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An Examination of the Impact of Covid-19 Pandemic on the Maritime Port of Singapore Container Port Productivity using Malmquist Productivity Index

Abstract

Given the Covid 19 Pandemic that swept the world suddenly during the period of 2019 even till 2021, resulting in severe measures being adopted by national governments, such as national lockdown to reduce the exponential rate of infection, it is important to examine the impact of this pandemonium on the port efficiency of the second largest port in the world. The crux of this paper is to examine the impact of the Coronavirus disease on port efficiency of one of the largest and busiest port in the world using the Malmquist Productivity Index. The paper will examine the trend in productivity and the drivers of productivity for the Maritime Port of Singapore for the years 2010-2020. Furthermore, assess the measures put in place to mitigate the impact of coronavirus. The measures put in place can be adopted by order ports as best practice to combat the scourge of the coronavirus disease. The key findings in the paper are: (1) An established consistency in the efficiency levels of the Maritime Port of Singapore despite the pandemic. (2) The drivers of port productivity for the port of Singapore are technology and efficiency. (3) Confirming that indeed the pandemic affected the total cargo throughput and vessel visit of the maritime port of Singapore

Keywords: Malmquist Productivity Index, Covid 19, Port, Efficiency and Productivity

1. Introduction

Coronavirus disease (COVID-19) is a pestilential disease caused by a newly discovered coronavirus [25]. The exponential rate of infection of Covid-19 (caused by breathing in the virus or being within proximity of someone who has COVID-19, or by touching a contaminated surface and then putting the fingers on your eyes, nose or mouth) has made nations lock down their borders and mandated people to obey social distancing as well as the perpetual use of facial masks and hand sanitisers.

Given the Covid-19 lockdown restrictions among nations, the importance of the seaports in trade facilitation is further accentuated. Many developing nations that are reliant on imports from other nations for food, raw materials as well as other essentials are affected by the scourge.

The port is defined as 'a harbour area in which marine terminal facilities are located for the transferring of cargo between ships and land transportation' [20]. The port is a critical node in the supply chain. The criticality of the port is emphasised by [8] where their statements highlights, that "the importance that ports make has increased over time; hence making them a vulnerable node as a port-related disruption can generate a domino effect on a network of supply chains." The seaports have a critical role to play in terms of global trade hence the need for an efficient seaport operation [22]. The coronavirus disease has disrupted global trade especially the maritime supply chain. It is therefore important that this crisis be effectively managed such that the vulnerability of the ports is reduced to ensure the enhanced functionality of ports and enhance supply chain resilience.

With over 80% of global trade by volume and more than 70% of its value being carried on-board ships and handled by seaports worldwide, the importance of maritime transport for business and development cannot be overemphasised [24]. The Coronavirus disease (COVID-19) triggered a global health and economic crisis with wide-ranging implications for maritime transport and trade [25]. The impact of the Coronavirus disease on ports around the world is tremendous to both developing and developed economies. The spread of the Covid-19 disease needs to be curtailed both on the vessel and in the port [7]. The IMO has officially declared through various circulars and guidelines the need to contain the spread of the disease. The resilience of the maritime supply chain is dependent on the ability of the supply chain to bounce back actively after a major disruption.

It is pertinent to examine the impact of the Covid-19 pandemic on a major port such as the maritime port of Singapore. The port of Singapore is amongst the busiest port in the world [14]. Hence, it is crucial to examine the impact of covid-19 on the efficiency level of the maritime port of Singapore and then determine the drivers of port productivity.

The members of the port authorities' roundtable (PAR) identified covid-19 as a precursor for global trade crises and the Maritime Port of Singapore is part of the PAR-Port Authority roundtable.

Singapore's interconnectivity makes it the 'go-to' port of call for more than 130,000 vessels totalling some 1.5 billion gross tons [10]. Singapore's hub port is a complex stream of activity that includes, handling a variety of cargoes at different terminals. About 30 million containers and 500 million tonnes of cargo are handled every year and more than 30 million tonnes of bunkers lifted annually [10]

The focus of this paper is firstly to assess the trends in general cargo throughput, vessel visits and then examine the efficiency level of the Maritime Port of Singapore and the drivers of port productivity. Finally, examine the measures put in place to mitigate the impact of the disease

The subsequent sections will focus on the background of the study, methodology, research results, the final section will end with a research discussion and conclusion.

