Port and container terminal characteristics and performance

Vítor Caldeirinha\textsuperscript{a}, J. Augusto Felício\textsuperscript{b}

\textsuperscript{a} Centro de Estudos de Gestão; School of Economics and Management; Rua Miguel Lupi, 20. 1249-078 Lisbon; Email address: vitorcaldeirinha@gmail.com; Phone: +351 - 213 970264

\textsuperscript{b} School of Economics and management; University of Lisbon; Rua Miguel Lupi, 20. 1249-078 Lisbon; Email address: jaufeli@iseg.ulisboa.pt; Phone: +351 - 213 3970264; Fax: +351 - 213 979 318

Abstract
This paper evaluates the influence of the port and container terminals characteristics on terminal performance. The sample is composed by 151 managers’ valid responses of 12 Portuguese and Spanish container terminals. The results confirm the influence of the port and container terminal characteristics on terminal performance. Container terminals customer satisfaction is associated with port and terminal characteristics, different from those that support the efficiency and activity of these terminals. This study provides important contributions to the literature on port management.

Keywords: Port characteristics, container terminal, performance, efficiency, satisfaction.

1. Introduction
Containerisation has facilitated the globalization of maritime shipping services based on global door-to-door logistic services (Cullinane, Song, Ping, & Wang, 2004). Moreover, in recent years, ships have increased their size, becoming more efficient, and increasing the competition between ports in relation to the hinterland and in major trade routes of transport. As consequence, the shipping companies gained more bargaining power demanding higher terminal performance, better quality service and lower prices, becoming more disloyal (Wang & Cullinane, 2006). On the land side, the growing choice of the terminal is made by logistics chain operators connected to specific shipping lines, based on the balance of price and quality service levels that can meet the requirements of complex systems of logistic chains (Bichou, 2007). In such competitive environment, the container terminal performance is very important for terminal success and is determined by several complex factors, such as its physical and organizational ability, proximity to consumption and production, integration in logistic chains, maritime and inland accessibility, the quay handling equipment, as well as the inland service and shipping networks connected (Tongzon & Heng, 2005).

This paper is justified by the insufficient knowledge of the relationship between port and container terminal characteristics and the container terminal performance (Estache, Perelman, & Trujillo, 2005). There are a limited number of studies which use the structural equation model methodology and usually are based only on factors reduction without confirmatory analysis of the complete structural model (Chang, Lee, & Tongzon, 2008; Woo, Petit, & Beresford, 2011).

This study is based on port choice theory (Tongzon & Sawant, 2007; Tongzon, 2009), on port efficiency theory (Martinez-Budria, Diaz-Armas, Navarro-Ibanez, & Ravelo-Mesa,
The focus of this study is concentrated in the relationship of the port and container terminals characteristics with terminal performance. The objectives are analysing the effect of port and container terminal characteristics in the terminal customer satisfaction, container terminal efficiency, and container terminal activity, and understanding what are the port and container terminal characteristics that have more influence in the terminal performance. The main questions addressed in this study are: Why do some container terminals have better performance than others? What are the most important characteristics of the container terminal for performance?

It concludes that customer satisfaction depends on the terminal logistics oriented management, inland accessibility, maritime accessibility and port specialization. The terminal efficiency and activity are related to the type and quantity of equipment, and location of the port. Furthermore, the container terminal efficiency affects the volume of activity. This study presents a very important contribution to the literature by demonstrating the importance of container terminal performance based on the characteristics of container terminals.

This paper is organized as follows: after the introduction, and the theoretical background we present the methods that consists of the research model and hypotheses, factors and variables, data collection and measurement, and statistical instruments. Following are the results and analysis, and discussion. Finally we present the conclusions, limitations, and future research.

2. Theoretical background

The ship owners to choose the port, especially the container terminal, take into account their performance, which is addressed in port choice theory (Tongzon & Sawant, 2007; Tongzon, 2009). For their part, the study of ports and container terminals in terms of the frontier efficient, intends to measure the relative efficiency of each unit terminal or port, considering input and output factors, which is supported on port efficiency theory (Budria-Martinez et al., 1999; Gonzalez & Trujillo, 2008). The performance of the port noted from the perspective of integration into the global supply chain, using various performance measures, in line with the multiple objectives of both the port and the terminal is analyzed in logistic theory performance (Bichou, 2007; Tongzon, 2001; Woo et al., 2011).

