



Exploring the drivers of port efficiency in Latin America and the Caribbean



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ABSTRACT

We developed a technical efficiency analysis of container ports in Latin America and the Caribbean using an input-oriented stochastic frontier model. We employed a 10-year panel with data on container throughput, port terminal area, berth length, and number of available cranes in 63 ports. The model has three innovations with respect to the available literature: (i) we treated ship-to-shore gantry cranes and mobile cranes separately, in order to account for the higher productivity of the former; (ii) we introduced a binary variable for ports using ships' cranes, treated as an additional source of port productivity; and (iii) we introduced a binary variable for ports operating as transshipment hubs. Their associated parameters are highly significant in the production function. The results show an improvement in the average technical efficiency of ports in the Latin American and Caribbean region from 52% to 64% between 1999 and 2009; the best performing port in 2009 achieved a technical efficiency of 88% with respect to the frontier. The paper also studies possible determinants of port technical efficiency, such as ownership, corruption and income per capita. The results revealed a positive and significant association between technical efficiency and private port operations.

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1. Introduction

1.1. Context

The Latin American and Caribbean (LAC) region is responsible for 8.0% of the world's Gross Domestic Product (GDP), is home to 8.5% of the world's population, and had an average annual economic growth rate of 4.9% during the period 2002–2012 (International Monetary Fund, 2013), higher than the worldwide average. Part of this consistent growth was brought about by an increasing interconnectedness with international markets that resulted in a notable growth in international trade. During the same period, in South America, the volume of merchandise exports grew by 44% and the volume of merchandise imports grew by 190%. In the rest of the LAC region these two indicators increased by 50% and 55%, respectively (United Nations Commission for Trade and Development, 2013). The observed growth in trade has put

pressure on the main international trade gateways in the region, and, as a result, LAC ports have been receiving significant attention from governments, regulators, and the private sector.

The importance of seaports to LAC's economic growth is rooted in the region's colonial history and natural endowment. LAC's economy has long depended more on seaborne international trade for income (from agricultural products and extractive industries exports) and consumer goods (from imports) purchased with the capital accrued from those commodity exports than it has on intra-regional trade over land corridors. Another determinant of the importance of maritime trade in LAC is the Panama Canal, a key element of the main East–West trade axis of the global economy, transforming the ports in Central America and the Caribbean into natural transshipment hubs, not only between the Northern and Southern hemispheres, but also between Asia, Europe, and both coasts of the United States of America (USA). Because of the planned expansion of the Panama Canal by 2015 and the expected traffic increase in associated maritime routes, ports throughout the region have been under stress, preparing for higher demand and larger vessels.

Port expansions in countries such as Brazil, Argentina, and Mexico have been driven by increasing exports and imports propelled by a significant growth in agricultural trade, moved as either bulk or container cargo. In other countries, such as Chile and

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Ecuador, ore and oil have been drivers of the expansion of the port sector, although merchandise trade of containerized commodities has also performed above expectations. This supply-led growth has taken place alongside a noticeable increase in household consumption and import demand for final, intermediate, and capital goods, propelled by appreciated exchange rates in many countries in the region. In 2011, LAC merchandise exports and imports reached US\$886 and US\$874 billion respectively, 81% of which was transported through seaports ([Economic Commission for Latin America and the Caribbean, 2012](#)).

Cargo in LAC is increasingly dispatched as container shipments, a situation that has led to an increasing trend of port terminals specializing in container handling. At the regional level, container traffic more than doubled in the last decade, from 17 million twenty-foot equivalent units (TEUs) in 2000 to 40 million TEUs in 2010 ([World Bank, 2013](#)), with an average compound annual growth rate of 10%. More than one-third of these container flows can be traced to Brazil (19%) and Panama (16%) combined. In the case of Brazil, container traffic is driven by the size of its market, while in the case of Panama, transshipment is the leading factor. Mexico, Chile, and Colombia have 7–10% each of the share of container flows. The Caribbean islands combined capture about 13% of containerized flows due to their strategic location connecting many intercontinental maritime routes ([Economic Commission for Latin America and the Caribbean, 2012](#)). In Central America, containerized cargo represented only 40% (by volume) of all cargo handled in 2003. By 2011 this share had increased to 59% ([Comisión Centroamericana de Transporte Marítimo, 2011](#)). Another factor that has helped increase container traffic is the acquisition of larger ships by shipping lines. According to [Blue Water Reporting \(2013\)](#), the average capacity of container vessels servicing Latin America doubled between 2000 and 2011, from roughly 2000 TEUs to over 4000 TEUs, a trend that has intensified since 2007. All previous facts turn the first decade of the 21st century into an ideal scenario to analyze the performance of ports in a period of major changes. How these ports have responded to this growing demand and the need to accommodate larger ships with more services required is vital to understand their potential for current and future needs and to identify the main bottlenecks.