2. Background of Study

This section describes the Maritime Port of Singapore, by providing insight into its facilities and operational capabilities. Twenty-Four years ago, the Maritime and Port Authority of Singapore (MPA) was created with the main purpose to metamorphosize Singapore into a world-class, global hub port and an international maritime centre (IMC), and to promote and protect Singapore's strategic maritime interests [11]. MPA is the propeller behind Singapore's port and maritime development, taking on the roles and responsibilities of Port Authority, Port Regulator, Port Planner, IMC Champion, and National Maritime Representative [11]. The transformation of a small regional port into one of the busiest ports in the world has undoubtedly been determined not only by its favourable geographical location at the crossroads of important trade routes but also by the courageous and visionary plan to build the first container terminal [14].

The port of Singapore comprises several facilities and terminals that handle a wide range of cargo transported in different forms, including containers as well as conventional and bulk cargo. The Maritime and Port Authority of Singapore (MPA) is responsible for the overall development and growth of the port of Singapore, which includes terminal operators, such as PSA Corporation and Jurong Port Pty Ltd. The excellence of the Maritime Port of Singapore was displayed when the port won the award for the best Asian Port for the year 2020 for the 32nd time [4]. The Maritime Port Authority of Singapore attests to the fact that the award is a result of its hard work, innovativeness and creativity [22]. The Port of Singapore serves as a benchmark for other ports [15]

The Port of Singapore is located at the southern tip of the Malay Peninsula and is considered to be the second-largest port in the world in terms of tonnes of cargo handled [10]. The port enables the transport of goods to over 600 ports in 123 countries [26]. The port itself is divided into two main terminals: container PSA- (Port of Singapore) Corporation Limited and Jurong Port, supporting, among other goods transported on-board in bulk. The Port of Singapore includes terminals located within Tanjong Pagar,

Brani, Pasir Panjang, Keppel, and Sembawang. Please see Figure 1 for the Map of the Maritime Port of Singapore.

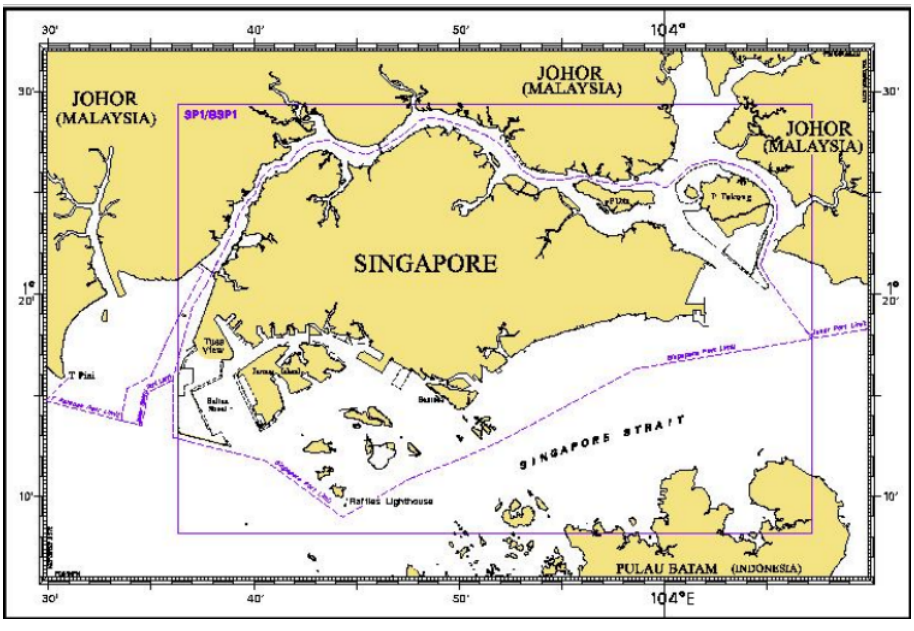

Figure 1: Map of Maritime Port of Singapore
Source: [10]