Port and terminal characteristics

Chang et al. (2008) identified terminal service, shipping services, port dues, market oriented and infrastructure as performance factors. Location, physical characteristics, liner frequency, infrastructure, quay equipment, operating time and productivity and information system are important factor of terminal performance (Onut, Tuzkaya, & Torun, 2011). Port activity is driven by liner services, location, accessibilities, information systems, productivity, reputation and port community (Notteboom, 2011).

Port specialization is a performance factor (Trujillo & Tovar, 2007; Medda & Carbonaro, 2007) that reflects the port evolution degree, from its industrial phase to a modern and commercial and intermodal port, and reflects the scale, learning and agglomeration effects of container and liner services with impact on performance.
The maritime accessibility is an important determinant of terminal performance, with diverse and frequent container maritime shipping services allowing a wider choice, greater flexibility and less transit times in the logistic chain, being associated to a higher port and terminal performance (Tongzon, 2002). Buckmann and Veldman (2003) explain the market shares of ports in northern Europe and its performance using factors such as liner shipping frequency. The maritime shipping services determine the success of the port based on its partnerships and the logistic networks in which are integrated (Tongzon & Heng, 2005). Maritime access depth is determinant of terminal performance, and allows serving bigger ships (Tongzon, 2003).

Turner, Windle and Dresner (2004) confirmed the importance of inland accessibilities impact on performance and Gaur (2005) identified factors that affect the terminal performance such as connections with the hinterland.

As referred by Magala and Sammons (2008) the selection of a port has become more a function of the overall logistic chain performance that provides an full integrated service, which need a logistic oriented management. Marlow and Paixão (2003) referred to the port operator’s ability to integrate their operations upstream or downstream the logistic chain, making use of value-added services, competing with other value-added chain systems.

The flexible organizational structure of the container terminal is important to provide an agile service that meets logistic customer’s demands (Liu et al., 2009). Internal flexibility, agility and capability towards cooperation on logistic chain depend on the terminal organization system, type of management and on the terminal managers’ training (Liu et al., 2009). Agile organizations include flexible and flattened organic (Liu, Xu, & Zhao, 2009). In the organizational integration context, the added value that ports can offer to logistic chains seems to be the key to succeed (Robinson, 2002).

Port integration in supply chains means a continuous terminal management improvement of lean elimination of redundancy, the reduction of handling costs, integrated information system, handling improvements and by offering value-added services to customers, specially contributing to ship-owner’s satisfaction (Panayides & Song, 2011).

Hung et al. (2010) used quay equipment and equipment while analysing efficiency. Wu, Yan, & Liu (2010) used the capacity of quay equipment as variables of the container terminal infrastructure as performance factors.

Onut et al. (2011) reported that the main performance criteria of the port include geographic location and physical characteristics. The location of the port is a key determinant of performance (Liu, 1995). Cheo (2007) refers to the importance of studying the influence of the port location where the port is located in its performance.

**Terminal performance**

In most port studies, the main performance indicators used for the terminal and port activity are the number of tonnes or containers throughput per year (Song & Yeo, 2004; Tovar & Trujillo, 2007; Garcia-Alonso & Martin-Bofarull, 2007). Cheon, Dowall, and Song (2010) consider the volumes of containers in TEU (twenty-foot equivalent unit) handled at the terminal as variable of port performance. In recent years, there has been significant progress in the literature on the measurement of efficiency in relation to productive activities. Approaches, called data envelopment analysis (DEA) and stochastic frontier analysis (SFA) have been increasingly used to analyze the performance of container terminals. Budira-Martinez et al. (1999) study the growth of Spanish ports from different groups based on their complexity in terms of relative efficiency using the DEA.

