IMPACT OF MARITIME CONNECTIVITY ON ECONOMIC GROWTH

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ABSTRACT

Purpose:
Much have been mentioned of the linkage between trade and transport connectivity on economic development. As such, this paper seeks to investigate the impact of maritime connectivity on the economic development of a country in the context of ASEAN specifically Singapore. Our intent is to determine if there is indeed a direct linkage between the constructs of maritime connectivity and economic growth.

Design/methodology/approach:
We adopt a system dynamics approach to understand the causal loops influencing economic development through industry growth, the multiplier effects, and maritime connectivity. For the data, we will draw on public domain information available on the web. The software AnyLogic will be employed for our analysis in this paper. In the analysis, GDP growth is taken as the dependent variable while factors such as import taxes, labor productivity, and connectivity index (outbound and inbound) are treated as the independent variables.

Findings:
Our results show that as maritime connectivity improves, economic growth proxy-ed by more GDP per year follows.

Research limitations/implications:
The quality of this effort depends very much on the quality and extent of data available in the public domain.

Practical implications:
Our work serves to inform policy makers, business strategists on how to string maritime connectivity into greater trade impact and hence the economic development for a country in ASEAN. Next, we can through, systems dynamics, appreciate the effects of vertical and horizontal integration between different segments of the economic cogwheel.

Originality/value:
The paper brings to focus the importance of effective maritime connectivity for the economic development of a nation in a quantitative and statistical manner through the simulation of a real world system. This work serves to inform policy makers, business strategists on how to string maritime connectivity into greater trade impact and hence the economic development for a country. While some of this work has been undertaken in Europe and other trading blocs, it remains un-investigated in ASEAN specifically Singapore.

Keywords: AnyLogic, Economic growth, Maritime connectivity, Singapore

Paper Type: Research paper

Introduction

A wide range of services is provided by the maritime sector worldwide, including freight and passenger transportation and the other related port services such as pilotage, towing and tug assistance, emergency repairs, anchorage, and berthing services. Since sea conveyance is the cheapest mode of transport of heavy goods, there has an uptake in the export, import and transshipment of cargo via ocean freight compared to the other modes of transport. The seaports connect the economic hinterland to other supply chain nodes overseas. Such ports not only provide economic benefits but also social benefits such as providing livelihood.

From Oxford Economics (2013), the UK ports industry has contributed nearly £7.9 billion to UK's GDP in 2011 (equivalent to 0.5% of UK's GDP). This was greater than the combined contribution of the aerospace, and the advertising and market research industries. As for Singapore, the maritime sector contributes 6 to 7 percent of the nation's gross domestic product, and employs over 170,000 people (http://www.mpa.gov.sg/web/portal/home/media-centre/news-releases/detail/05460688-fe49-42e7-9740-4ce88b157b46). According to Jacobs (2011), countries that have invested heavily in trade infrastructure and have reformed port management have benefited from global trade. There are a number of methods available (for example, the input-output model to measure port traffic and regional employment). Enhanced port connectivity allows for more transactions of goods and services. This may lift exports and imports, suggesting economic growth.

Therefore, this paper seeks to examine the impact of port connectivity on the economic growth of a nation. Specifically, we look at the impact of the Port of Singapore on the economic growth of Singapore.

The rest of this paper is organized as follows. Section 2 reviews the existing literature in maritime trade and economic growth. Section 3 provides the research method used to address the research question in the paper. In Section 4, we provide the model design, validation criteria, and assumptions. Section 5 presents the results and discussion. In this Section, we look at the effect on the GDP and total ship calls in a year by varying the outbound container shipping connectivity. Section 6 concludes with some research directions.

Literature Review

The extant literature on the impact of trade and transport on economic development has provided some interesting results. For instance, Balassa (1978) applied regression analysis to a sample of eleven developing countries that have already established an industrial base and found that a country's economic growth increases with exports. Likewise, Zou et al. (2008), who examined the effect of transport infrastructure on economic growth and poverty alleviation in Eastern and Central China, found that improved transport infrastructure enhances economic growth. Furuoka (2009), using panel data, found a positive significant relationship between exports and economic growth in five ASEAN countries. Similarly, Sampathkumar and Rajeshkumar (2016) have investigated the relationship between export and economic growth in the SAARC countries.

Further, several studies have focused on the effects of maritime trade and transport on economic growth. For instance, Wildenboer (2015) focused on the impact of the economic development of a country on the performance of a port. Berköz and Tekba (1999) applied regression analysis to examine the role of the port as a part of transportation services on a country's development. Koner and Purandare (2017) have examined the impact of container

traffic flow on gross domestic product (GDP) in India and measured the impact on GDP from selected container ports in India.