3. Methodology

This section discusses the methods used for the analysis of the Port Data. Two methods are used for this study, descriptive statistics and the Malmquist Productivity Index Data Envelopment Analysis (MPI-DEA). Descriptive Statistics will be used to analyse the trends in the container for the years 2010-2020. Consequently, MPI-DEA is used because it is a proven and useful tool for the analysing of the efficiency level of ports as well as the determination of the drivers of port productivity.

DEA is a non-parametric mathematical programming approach to frontier estimation [13]. A useful tool to investigate the performance of decision-making units [5]. Based on the study, within the last two decades, DEA has gained considerable research attention for solving transportation problems [2]. Over forty research articles were examined between 2007-2018 [2].

The standard approach to the measurement of productivity change over time is the Malmquist index [1][6]. The researcher, Malmquist, first introduced the Malmquist total factor productivity index before being further developed in the frame of DEA [9]. The Malmquist is defined as a quantity index (QI) as ratios of distance functions where

observations were evaluated relative to an indifference curve (IC) [9]. 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 [6]. The Malmquist index is a geometric mean of two indices, evaluated concerning period t and period t+1 technologies [3]. Figure 2 graphically illustrates the frontier shift which is a result of the technology change. This is the change in frontier a to frontier b. C1 and C2 display a movement upward on the frontier. This is caused because of change in efficiency.

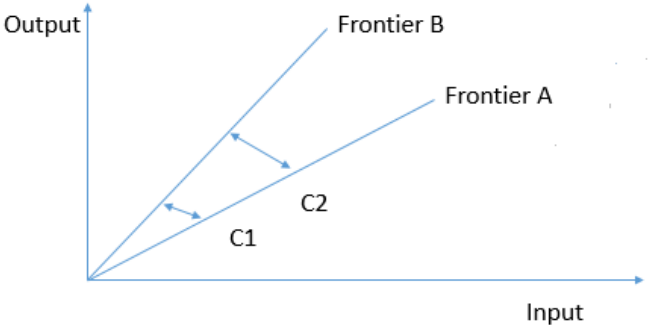

Figure 2: Decomposition of Malmquist Productivity Index
Source: [17]

Figure 3, illustrates the Malmquist equation that measures the efficiency. The product of efficiency change and technological change makes up the MPI.

$$M\left(Y_{t+1},X_{t+1},Y_t,X_t,\right)=\frac{D^t\left(Y_{t+1},X_{t+1},\right)}{D^t\left(Y_t,X_t,\right)}\left[\frac{D^t\left(Y_{t+1},X_{t+1},\right)}{D^{t+1}\left(Y_{t+1},X_{t+1},\right)}X\frac{D^t\left(Y_t,X_t,\right)}{D^{t+1}\left(Y_t,X_t,\right)}\right]^{1/2}$$

Efficiency change | Technological Change

Figure 3: Malmquist Production Index
Source: [9]

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. Research Results and Discussion

This section deals with the trends in general cargo throughput examining how the pandemic has affected total cargo throughput and vessel visits/calls. A month by month comparison for the year 2020 was done as well as a year by year analysis.

4.1. Trends in Total Cargo for Maritime Port of Singapore between 2010 and 2020

This section examines the trends in total cargo for the Maritime Port of Singapore. Total cargo or general cargo is made up of containerised and conventional cargo as well as bulk cargo which includes oil and non-oil bulk cargo. Figure 4 shows the graphical illustration of a decline of 6% in total cargo between the year 2019 and 2020. The decline though slight can be attributed to the pandemic. This is because from 2015 up to 2019 the Maritime Port of Singapore experienced a gradual increase in Total cargo.