Because of the continued maritime trade growth across LAC and the larger vessel sizes, many countries are already expanding their container handling facilities and establishing institutional reforms to accommodate increasing demand. Beyond the major transshipment ports of the Caribbean and large container terminals of Brazil, Argentina, Uruguay and Chile, expansions can be seen even in the smaller sub-regions, such as Central America, where neighboring ports are competing to retain and attract more direct liner services.

In terms of institutional reforms, beginning in the early 1990s many LAC countries (including Argentina, Colombia, Chile, Brazil, Mexico, and Panama) started the dual processes of decentralization and concessions, transitioning ports to landlord systems with high foreign participation ([Sanchez, 2004](#)). In the last two decades, LAC countries have been very active in promoting port service concessions. In our sample of 63 ports in the region, almost two-thirds had privately operated terminals under concession agreements in 2009.

1.2. Motivation

The dynamic growth in container shipments, ongoing investment in physical capacity and institutional and market reforms indicate that both private and public actors in the region could benefit from a rigorous assessment of the current and achievable efficiencies in the LAC port sector. Several benchmarking studies have addressed efficiency calculations either through case studies

or through estimation of technical efficiency frontiers, but to our knowledge none of these studies have focused on a large sample of ports in LAC.

One of the reasons for the dearth of LAC-specific analyses to date has been the lack of data. In an effort to fill the existing gap of harmonized time series data and therefore develop an analysis of the technical efficiency of ports in the region, we have put together a database that draws primarily on information provided in the Containerization International Yearbooks ([Informa, 2009](#)).

In order to assess the technical efficiency of ports, we employed an econometric model based on a Stochastic Frontier Analysis (SFA). The model consists of an estimation of a production function for container terminals, in which cranes, berths, and terminal area are the inputs, and port container throughput is the output. As a result, time-varying technical efficiency is calculated as part of the residual term, conditional on a set of independent variables. The results provide a guideline for understanding technical efficiency's explanatory factors and trends across time, sub-regions, and countries. Moreover, they are a valuable input for regulatory and operational decision-making in the port sector.

When applying this model in LAC, it is challenging to capture all sources of productivity in container ports. The first challenge is the use of cranes mounted on vessels, which expedite the process of container handling, an arrangement usually seen more frequently in ports with limited infrastructure. Moreover, some ports in the Caribbean and in adjacent regions also benefit from quicker container turnaround due to the transshipment nature of their container traffic, *i.e.* transferring containers between vessels without requiring much terminal space or container processing time. In this paper we propose a methodology to account for the impact of these two characteristics on technical efficiency. The explicit inclusion of a variable that measures the impact of ships' cranes on productivity deals with a specific shortcoming of previous studies and attempts to address an important issue in developing countries.

In summary, we attempt to address several aspects of port technical efficiency: (i) the contribution of the different inputs related to container traffic; (ii) the level of technical efficiency in LAC ports and their relative position in the region; (iii) the growth in technical efficiency between 1999 and 2009; and (iv) the explanatory factors of port technical efficiency.

The paper is structured as follows: [Section 2](#) summarizes concepts and approaches used to assess efficiency, and the existing literature on port efficiency. [Section 3](#) presents an analysis of the database. [Section 4](#) provides a discussion of the model. [Section 5](#) presents the estimation results and [Section 6](#) provides an analysis of the results and a benchmark of port technical efficiency in the region. Finally, [Section 7](#) concludes the paper.

2. Methodological review

2.1. Port efficiency and other measures of performance

Port performance is often associated with measures of partial productivity, commonly defined as ratios of output volume to input volume, and with different measures of efficiency. These productivity indicators are usually related to time variables that aim to assess, for example, how fast cargo is handled. Examples of these indicators include *moves per ship-hour*, *moves per crane-hour*, *ship delay*, *ship dwell time* and *ship productivity*, among others. This type of port indicator provides important operational efficiency measures and may draw a detailed picture of performance at each stage of maritime shipping. However, it is difficult to gather consistent time series data on partial productivity indicators for very large samples of ports. In LAC, for example, recent efforts to

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