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The Drivers of Port Productivity for Selected Indian Ocean Ports Using the Malmquist Productivity Index

Abstract

Efficient ports are pivotal to the health of the nation's economy. For instance, when the port of Seychelles and Port Louis are put into consideration, it is noted that their respective ports are a major source of revenue. In Seychelles, the economy depends largely on the revenue it derives from imports and exports as well as tourism. In Mauritius, the port of Port Louis, handles the entire shipment that comes in to the country via sea. This paper examines the efficiency levels of these ports using the Malmquist based Data Envelopment Analysis. The review of literature lays further credence to the importance of this paper as there has been a paucity of articles on the efficiency level of the port of Port Louis and Port Victoria. Hence, this paper contributes to the growing body of knowledge on the efficiency analysis of ports using Data Envelopment Analysis based Malmquist Productivity Index. The period of examination is from 2008-2018. The results indicated that over the period of 2008 to 2018 the port of Port Louis achieved an annual average productivity gain of 0.91 whilst the Port of Victoria achieved 0.95. The drivers of productivity being tilted more towards technology change.

Keywords: Mauritius, Victoria, Data Envelopment Analysis, Port Efficiency, Malmquist Productivity Index

1. Introduction

Seychelles lies in the western Indian ocean between Madagascar and India[2]. The main engine of economic growth rests on tourism and fisheries[18]. The country relies heavily on international trade for importing goods as well as for income [17]. The dependence of the country on international trade lends credence to the need to examine the efficiency levels of the port of Victoria, Seychelles.

The port of Port Louis is strategically situated in the Indian Ocean some 2000 kms off the eastern coast of Africa and 890 km to the east of Madagascar[12]. With the upsurge in South-South trade, Port Louis has emerged as a preferred way port for vessels plying on the key maritime routes to Asia, Africa and Latin America [13]. The port handles 99.5% of the country's total volume of external trade, that is almost 7.5million tonnes of cargo annually.

The body of knowledge has confirmed that to effectively measure port efficiency and port performance, the Data Envelopment Analysis is a veritable tool to provide the necessary results [20]. This study focuses on using the Malmquist Productivity Index to evaluate the efficiency level for Port of Seychelles and Port Louis because these ports are part of the transport system.

In an instance when transport systems are deficient regarding capacity or reliability, they can have an economic cost such as reduced or missed opportunities and lower quality of life [16]. Ports efficiency has become an increasingly important topic because of the connecting links between different transport modes in the global logistics chain, especially the container terminals that are vital to the efficiency of the whole supply chain.[10]. When transport systems are efficient, they provide economic and social opportunities and benefits that result in positive multiplier effects such as better accessibility to markets, employment and additional investments [16].

Ports form a vital link in the overall trading chain; consequently, port efficiency is an essential contributor to a nation's international competitiveness [6]. Hence, it is crucial to analyse the effectiveness of transit corridors in other to be able to improve the service of these corridors. The evaluation of efficiency is imperative to sustain a competitive and flourishing global business environment [7].

Data Envelopment Analysis (DEA) has been used frequently to analyze port efficiencies in many part of the world [14]. With respect to this paper, the Data Envelopment Analysis based Malmquist Productivity Index model will be used to establish the drivers of productivity of these selected ports for the period of 2008-2018.

The paper proceeds as follows. In the next section, we will review articles that made use of the DEA model to analyze port efficiency, Section 3 discusses the data used, while section 4 deals with the results. Section 5 concludes with discussion on policy implications.

2. Back Ground of Study

The DEA techniques was developed, notably by [5][1]. DEA was initially developed to evaluate nonprofit and governmental organisations, but it has subsequently been applied to the service operations of a variety of private companies [17]. The review of literature in DEA indicated its application numerously in ports situated in Asia, America, Latin America, Middle East, Mediterranean, Europe and North America, but very few studies for ports located in Indian Ocean Countries.

The Port of Victoria is a small island developing state and a net importer, its shipping industry is critical for the economy [18]. As the country's primary maritime gateway, the port of Port Louis plays a crucial role in the national economy [12].

The two ports under examination plays a significant role in the boosting of their nation's economy, hence it is important to use the Malmquist productivity index to determine what are the drivers of productivity for these two major ports. The standard approach to the measurement of productivity change over time is the Malmquist index[4][8][9].

