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Cluster analysis of the competitiveness of container ports in Brazil

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ABSTRACT

The container cargo proportion of total maritime transport increased from 3% in 1980 to 16% in 2011. The largest Brazilian port, the port of Santos, is the 42nd largest container port in the world. However, Santos' performance indicators are much lower than those of the world's largest ports, so comparisons with them are difficult. This article focuses on the Brazilian container terminals that handled containers in 2009 and compares port competitiveness. This study classified seventeen Brazilian container terminals into three distinct groups based on the following competitiveness criteria: number of containers handled, berth length, number of berths, terminal tariffs (in US$), berth depth, rate of medium consignment (in containers/ship), medium board (containers/hour), average waiting time for mooring (in hours/ship), and average waiting time for load or unload cargo (in hours/ship). This classification used a hierarchical cluster analysis. The classification shows that the terminal of Tecon in the port of Santos has the best performance of all, while small terminals (<150,000 container units) are the worst performing terminals in Brazil.

1. Introduction

Interest is growing in the major world ports for the transport of cargo in containers. In 1970, the ten largest container ports were located mostly in America and Europe; these ports handled just 2,830,709 twenty-foot equivalent units (TEUs)[2] in that year. In 2011, the new top ten ports moved 191,759,327 TEUs, which represents a 6674% increase over 41 years. This rate equates to an average growth rate of 10.43% per year. In this same period, the international maritime trade did not even remotely approach this growth rate (3.00% per year). The number of specialised terminals in container transport also increased significantly, following the continuous improvement in productivity (Containerisation International, 2012; UNCTAD, 2012).

In conjunction with the increase of containerisation in the shipping matrix, which increased from 3% in 1980 to 16% in 2011 (UNCTAD, 2012), there was also a complete change in the top ten ports for container handling. In 1970, the American and European ports were the largest ports, and no Asian port appeared in the top ten list. In 2011, the only European port in

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[2] One TEU is the load capacity of a standard shipping container: 20 feet long by 8 feet wide by 8 feet high. It is a standard measurement of volume.

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the top ten largest ports was the port of Rotterdam, and no American ports were on the list; all of the others were Asian ports.

With a growth rate of 8.2% in 2012 (UNCTAD, 2012) and a projected rate of approximately 8% for 2013 (Containerisation International, 2012), the transport of containerised cargo has received large investment. The overall goal of specialised terminals is to reduce costs while preserving service quality. In this context, the port of Shanghai (China) is the largest port in the world in cargo volume transported and is also the biggest container port. The Shanghai port transported 727.6 million tonnes of all types of cargo in 2011, including 31.7 million TEUs of cargo in containers. Rotterdam is the largest port in Europe, moving 434.6 million tonnes of all types of cargo and 11.88 million TEUs of containers (Containerisation International, 2012). The other ports in descending order of importance are shown in Table 1.

In Brazil, the port of Santos (located in the state of São Paulo) is the 42nd largest container port in the world (2.96 million containers handled in 2011) and is also the only Brazilian port among the 100 largest ports in the world. In 2011, Santos transported 97.17 million tonnes of cargo, which represents an increase of 1.2% compared to the 96.02 million tonnes transported in 2010.

These data provide an idea of the size of Brazilian ports compared to major ports around the world. However, other differences exist beyond size. Some additional indicators of productivity are useful to understand the gaps to be filled for Brazilian ports to become more competitive. One of these indicators is the medium board, which indicates the average productivity of each terminal, i.e. the length of time ships are berthed, which is taken as service time. According to World Bank data, service time in Singapore is 100 containers/hour. In Rotterdam, service time is 60 containers/hour. In the port of Santos, service time falls to 39 containers/hour. Regarding the time required to load or unload a container, Santos needs 22 man-hours/container, compared to only 2 and 5 man-hours/container in Singapore and Rotterdam, respectively (World Bank, 2010).

In addition to these indicators, if we include cultural factors, the administrative management of the port, tariffs, location, the depth of the quay, the number of berths, the number of incoming vessels, the quay length, the container storage areas, and the crane and scanner equipment, it is not useful to compare the largest port in Latin America to the major world ports.

This article focuses on 17 Brazilian terminals responsible for 75% of all containerised cargo moved in Brazil in 2009. The main objective is to classify these terminals into different groups according to competitive criteria available for container ports in Brazil. This approach allows easy comparison of port terminals with different characteristics and constraints, because similar terminals will be grouped together.

We employed three different clustering algorithms to form the groups: Kmeans, PAM (partitioning around medoids) and Hierarchical (Unweighted Pair Group Method – UPGMA). For statistical analysis, we used the *clValid* package for cluster validation (Brock et al., 2008) from computational platform software R (R Core Team, 2013).

Section 2 provides a brief literature review on port competitiveness and efficiency. Section 3 presents the definition of the variables and the methodology used to classify the terminals in the sample. Section 4 reports the results. Finally, Section 5 concludes the paper.

2. Literature review

Porter (1990) defines competitiveness as the skill or talent resulting from acquired knowledge that is capable of creating and sustaining superior performance developed by competition, and according to him, competitiveness is the same as productivity. Despite productivity and efficiency are the two most important concepts in measuring performance, these two definitions have mistakenly been treated as the same in most of the literature (Wang et al., 2002), and it is very important to differentiate between these two concepts.

A producer's productivity can be loosely defined as its ratio of output(s) to input(s). This definition easily enables explaining any situation where there is a single input and a single output. However, it is more common that production has multiple inputs and outputs, in which case productivity is related to *total factor productivity*, a productivity measure involving all fac-

Table 1
Top 10 ports: 2011.

Rank	Port	Country	TEU
1	Shanghai	China	31,700,000
2	Singapore	Singapore	29,937,700
3	Hong Kong	China	24,384,000
4	Shenzhen	China	22,569,800
5	Busan	South Korea	16,184,706
6	Ningbo	China	14,686,200
7	Guangzhou	China	14,400,000
8	Qingdao	China	13,020,000
9	Dubai	UAE	13,000,000
10	Rotterdam	Netherlands	11,876,921

Source: Containerisation International, (2012).