Brooks and Pallis (2013) report that port performance and competitiveness should be measured by efficiency and effectiveness. They report that performance is usually associated with operational efficiency, cargo physical quantities and efficiency in resource use (occupancy pier, revenue per ton, investment per ton, and ship waiting time). However, the efficiency does not necessarily lead to greater competitiveness, which is also the result of effectiveness in delivering services desired by customers. Sometimes the efficiency of the terminal may even be contradictory to the effectiveness of the service satisfaction, being necessary balance (Brooks & Pallis, 2013). These authors refer that the customers and stakeholders perception measurement is very important for terminal management and investment plans to meet supply chain needs, but terminal users may rate satisfaction differently. The fulfilment of container terminal customers’ needs and their satisfaction, goes beyond the efficiency that was traditionally been considered in the perspective of infrastructures, meaning that the creation of value has changed from the simple efficient container terminal operation to an effective integrated service in supply chains (Robinson, 2002; Bichou, 2007).

3. Methods

Research model and hypothesis

The research model is based on the definition of a global conceptual and holistic model that includes the port and container terminal characteristics and their relation with the terminal performance (Figure 1). Port and terminal characteristics considered are port location, port specialization in containers, terminal inland accessibility, logistic oriented terminal management, maritime accessibility and terminal quay equipment. Container terminal performance is measured by customers’ satisfaction, efficiency and activity.

Figure 1 – Research model

![Research model diagram](Image)

- Port location
- Port specialization
- Inland accessibility
- Logistic oriented management
- Maritime accessibility
- Quay equipment

H1 → Satisfaction
H2 → Efficiency
H3 → Activity
Based on the theoretical background, we present the following hypotheses:

Hypothesis 1: Terminal customer satisfaction is influenced by port and terminal characteristics;
Hypothesis 2: Container terminal efficiency is influenced by port and terminal characteristics;
Hypothesis 3: Container terminal activity is influenced by port and terminal characteristics;

Factors and variables

Based on literature and on the results of the exploratory analysis made to data resulting from the questionnaire and physical data, the port and terminals characteristics are explained by six constructs: (i) port location, (ii) port specialization, (iii) inland accessibility, (iv) logistic oriented management, (v) maritime accessibility, and (vi) quay equipment. The constructs satisfaction, efficiency, and activity were also found.