3. Methodology

The method adopted in this research is exploratory as it is designed to determine the drivers of the productivity for the port of Port Louis and the Port of Victoria that are located Indian Ocean. In this research, the DEA empirical analysis uses two outputs, which are the vessel visits and the container throughput. The four inputs used include the number of berths, the number of cranes, number of tugs and the length of quays. The data sources were obtained from the port authority and also from port websites. Figure 1 captures the countries represented in the study.

Figure 1: Map of Africa showing Port Louis and Port Victoria
Source: Osundiran, 2023

The Malmquist total factor productivity index was introduced in 1953 before being further developed in the frame of DEA[11]. It was defined as quantity index (QI) as ratios of distance functions where observations were evaluated relative to an indifference curve (IC)[11]. The Malmquist index decomposes productivity change into two components: Catch-up which captures the change in technical efficiency over time, and frontier-shift, which captures the change in technology occurring over time [9]. The Malmquist index is a geometric mean of two indices, evaluated concerning period t and period t+1 technologies [8].Figure 2, illustrates the Malmquist equation that measures efficiency. The product of efficiency change and the technological change makes up the MPI.

$$M\left(Y_{t+1},X_{t+1},Y_t,X_t,\right)=\underbrace{\frac{D^t\left(Y_{t+1},X_{t+1},\right)}{D^t\left(Y_t,X_t,\right)}}_{\text{Efficiency change}}\underbrace{\frac{D^t\left(Y_{t+1},X_{t+1},\right)}{D^{t+1}\left(Y_{t+1},X_{t+1},\right)}X\frac{D^t\left(Y_t,X_t,\right)}{D^{t+1}\left(Y_t,X_t,\right)}}_{\text{Technological Change}}$$

Figure 2: Malmquist Productivity Index Formula
Source: Malmquist (1953)

Where:

X_t and X_{t+1} input vectors of dimension at time t and t +1

Y_t and Y_{t+1} corresponding k- output vectors

D_t and D_{t+1} denote an input

$D(x,y) = \max(\rho:(s/\rho s \in L(y)$ (1)

- ◊ Where L(y) represents the number of all input vectors with which a certain output vector y can be produced, that is L(y) = (x:y can be produced with x).
- ◊ P in equation (2) can be understood as a reciprocal value of the factor by which the total inputs could be maximally reduced without reducing output.
- ◊ M= measures the productivity change between periods t and t+1. Productivity declines if M<1, remains unchanged if M=1 and improves if M>1.

4. Results

The Malmquist model captures the variations in the port performances for the Port of Victoria and port of Port Louis. In the computation of DEA MPI, two significant issues are established, firstly it is the efficiency catch up also known as technical efficiency and the boundary shift technological change, which is also known as the technology change. The Malmquist model allows for the determination of the drivers of productivity which could be efficiency or technology. All the ports reveal several fluctuations in their efficiency levels in the 11-year period examined.

4.1. Efficiency Change

The efficiency change (EC) is linked to management's efficiency that causes movement upward or downwards on the production possibility frontier. Hence, ports that have EC=1 are static regarding efficiency level, therefore revealing no improvement. Ports with EC>1 indicate improvement in efficiency levels while ports with EC<1 denote a decline in efficiency level. Figure 3 describes the results. The red colored graph represents Port of Port Louis whilst the blue colored graph represents the Port of Victoria. For the eleven years examined the port of Port Louis maintained an EC=1. The implication of which there has not been any major improvement with regards to efficiency change. On the contrary the Port of Victoria exhibited EC>1 for the years 2008-2009;2010-2011;2013-2014;2014-2015 and 2016-2017. The implication that these years indicates improvement in efficiency levels.