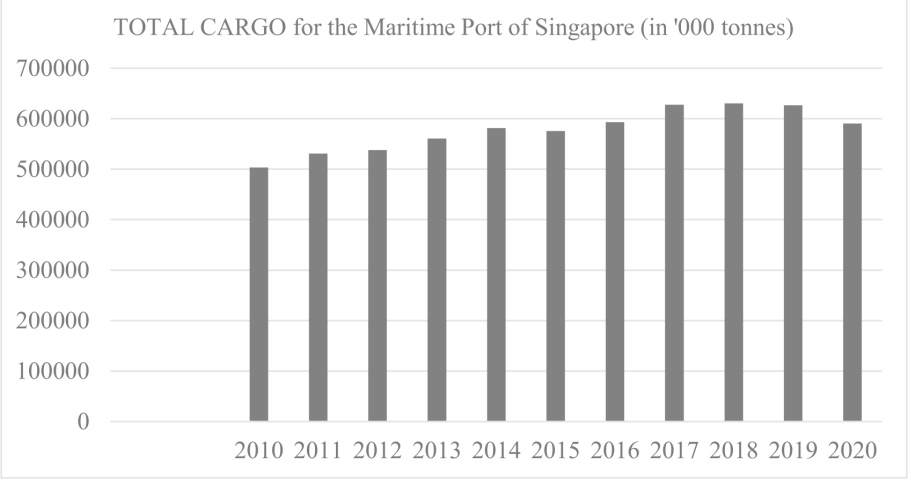

Figure 4: Graphical illustration of Total Cargo for the Maritime Port of Singapore. Source: Author's representation

A month by month comparison for the year 2019 and 2020 as displayed in Figure 5 further lays credence to the fact that there was a decline in total cargo, especially during the Lockdown periods. A closer look at April to December shows a consistent decline in total cargo tonnage. This is to take note that there was a slight increase of 2.5% in total cargo tonnage for March.

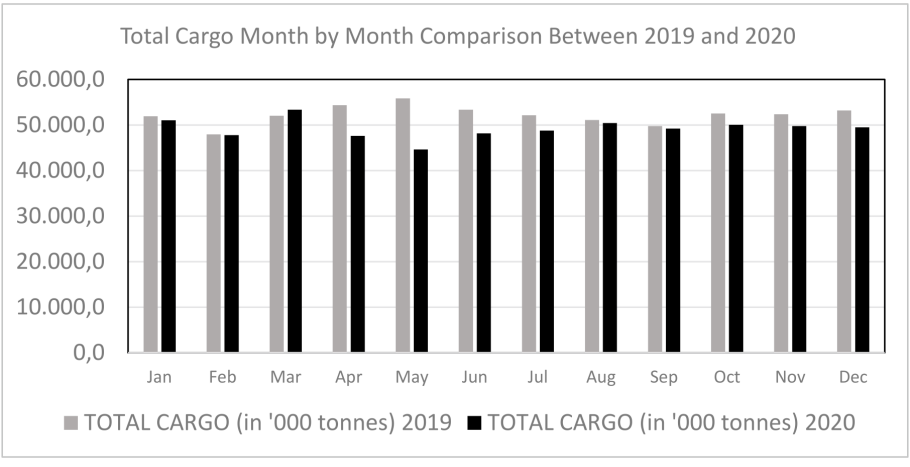

Figure 5: Graphical illustration of the month by month comparison between the Year 2019 and 2020 of Total Cargo
Source: Author's representation

4.2. Trends in Vessel Visits

With a careful examination of the vessel visit for the Maritime Port of Singapore, Figure 6 display a decline of 27%. The traffic into the port declined as a result of the pandemic. The Covid-19 pestilence affected the number of vessels that visited the Maritime Port of Singapore.