Table 1 – Constructs and variables

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Variables</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction</td>
<td>Shipper /logistic chain operator satisfaction</td>
<td>Robinson, 2002; Liu et al., 2009</td>
</tr>
<tr>
<td></td>
<td>Ship owner’s satisfaction</td>
<td>Liu et al., 2009</td>
</tr>
<tr>
<td></td>
<td>Shipping agent’s and freight forwarder’s satisfaction</td>
<td>Liu et al., 2009; Magala and Sammons, 2008</td>
</tr>
<tr>
<td></td>
<td>Satisfaction with domestic flows</td>
<td>Sharma &amp; Yu, 2009; Acochrane, Veldman et al., 2011</td>
</tr>
<tr>
<td></td>
<td>Satisfaction with economic impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Satisfaction with productivity</td>
<td>Onut et al., 2011; Talley, 2006</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Data Envelopment Analysis index</td>
<td>Cullinane and Wang, 2006; Cullinane et al., 2004 and Cheon, 2007</td>
</tr>
<tr>
<td>Activity</td>
<td>Number of TEU per year</td>
<td>Song and Yeo, 2004; Tovar and Trujillo, 2007; Garcia-Martin-</td>
</tr>
<tr>
<td>Port location</td>
<td>Region GDP per capita where port is located</td>
<td>Cheo (2007); Onut et al., 2011; Liu, 1995</td>
</tr>
<tr>
<td>Port specialization</td>
<td>Port specialization in container</td>
<td>Trujillo and Tovar, 2008; Medda and Carbonaro, 2007</td>
</tr>
<tr>
<td></td>
<td>Frequency of SSS/feeder services</td>
<td>Chou, 2010; Veldman et al., 2011; Onut et al., 2011; Tongzon, 2002; Veldman and Buckmann, 2003; Hung et al., 2010</td>
</tr>
<tr>
<td>Inland accessibility, Turner,</td>
<td>Railway accessibilities</td>
<td>Juang and Roe, 2010; Onut et al., 2011; De Langen, 2004</td>
</tr>
<tr>
<td>Windle and Dresner (2004) and Gaur (2005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road accessibilities</td>
<td>Juang and Roe, 2010; Tongzon, 2002, Wiegmans, 2003; Turner, Windle and Dresner, 2004; Gaur, 2005</td>
</tr>
<tr>
<td></td>
<td>Terminal land size</td>
<td>Sharma e Yu, 2009; Cullinane and Wang, 2010; Hung et al., 2010; Wu et al., 2010</td>
</tr>
<tr>
<td></td>
<td>Terminal connections layout</td>
<td>Authors</td>
</tr>
<tr>
<td></td>
<td>Railway connections to inland terminals</td>
<td>Juang and Roe, 2010; Chang et al., 2008; Bruce et al., 2008; Tongzon et al., 2009; Panayedes and Song, 2011; Panayedes and Song, 2009</td>
</tr>
<tr>
<td>Logistic areas near the port</td>
<td>Authors</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Quay water depth</td>
<td>Wang and Cullinane, 2006</td>
<td></td>
</tr>
<tr>
<td>Maritime access</td>
<td>Tongzon 2003; Wang and Cullinane, 2006; Gaur, 2005; Turner et al., 2004</td>
<td></td>
</tr>
<tr>
<td>Vessels size allowed</td>
<td>Acochrane, 2008; Veldman et al., 2011; Turner et al., 2004; Hung et al., 2010</td>
<td></td>
</tr>
<tr>
<td>TOP10 liner services calling the terminal</td>
<td>Liu et al., 2009</td>
<td></td>
</tr>
<tr>
<td>Frequency of TOP10 liner services</td>
<td>Song e Yeo, 2004; Tongzon 2003; Tongzon and Heng, 2005</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Logistic oriented management</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminal brand</td>
<td>Juang and Roe, 2010; Onut et al., 2011; Chang et al., 2008; Cheo, 2007; Pando et al., 2005; Pardali and Kounoupas, 2007; Cahoon and Hecker, 2007</td>
</tr>
<tr>
<td>Type of terminal manager</td>
<td>Liu et al., 2009</td>
</tr>
<tr>
<td>Overall services quality</td>
<td>Veldman et al., 2011; Woo et al., 2011; Juang and Roe, 2010; Hung et al., 2010; Liu et al., 2009</td>
</tr>
<tr>
<td>Customer oriented terminal</td>
<td>Juang and Roe, 2010; Onut et al., 2011; Carbone and De Martino, 2003; Liu et al., 2009</td>
</tr>
<tr>
<td>Terminal organization</td>
<td>Bichou and Gray, 2004; Robinson, 2002; Liu et al., 2009</td>
</tr>
<tr>
<td>Information system</td>
<td>Carbone and De Martino, 2003; Panayedes and Song, 2009; Cachon and Fisher, 2000; Zhao et al., 2002; Liu et al., 2009</td>
</tr>
<tr>
<td>Agility face to changes</td>
<td>Woo et al., 2011; Onut et al., 2011; Liu et al., 2009</td>
</tr>
<tr>
<td>Operational and commercial flexibility</td>
<td>Liu et al., 2009; Notteboom and Winkelmans, 2004</td>
</tr>
<tr>
<td>Terminal reliability</td>
<td>Chang et al., 2008; Tongzon et al., 2009; Notteboom and Winkelmans, 2004</td>
</tr>
<tr>
<td>Berth productivity and vessels time</td>
<td>Onut et al., 2011; Tongzon et al., 2009; Juang and Roe, 2010; Liu et al., 2009</td>
</tr>
<tr>
<td>Vessels waiting time</td>
<td>Onut et al., 2011</td>
</tr>
<tr>
<td>Port community integration and dynamics</td>
<td>Van Der Horst &amp; De Langen, 2008</td>
</tr>
<tr>
<td>Terminal integration in logistic chains and add value services</td>
<td>Juang and Roe, 2010; Tongzon and Heng, 2005; Hung et al., 2010; Panayedes and Song, 2009; Paixão and Marlow, 2003; Liu et al., 2009</td>
</tr>
<tr>
<td>Terminal Handling charge</td>
<td>Onut et al., 2011; Song e Yeo, 2006; Veldman and Buckmann, 2003; Tongzon et al., 2009; Juang and Roe, 2010</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quay equipment</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cranes per quay meter</td>
<td>author</td>
</tr>
</tbody>
</table>
Data collection and measurement
Qualitative data were collected based on a survey sent to the main Portugal and Spain container terminal’s users. A question was addressed to each variable, concerning the evaluation of terminal characteristic and the customers’ satisfaction level, using a 7-point Likert scale. The questionnaire was submitted to 1139 managers from companies operating in the selected terminals, with a 151 valid answers (Table 2).