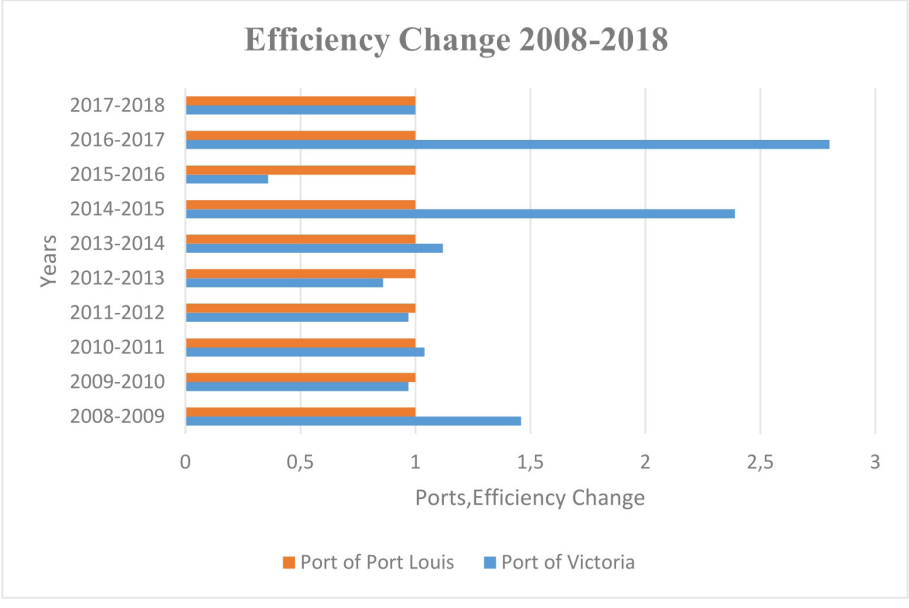

Figure 3: Efficiency Change 2008-2018
Source: Osundiran, 2023

4.2. Technology Change

The technology change is the second aspect of the Malmquist Productivity Index. This is evaluation of the ports based on improvement in technology. With regards to technological change, values above 1 represent technological progress in the sense that more can be produced using fewer resources [3]. Technology change (TC) causes

an outward shift in the production frontier. When ports have TC=1, then there is no improvement in technology. When TC<1 then there is a need for technological advancement. Figure 4, illustrates the results of a technological change. The red colored graph represents Port of Port Louis whilst the blue colored graph represents the Port of Victoria. For the Port Victoria, the first two years of examination shows TC=1, an indication of no improvement. The next three years indicated a slight improvement where TC>1. There was a slight decline where TC<1 for years 2013-2014 and 2014-2015. However, between 2015-2016 a leap in TC where TC>1. The subsequent years up until 2018 shows a decline in TC. For the port of Port Louis, the first two years shows TC=1 a static or no improvement. The next two years witnessed another TC>1 and then a decline for the next three years. The fluctuations continued until 2017-2018 where there was an increase in TC. TC>1.

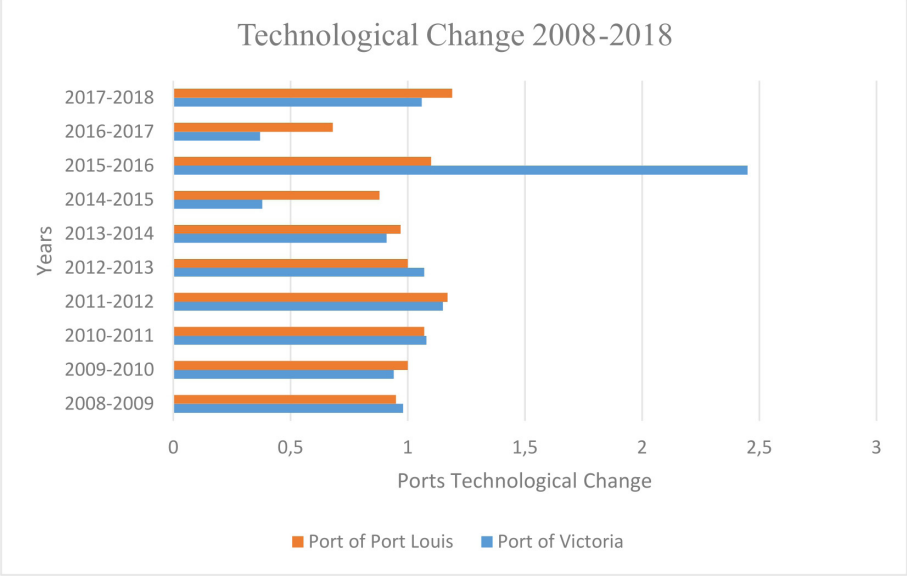

Figure 4: Technological Change 2008-2018
Source: Osundiran, 2023

4.3. Malmquist Productivity Index

The Malmquist productivity index is obtained by the product of TC and EC. Where the MPI>1 means there is progress in productivity, where MPI<1 signifies a decline in productivity and where MPI=1 indicates stagnancy. Figure 5 provides the MPI results for the ports. On the average both ports had MPI<1. Both Ports showed remarkable fluctuations in their MPI.