Using the Cobb-Douglas production function on the Pearl River Delta, Zhang et al. (2005) investigated the relationship between container throughput, foreign direct investment (FDI), and gross product value of industry. They found that regional economic growth and FDI depend on local container transport development. In Liu (2012), the correlation between port logistics and regional economic development were analyzed using a vector auto-regressive model and Liu found that port logistics development can improve the economic growth of Qinhuangdao. Recently, Rijkure and Sare (2013) studied the role of Latvian ports in the Baltic. Despite this development, not much have been discussed on the impact of the maritime connectivity on the economic development of a country. Thus, we seek to fill this research gap.

Method

In this paper, the system dynamics approach is used to understand the causal effects influencing economic development through the multiplier effect and maritime connectivity. For the data, we draw on public domain information available on the web (For e.g. the website of the Maritime Ports Authority). The software AnyLogic has been employed for our analysis. For simplicity, we focus on the container vessels visiting the Port of Singapore. In the analysis, GDP growth, a proxy for economic growth, is taken as the dependent variable while factors such as import taxes, labour productivity, and connectivity index (outbound and inbound) are treated as the independent variables.

We use the Container Port Connectivity Index (CPCI), as discussed in Bartholdi et al. (2016), to measure the trade connectivity of ports within the network of container shipping. The impact of the variation of the outbound connectivity index is compared to the change in the GDP over a year.

Model Design

The following assumptions were made and the validation criterion below was followed.

Assumptions

As access to public domain data available on the web is limited, we assume the following for the AnyLogic model:

- Cost per TEU is SGD 450.
- Total import per second (includes domestic and transhipment demand) is 7 TEUs.
- Ratio split for imported goods as finished goods and raw materials is 3:1.
- Goods produced domestically for export per second (raw materials and finished goods) are 2.5 TEUs.
- The value of the goods carried by the container ships is proportional to the number of the container vessel arrivals.

Validation

We validate the AnyLogic model by satisfying the numerical values of the given dynamic variable.

- TSCallFY, from the number of vessel arrivals obtained from the MPA.

GDP calculation
Using the consideration that the value of the goods carried by the container ships is proportional to the number of the container vessel arrivals we calculate the contribution of the container vessels on Singapore's annual GDP.

Import tax
To account for the causal effect by the variation in the import taxes, the ratio between the taxes after and before the change over a year is taken as the independent variable, "ImpTx".

Export tax
Since there is no export tax in Singapore, we model in a way that the causal effect of variable "ExTx" on the variable "ToExp" to be zero.

Labor productivity
Based on Trading Economics (https://tradingeconomics.com/singapore/productivity), labor productivity in Singapore is measured using the index points. We fix the boundaries in the AnyLogic model for the highest and lowest labor productivity as 127.2 and 102.6 respectively considering the data from July 2014 to Jan 2017. The ratio of the current index point to the baseline index point (100) is taken as the independent variable "LbrProd" in the AnyLogic model.

Port connectivity
The port connectivity attribute is measured by the liner shipping connectivity index**,** computed from factors such as **containership deployment, container capacity, number of liners, liner services and vessels per liner, and average and maximum vessel size.** Following Bartholdi et al. (2016), we use the CPCI to measure the trade connectivity of ports within the network of container shipping, with separate scores for inbound and outbound container movements. A port with strong trade connections possesses a high CPCI. We take the inbound and outbound connectivity indices of Singapore as 0.2456 and 0.3420 respectively.

Services
The contribution of port services towards Singapore's GDP is accounted by coding the port tariff obtained from the MPA (http://www.mpa.gov.sg/web/wcm/connect/www/812448e8-eb35-40b6-ab26-78dbceb2baad/pn13-47.pdf?MOD=AJPERES).The services considered here are bunkering, ship supplies, changing crew, and ship repairs. The functions similar to the MPA port dues calculator (http://www.mpa.gov.sg/web/portal/home/e-services-forms/e-finance/fees-charges/port-dues/port-dues-calculator) are modeled and the income from the services is obtained.

Figure 1 shows the causal diagram. For the ease of understanding, the material flow is shown by the brown links. Other causal relations are shown as blue links. The relations between the other parameters and the variables are shown as grey links. Table 1 provides the notations used in the AnyLogic model.