The component of the survey relating to the construct costumer’s satisfaction was based on the question "Do you agree that the container terminal satisfies the customer?", identifying each type of customer and issue. The remaining qualitative variables were based on the general question "Do you agree that the container terminal is good in the variable x?". Factor analysis has reduced the number of variables to continuous ones using the score factors and applied in model tests (Table 3).

The quantitative variables Activity and Quay equipment were obtained from port information books and Eurostat. The efficiency quantitative variable result from the Data Envelopment Analysis index and was calculated using terminal quantitative information of terminal throughput, quay length, terminal area and number of cranes, collected in port internet sites. We used the quay length as capital proxy, number of gantry cranes as labor proxy and terminal area as land proxy, as input variables of DEA model, and terminal TEU throughput per year as output variable (Cheon, 2007).

<table>
<thead>
<tr>
<th>Table 2 – Sample definition, Iberian Peninsula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Portugal</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Spain</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Statistical instruments
The structural equation model (SEM) is a linear model that sets a relation between observed and latent variables and between endogenous and exogenous variables, whether latent or observed. It is divided in two sub-models: the measurement model and the structural one.

The measurement model defines how the latent variables are operationalized by the observed ones, including exogenous variables and endogenous ones. The structural model defines the causal relations between latent variables.

The path analysis methodology of SEM was used to confirm the structural model of latent factors and observed variables explaining the container terminal performance, as well as the latent variables of performance, by using AMOS18 software.
DEA (Charnes, Cooper & Rhodes, 1978) was used to determine the terminal efficiency variable, an endogenous variable in terminal performance model. The goal was to explain DEA rank with factor variables from terminal characteristics, not to determine the DEA rank itself.

4. Results and analysis

Data analysis

By using the structural equation model methodology, the confirmatory analysis of the research and hypothesis model was performed. The collected variables were used to determine the model latent variables. In the questionnaire, user managers were asked to choose, on the scale between total agreement (7) and total disagreement (1) regarding the high customer’s satisfaction of a specific terminal previously identified. It was also asked the scale of appreciation of each of the factors of port and terminal characterization, qualified in a positive way in the question with customer’s satisfaction. Average high results to customer’s satisfaction (between 4.89 and 5.35) and important results to characterization factors (between 3.30 and 5.23) were obtained, which confirmed the potential importance of these factors to terminal performance in the opinion of user managers who answered the questionnaire (Table 3). The quantitative variables were transformed in 7-Likert scale to allow working with the other variables in SEM model.