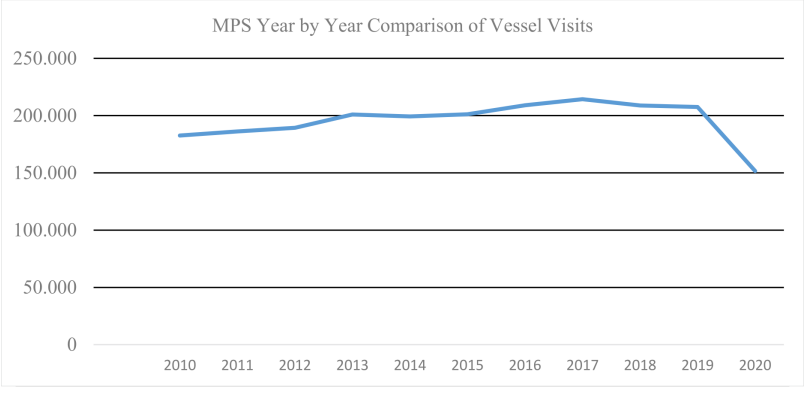

Figure 6: Maritime Port of Singapore Year by Year Comparison of Vessel Visits
Source: Author's representation

Further analysis on the purpose of the vessel visits per year from 2010 to 2020 also indicated a steady decline. Only vessel calling on the port to deliver supplies had a steady or consistent trend. This is displayed in Figure 7. Indeed, the pandemic affected the vessel call irrespective of the purpose for which the vessel was visiting the port.

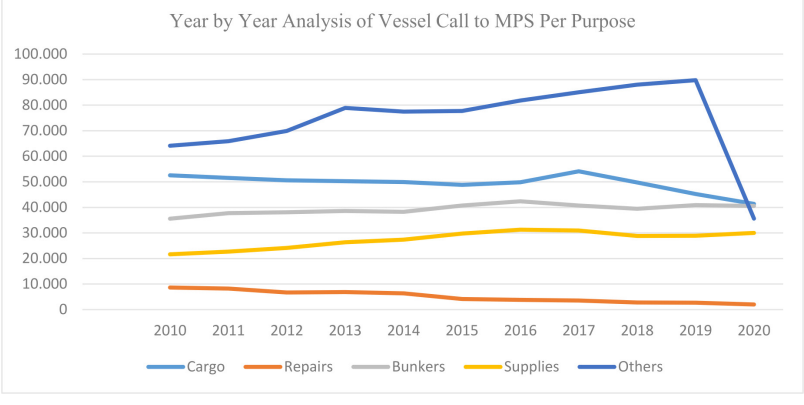

Figure 7: Year by Year Analysis of Vessel Calls per Purpose
Source: Author's representation

4.3. Trends in Various Cargo Throughput

This section examines the trend in the various cargo throughput. Figure 8 reflects the year by year comparison amongst the cargo type. The various cargo types include containerized, conventional, oil and non-oil cargo. It is interesting to note how oil-related cargo nosedived in the year 2020.

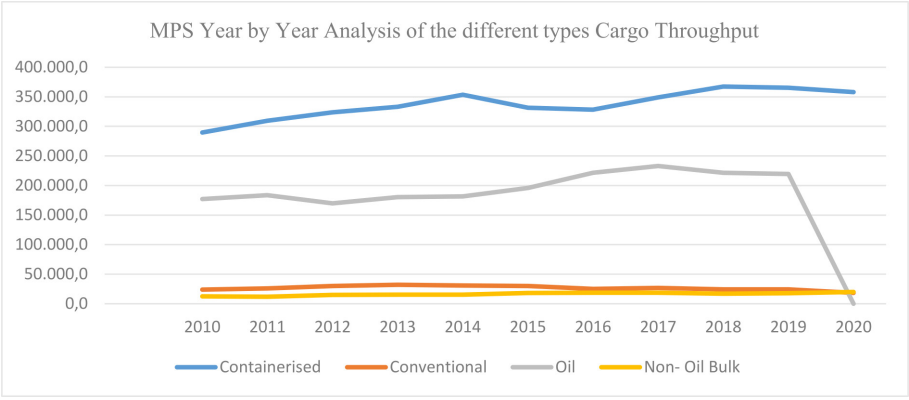

Figure 8: Trends in the types of cargo throughput
Source: Author's compilation

4.4 Malmquist Productivity Index-DEA

The second aspect of this research is to examine if there is a change in the efficiency and productivity level of the Maritime Port of Singapore. The Malmquist model captures the variations in the port performances at the Maritime Port of Singapore over the 11 years. In the computation of DEA MPI, two significant issues are emphasised, 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.