Notation	Variable/Parameter	Unit	Description
GDP_t	Gross Domestic Product at time t	SGD	
UC	Unit cost	SGD/TEU	Notwithstanding cost of individual items shipped, the cost per TEU is SGD 450.
FGImpSplit	Finished goods imports	-	Constant 1

	split (Constant 1)		
Connec_ibound	Connectivity inbound	-	
ImpTx	Import tax	-	Ratio of taxes was considered as explained in model design
ToDomGdExp	Total domestic goods exported	TEU	
FGImpDom	Finished goods imported for domestic use	TEU	
FGImpTrans	Finished goods imported and transshipped	TEU	
FGImp	Finished goods import	TEU	
ToImp	Total imports	TEU	
ImpDd	Import demand	TEU	
RMImp	Raw material import	TEU	
RMImpMfg	Raw materials import to be manufactured	TEU	
RMImpTrans	Raw material imported to be transshipped	TEU	
ComGdExp	Completed goods exported	TEU	
ComGdDom	Completed goods for domestic use	TEU	
DerivedK3	Constant 2	-	Constant 2
FrSplit_ToImp	Constant 3	-	Constant 3
DomGdExp	Domestic goods exported	TEU	
ExpDd	Export demand	TEU	
ExTx	Export tax	-	
Connec_obound	Connectivity outbound	-	
ToExp	Total goods exports	TEU	
LbrProd	Labour productivity	-	Ratio of obtained index point and baseline index point
SCallImp	Ship calls for imports	TEU	
SCallExp	Ship calls for exports	TEU	
CTraffic	Container traffic	TEU	
TSCallFY	Total ship calls in a year	-	
PDue	Port dues	SGD	
PDueInc	Port dues income	SGD	
Load_UnPPS	Loading and unloading profit per ship	SGD	
ARprPPS	Average repair profit per ship	SGD	
BunkerPPS	Bunkering profit per ship	SGD	