Table 3– Descriptive statistics, Iberian Peninsula

<table>
<thead>
<tr>
<th>Construct/Latent Variable</th>
<th>Latent Factorial Loadings</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shipper/logistic chain operator’s satisfaction</td>
<td>0.86</td>
<td>2</td>
<td>7</td>
<td>4.95</td>
<td>1.145</td>
</tr>
<tr>
<td>Traveler’s satisfaction</td>
<td>0.86</td>
<td>1</td>
<td>7</td>
<td>4.96</td>
<td>1.311</td>
</tr>
<tr>
<td>Shipping agent and freight forwarder's satisfaction</td>
<td>0.87</td>
<td>2</td>
<td>7</td>
<td>4.97</td>
<td>1.180</td>
</tr>
<tr>
<td>Satisfaction with domestic flows</td>
<td>0.51</td>
<td>1</td>
<td>7</td>
<td>4.93</td>
<td>1.592</td>
</tr>
<tr>
<td>Satisfaction with economic impact</td>
<td>0.70</td>
<td>1</td>
<td>7</td>
<td>5.35</td>
<td>1.239</td>
</tr>
<tr>
<td>Satisfaction with productivity</td>
<td>0.86</td>
<td>1</td>
<td>7</td>
<td>4.89</td>
<td>1.490</td>
</tr>
<tr>
<td>Efficiency index</td>
<td>1</td>
<td>7</td>
<td>3.40</td>
<td>1.697</td>
<td></td>
</tr>
<tr>
<td>Activity TEU per year</td>
<td>1</td>
<td>7</td>
<td>2.13</td>
<td>1.838</td>
<td></td>
</tr>
<tr>
<td>Region GDP per capita where port is located</td>
<td>1</td>
<td>5</td>
<td>3.58</td>
<td>1.812</td>
<td></td>
</tr>
<tr>
<td>Port specialization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port specialization in containers handling</td>
<td>0.71</td>
<td>1</td>
<td>7</td>
<td>5.12</td>
<td>1.336</td>
</tr>
<tr>
<td>Frequency of SSS/feeder services</td>
<td>0.76</td>
<td>1</td>
<td>7</td>
<td>4.81</td>
<td>1.392</td>
</tr>
<tr>
<td>Railway accessibilities</td>
<td>0.81</td>
<td>1</td>
<td>7</td>
<td>4.44</td>
<td>1.668</td>
</tr>
<tr>
<td>Road accessibilities</td>
<td>0.63</td>
<td>1</td>
<td>7</td>
<td>4.97</td>
<td>1.655</td>
</tr>
<tr>
<td>Terminal land size</td>
<td>0.60</td>
<td>2</td>
<td>7</td>
<td>4.64</td>
<td>1.463</td>
</tr>
<tr>
<td>Terminal connections layout</td>
<td>0.56</td>
<td>2</td>
<td>7</td>
<td>4.94</td>
<td>1.218</td>
</tr>
<tr>
<td>Railway connections to inland</td>
<td>0.71</td>
<td>1</td>
<td>7</td>
<td>4.20</td>
<td>1.755</td>
</tr>
</tbody>
</table>
Endogenous DEA efficiency variable data statistics for Iberian Peninsula was determined (Annex 1).

**Results of confirmatory analysis**

Based on the hypotheses, it was found that the initial constructs have an high adequate fit. The model latent exogenous variables, with internal consistency, reliability validity and unidimensionality validity, were determined (Hair et al., 1998; Tabachnick & Fidell, 2001).

After different tests, we found that not all factors explain the dependent variables of the model, so we divide into two sub-models, to enable to test the qualitative variable satisfaction based on extraneous qualitative factors and to test the variables efficiency and activity based on the quantitative independent factors. First it was developed the customer satisfaction model for the Iberian Peninsula. The qualitative variables in the structural equation model were first transformed and new latent variables were obtained from the
scores of the factorial analysis with KMO 0.773 for satisfaction and KMO 0.751 for the independent qualitative variables of the model.

In order to test the determinants of dependent variables we used the path analysis method of the structural equation model. Significant overall results were obtained with the following indicators of goodness-of-fit (GoF) of the model, $\chi^2$ 0.0; $\chi^2$/df 0.0;IFI: 1.035 (> 0.9);CFI: 1.00 (> 0.9);RMSEA: <0.0001 (<0.1), indicating a good fit of the measurement model of latent variables. Results show that 69% variance of the customer satisfaction is explained by the logistics oriented management ($\beta = 0.68$; p-value < 0.001), inland accessibility ($\beta = 0.40$; p-value < 0.001), port specialization ($\beta = 0.25$; p-value < 0.001) and maritime accessibility ($\beta = 0.10$; p-value = 0.026). The results also confirm the unidimensionality of the structural equation model (Hair et al., 1998; Tabachnick and Fidell, 2001).

