAÇADA, A.C.: Analysing the relative efficiency of container terminals of Mercosur using DEA, Maritime Economics & Logistics, 8, 2006

RIGO, N., HEKKENBERG, R., HADAHZI, D., NDIAYE, A.B., SIMONGATI, G., HARAGITAI, C. ,LUNDOLUKA, F., HALET, F.: Integrated Indicator fort he sustainable assessment of intermodal chains; Application to the transport cargos from Frankfurt am Main (Germany) to Sofia (Bulgaria). European Inland Waterway Navigation Conference, 27-29 June, Visegrád, Hungary, 2007

SHAHIN, A., MAHBOD, A.M.: Prioritization of key performance indicators, An integration of analytical hierarchy process and goal setting. International Journal of Productivity and Performance Management, Vol. 56, No. 3, 2007

SONG, D.W., YEO, K.T.: A competitive analysis of Chinese container ports using analytical hierarchy process, Maritime Economics & Logistics, 6, 2004

TONGZON, J.: Determinants of port performance and efficiency, Transportation Research Part A, Vol. 29A, No. 3, 1995

TONGZON, J.: Efficiency measurement of selected Australian and other international ports using data envelopment analysis, Transportation Research Part A, 35, 2001

TONGZON, J., HENG, W.: Port privatization, efficiency and competitiveness: some empirical evidence from container ports (terminals), Transportation Research Part A, 39, 2005

WANG, T.F., CULLINANE, K.: The efficiency of European container terminals and implications for supply chain management, Maritime Economics & Logistics, 8, 2006