4.4.1. Efficiency Change

The efficiency level for the Maritime Port of Singapore did not decline tremendously during the pandemic era. Efficiency change (EC) is linked to managerial efficiency that causes movement upward or downwards on the production possibility frontier. Therefore, the Maritime Port of Singapore exhibiting EC=1 constantly and continuously over the years indicates consistency in efficiency level. Table 1 describes the results.

Table 1. Efficiency Change for the Maritime Port of Singapore

Port of Singapore	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Efficiency Change	1	1	1	1	1	1	1	1	1	1

Source: Author's Calculation

4.4.2. Technology Change

The second aspect of the Malmquist Productivity Index is technological change. This is evaluating the Maritime Port of Singapore based on technology. Technology change (TC) causes an outward shift in the production frontier. Table 2 indicates that the Maritime Port of Singapore have TC=1, or approximately. In terms of technology, the port shows consistency and continuity.

Table 2. Technological Change for the Maritime Port of Singapore

Port of Singapore	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Technology Change	1.02	1.017	1	1	1	0.975	1.025	0.999	0.993	0.978

Source: Author's Calculation

4.4.3. Malmquist Productivity Index

The drivers of port productivity for the Maritime Port of Singapore is both efficiency and technology. The product of TC and EC is the MPI. Where the MPI>1 means there is progress in productivity, where MPI<1 signifies a decline in productivity and where MPI=1 indicates consistency.

Table 3. Malmquist Productivity Index for the Maritime Port of Singapore

Year	Efficiency Change	Technology Change	MPI
2010-2011	1	1.02	1.02
2011-2012	1	1.017	1.017
2012-2013	1	1	1
2013-2014	1	1	1
2014-2015	1	1	1
2015-2016	1	0.975	0.975
2016-2017	1	1.025	1.025
2017-2018	1	0.999	0.999
2018-2019	1	0.993	0.993
2019-2020	1	0.978	0.978

Source: Author's Calculation

5. Measures to Reduce the Impact of Covid-19 Pandemic

This section examines the measures put in place by the Maritime Port of Singapore to curb the excessiveness and the spread of the Covid-19 pandemic. The MPS focuses on preventive measures to curb the spread of the disease. Firstly, the Maritime Port of Singapore engaged all the Maritime Port Stakeholders early. This was done through a Multi-Ministry Taskforce (MTF) on COVID-19 to coordinate government response as well as consultations with port terminal operators [12]. This coordination is still ongoing.

Secondly, pre-emptive measures such as temperature screening at sea checkpoints to detect suspect cases; submission of a health questionnaire and reports to the Maritime Declaration of Health; cleaning and disinfection of cruise and ferry operators; and constant update on affected regions and countries were also put into consideration. The port is doing its possible best to remain open to minimise the impact of Covid-19 on the global supply chain and economy.

Finally, those that contacted the Covid-19 while on-board the vessel was quarantined for 14 days. [12]

6. Conclusions

The Maritime Port of Singapore is a Mega Port with so much traffic in and out has shown by the eleven-year trend analysis of total cargo and vessel visits. The study indicated that there was a decline in containerised and conventional cargo as well as bulk cargo which includes oil and non-oil bulk cargo. Before the pandemic, the port had consistently experienced growth in its general cargo throughput. With a close examination of the trend in vessel visits, there was also a recorded decline in vessel visits for all types of commodities. Even though the covid-19 pandemic affected the container throughput, general cargo throughput and vessel visit, the Maritime Port of Singapore has strived to ensure that efficiency level and technology level remain consistent. This was proven by the Malmquist Productivity Index, Data Envelopment Analysis done. It is important to note the effort and the determination of the Maritime Port of Singapore to minimise the impact of the pandemic on the global supply chain. This deliberate action is commendable and recommendable.

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