The content validity or face validity of the latent variables was verified, consistent with the concepts and definitions in the literature, and the convergent validity was also verified with loadings of latent variables always significant and higher than 0.5 in factorial analyses (Anderson et al., 1987).

It was developed the efficiency and activity model for the Iberian Peninsula. Significant overall results were obtained with the following indicators of goodness-of-fit (GoF) of the model, $\chi^2$ 3,822; $\chi^2$/df 3,822;IFI: 0.991 (> 0.9);CFI: 0.991 (> 0.9);RMSEA: 0.137 (<0.1) indicating a tolerable adjustment of the latent variables, due to the small sample size number of terminals. It was concluded that 23% of the variance of the terminal efficiency is explained by quay equipment ($\beta = 0.48$; p-value < 0.001) and 80% of variance of the terminal activity is explained by quay equipment ($\beta = 0.57$; p-value < 0.001), by port location ($\beta = 0.18$; p-value < 0.001), and efficiency ($\beta = 0.53$; p-value < 0.001) as a mediator variable, showing that the activity of the terminal depends on economic location factors, efficiency of the terminal and quay equipment (Figure 2). Satisfaction has no significant relation with activity (Annex 2).

**Figure 2 – Performance structural model, Iberian Peninsula**
5. Discussion
The obtained results allow us to consider as pertinent the research model, as a global vision, about influence of container terminal characteristics on terminal performance. The Activity is related with Efficiency, but these are not related with customers’ satisfaction. The variables that influence activity and efficiency are not the same that influence Customer’s’ satisfaction.
Satisfaction is influenced by logistic oriented management (β=0.68), the most important factor. This demonstrates the importance of the integration of container terminals in the logistic chain, to overall performance (Robinson, 2002). Logistic integration of ports requires a strong orientation to customer and logistic need, compatible information systems, agility, flexibility, reliability, price and service quality (Notteboom & Winkelmans, 2004). The results confirm Robinson (2002) findings about the port selection being made in the context of the supply chain, which demands an enlarged vision of the port and terminal. It is confirmed that management orientation towards logistics is very important to customers’ satisfaction. The importance of the information systems is confirmed as it allows information sharing, leading to high levels of the container terminal’s integration in the supply chain. Also, the importance of the type of manager and the type of organization that determines the terminal agility while answering to logistic network demands (Liu et al., 2009).
Satisfaction is influenced by inland accessibility (β=0.40), showing the importance of inland infrastructures to customer’s satisfaction, especially inland accessibilities, to enlarge the hinterland and contribute to maximize terminal investments. The conclusions of Turner, Windle and Dresner (2004) and Gaur (2005) about the impact of inland accessibilities on performance were confirmed. The hinterland accessibilities allow terminal expansion beyond the port limits, enlarging its influence area, connected by road and rail. This variable also includes the existence of logistic areas nearby, as being determinant to the customer’s satisfaction. These findings support the conclusions of various authors such as Hung et al. (2010) and Wu et al. (2010).
Satisfaction is influenced by maritime accessibility (β=0.10), and this results are consistent with those of Tongzon (2002) about the importance worldwide shipping lines to a higher customer’s satisfaction. And it confirms the importance of partnerships with logistic networks (Tongzon & Heng, 2005) and of maritime access depth allowing serving bigger ships, as determinants of performance (Tongzon, 2003).
Satisfaction is influenced by port specialization (β=0.25), which demonstrates the importance of specialization as a model factor, namely the containerization rate, already referred by Trujillo and Tovar (2007) and Medda and Carbonaro (2007). This demonstrates that terminals located in ports with higher container specialization usually have higher customer’s satisfaction levels when using the respective infrastructures. A specialized port can usually achieve high performance levels due to the port overall services and infrastructures’ suitability to container handling and operations. We confirm the hypothesis 1, namely that the terminal customer satisfaction is influenced by port and terminal characteristics.
Efficiency is influenced by quay equipment (β=0.48), which confirms Wu et al. (2010) findings about quay equipment being a variable of the container terminal infrastructure as performance factor. We confirm the hypothesis 2, namely that the container terminal efficiency is influenced by port and terminal characteristics.
Activity is influenced by quay equipment (β=0.57) directly, and mediated by efficiency (β=0.53), confirming Wu et al. (2010) findings once more. Efficiency as influence on activity as efficient ports usually has low prices rates and higher productivity, attracting more cargo and customers.