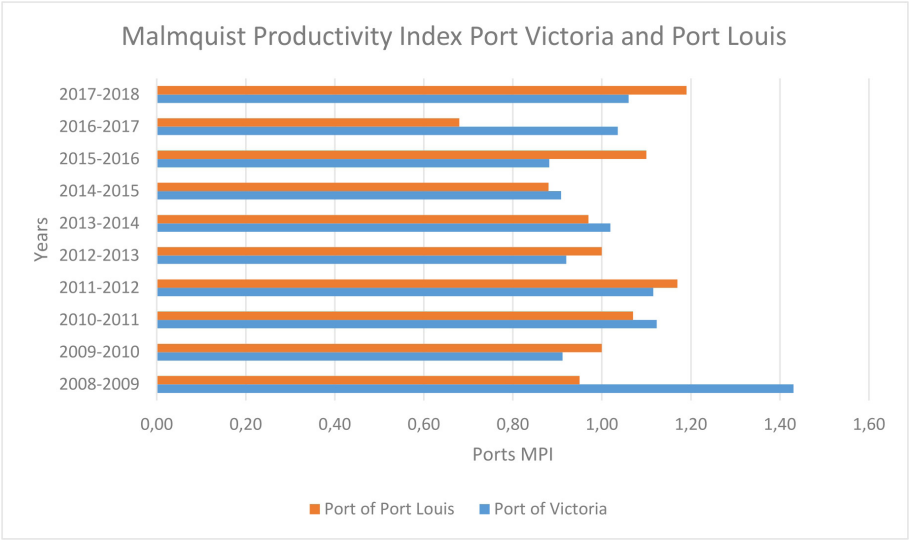

Figure 5: Malmquist Productivity Index 2008-2018
Source: Osundiran, 2023

5. Conclusion and Recommendation

The results indicated that over the period of 2008 to 2018 the port of Port Louis achieved an annual average productivity gain of 0.91 whilst the Port of Victoria achieved 0.95. The drivers of productivity being tilted more towards technology change. For the Ports of Port Louis and Port Victoria there is need to pay attention to the drivers of productivity which are technology and technical efficiency. This is because the Malmquist productivity Index of the two ports fluctuated. Figure 6 indicates the Malmquist Productivity Index for both the Port of Victoria and Port Louis.

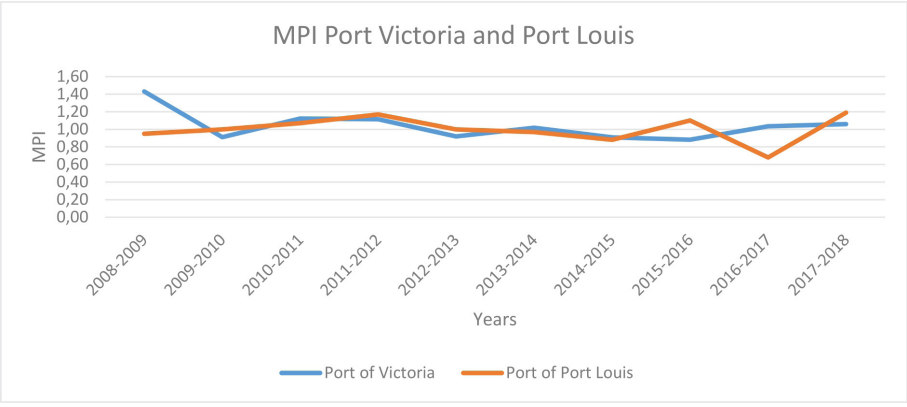

Figure 6: Malmquist Productivity Index 2008-2018
Source: Osundiran, 2023

The purpose of examining port operations is to ensure that there is improvement both in the short term and in the long term. It is important to evaluate port efficiency because it promotes sustainable port. Port efficiency has become increasingly important because ports are part of the connecting links between different transport modes in the global logistics chain; hence, container terminals are vital to the efficiency of the whole maritime supply chain [10]. Based on the study, it is recommended that the ports continue to build their technological efficiency through engaging state of the art software and applications. This is because development and improvement at ports level will have its impact on the economy of the countries involved. When improvement in efficiency level is the focus, port managers can leverage their available resources to ensure that it is achievable. Port authorities should maintain efficiency in all ramifications and at all levels.

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