Table 1: Notations used in AnyLogic model

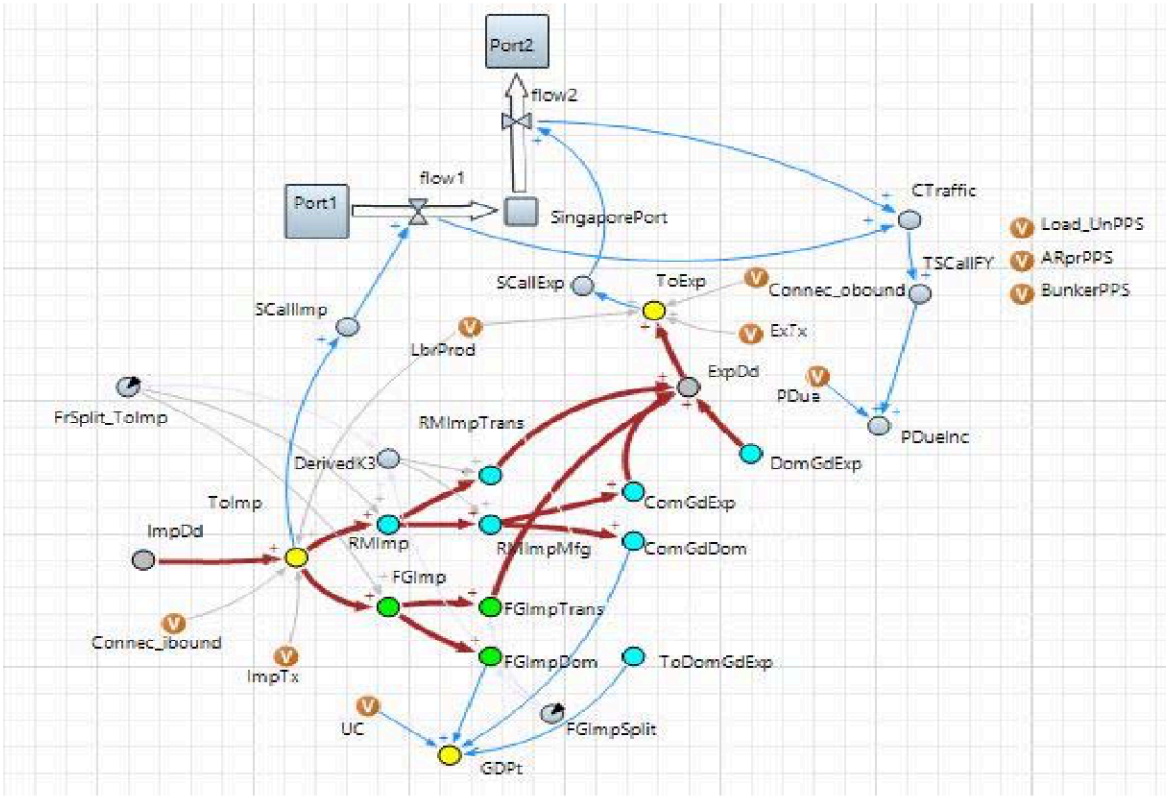

Figure 1: Systems dynamics model

Results and Discussion

Table 2 shows the GDP (SGD/year) change with the outbound connectivity index. Clearly, the connectivity index increases with an increase in annual GDP. Also, the results are influenced by the assumptions made, and hence variations in the numerical value of the assumptions made affects the values in Table 2, which suggests that maritime connectivity affects economic development.

Outbound connectivity index	GDP($/year) (in billions)	Economic growth (%)
0.3	6.99	
0.31	7.40	5.86
0.32	7.82	5.67
0.33	8.23	5.24
0.34	8.64	4.98
0.35	9.05	4.75
0.36	9.46	4.53
0.37	9.87	4.33
0.38	10.28	4.15
0.39	10.69	3.99
0.40	11.10	3.84

Table 2: Effect of outbound connectivity index on rate of change of GDP

Figure 2 shows that the increase in the GDP for 2015 with the increase in the outbound connectivity index changes as a step function.

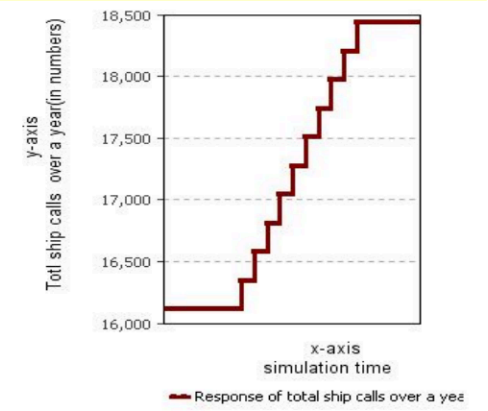

Figure 2: Response of GDP (SGD/year)

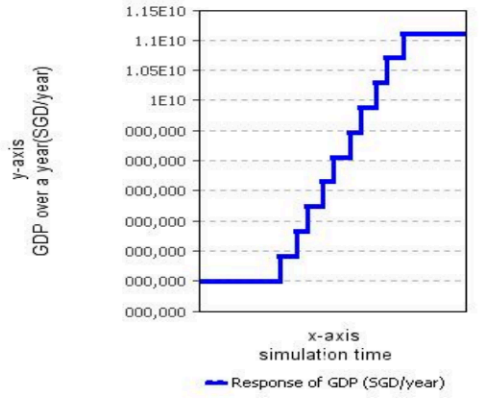

Figure 3: Response of total ship calls over a year

Table 3 gives the response of the total number of ship calls per year to the change in the outbound connectivity index. Figure3 shows the increase in the total number of ship calls per year with the increase in the outbound connectivity index. From Figure 3, we infer that enhanced port connectivity allows for more transactions of goods and services, leading to the increase of ship calls. Moreover, the increase in ship calls may also provide a benefit of contribution towards Singapore's GDP by income from port services.

Outbound connectivity index	Total number of ship calls / year	Percentage variation in total number of ship calls (%)
0.3	16111	
0.31	16343	1.44
0.32	16575	1.42
0.33	16807	1.40
0.34	17039	1.38
0.35	17271	1.36
0.36	17503	1.34
0.37	17735	1.32
0.38	17967	1.31
0.39	18200	1.30
0.40	18432	1.27

Table 3: Impact of outbound connectivity index on total ship calls

Conclusion

In this paper, the system dynamics model involving the causal effects influencing economic development through industry growth, multiplier effects and maritime connectivity, over a period of one year is simulated. Our results show that as maritime connectivity improves, economic growth proxy-ed by more GDP per year follows. This work can therefore serve to inform policy makers, and business strategists on how to string maritime connectivity into greater trade impact and hence the economic development of a country. Moving forward, we can investigate other forms of maritime connectivity such as bulk carriers, tankers, and so on. Further, though the system dynamics model investigates the various sub systems' behavior (such as causal effect caused by domestic goods exports); the model may become more complex when the exact detailed scenario is replicated as it increases the number of variables. As a result of this limitation, the SD model is not able to study the specific sub-system behavior. We can only run independent versions of a scenario singly by altering the values of the dynamic variables separately each time. To overcome this limitation, we can consider in future combining the systems dynamic approach with other models such as agent based modeling.

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