Activity is also influenced by port location (β=0.18), confirming Onut et al. (2011), Cheo (2007) and Liu (1995) results about geographic location being the main performance criteria of the port and a key determinant of performance. We confirm the hypothesis 3, namely that the container terminal activity is influenced by port and terminal characteristics.

6. Conclusions, limitations, and future research

This study allowed the development of an explanatory overall model of terminal performance, based on the port and on the terminal characteristics. The activity and efficiency can be explained through quantitative and physical terminal characteristics. Moreover, container terminal customers’ satisfaction is explained by qualitative terminal characteristics. There is no relation between customers’ satisfaction, and container terminal activity or efficiency.

The main characteristic of the terminal that supports the customers’ satisfaction is the terminal logistic oriented management. This characteristic is not relevant for terminal efficiency or activity. The terminal is part of global logistic chain and cannot work isolated. It was found that the efficiency is derived from the quality of the equipment and influencing the volume of activity. The quay equipment is the most important characteristic of port and container terminal that supports the activity and efficiency. If the terminal has more cranes per quay meter, will be more efficient and will have more activity. Terminals are built in local with characteristics regarding the traffic volume. Location is other important characteristic influencing terminal activity.

Inland accessibility and maritime accessibility are factors very important of the terminal characteristics to the customers’ satisfaction. Also are important of the logistic chain point of view, to adequate terminal links to hinterland and foreland. Port customers are more satisfied with terminals inside container ports specialized, because they have adequate infra and superstructure with services and equipment more appropriate and accessibilities to set their logistic chain, with the possibility to choose between several terminals.

This study contributes to a better knowledge of ports and container terminals, namely, because distinguish the importance of the services for the customers satisfaction and the equipment and local for efficiency and terminal activity. This research contributes to a better understanding that the successful of the container terminals is associated with a high quality service, and orientation towards the customer. To this contribute the conditions to meet the logistic chain, in which the terminal is integrated in terms of agility, flexibility, reliability, information systems, prices, berth occupancy and vessels waiting time.

The main limitation is the sample size considering the number of terminals observed, although being representative of the population of the Iberian Peninsula ports.

An interesting future research work would apply this model to other worldwide port terminals, in an enlarged geographical context. Moreover, it should be developed analysing the customers’ satisfaction, trying to detail the factors that are important to the satisfaction and the different type of segments.
References


Tongzon, J. (2002). Port choice determinants in a competitive environment. IAME, Conference, Panama.


**Annex 1 – DEA statistics**

**Iberian Peninsula and Europe**

<table>
<thead>
<tr>
<th>Location</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeciras</td>
<td>1.00</td>
</tr>
<tr>
<td>DPWT Tarragona</td>
<td>0.30</td>
</tr>
<tr>
<td>Figueira</td>
<td>1.00</td>
</tr>
<tr>
<td>Liscont Lisbon</td>
<td>0.52</td>
</tr>
<tr>
<td>NCTB Bilbao</td>
<td>0.32</td>
</tr>
<tr>
<td>Noatum Valência</td>
<td>1.00</td>
</tr>
<tr>
<td>Sadoport Setúbal</td>
<td>0.15</td>
</tr>
<tr>
<td>TCB Barcelona</td>
<td>0.64</td>
</tr>
<tr>
<td>TCL Leixoes</td>
<td>0.61</td>
</tr>
<tr>
<td>TCSA Lisbon</td>
<td>0.35</td>
</tr>
<tr>
<td>TML Lisbon</td>
<td>1.00</td>
</tr>
<tr>
<td>XXI Sines</td>
<td>0.48</td>
</tr>
</tbody>
</table>

**Annex 2 – Relation between activity and customers’ satisfaction**