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Forecast of Major Port Throughput in Malaysia by using Multiple Linear Regression Model

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ABSTRACT

Malaysia strategically located between East and West serves as a crossroads for the global marine trade and is a key player in the industry of transporting cargo within Southeast Asia. Between 2000 and 2010, Malaysian container ports saw a more than threefold increase in throughput on a yearly average basis. This phenomenon has caused port congestion, preventing ships from loading or unloading because the terminal is already full. Consequently, they can only queue up and wait in line for their turn at the port. This affects port efficiency by having ships waiting longer at the berth while more vessels keep joining the queue. This research attempts to develop the need for port capacity growth. In this study, the data will be extracted using Microsoft Excel and analyzed by Multiple Linear Regression using Minitab Software. The analysis's possible findings indicate that seaports rise in response to trade expansion, forcing the development of effective ways to lessen logistical pressures at Malaysian seaports. The potential significance of this study provides a recommendation for the strategies of seaports for capacity augmentation and creating effective distribution networks to satisfy growing needs.

1. Introduction.

Seaports are an essential element of the supply chain that facilitates the continuous movement of freight through the transportation system. Malaysia is a well-known country having some of the busiest ports in the world. The volume of maritime trade has increased to nearly 10.7 billion tonnes, with Southeast Asia accounting for about half of it (UNESCAP, 2019). Malaysia's maritime sectors contributed 2.9% to the export of transportation services consisting of 84,384 million US dollars in 2019 (UNCTAD, 2021). Malaysian ports had experienced an average gain of 3% in cargo throughput across decades. Malaysia is a favored entry point for Southeast Asians due to its strategic position and excellent connections.

Container traffic has increased by 400 percent in the last two decades at the ports (Heide, 2019). In Malaysia, there are now ten managed ports. They include the Port of Tanjung Pelepas, Port of Klang, Port if Penang, Port of Johor, Port of Kuantan, Port of Bintulu, Port of Kuching, Port of Miri, Port of Rajang, and Port of Sabah. The Sabah and Sarawak state governments are in charge of the ports in East Malaysia. Apart from these ports, Malaysia also has several privately operated port services and jetties, particularly in the oil and as sector including those at Port Dickson and Lumut (Ministry of Transport Malaysia, 2022).

The most significant ports are the Port of Klang and Port of Tanjung Pelepas, which accounted for 64% of all cargo throughput of Malaysia in 2018. The entirety of transshipment from Malaysia comes from these two ports (Port of Klang and Port of Tanjung Pelepas).

1.1. Problem Statement.

Port congestion is a circumstance when a ship arrives at a seaport for the loading or unloading of goods or for other purposes but does not able to berth and must wait outside at anchorage for a berth to open up. According to (Pioneer Freight, 2022), in container ports all throughout the world, there is a lot

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of port congestion, which attribute to the 1452.68% increase in cargo vessels during the previous 50 years. Container rollovers-which are required when a container is unable to load aboard the intended cargo vessel that it be accommodated on the subsequent ship. The port traffic has resulted in significant cargo disruptions for about 2 to 3 weeks, which have had an impact on the supply chain and therefore will ultimately affect businesses and customers throughout the world (Azman, 2021).

In the first ten months of the year, the Malaysian port has seen a 980 percent spike in blanked sailings. Port of Klang had the greatest rollover rate in 2021 with 58.45 percent, up 37.94 percent from the previous year (Murugiah, 2021). For import and export containers, Port Klang has a storage capacity of 120,000 TEUs, which it is currently using 60% of its capacity (Port Klang Authority, 2018). In 2021, global supply networks will face a number of big disruptions, with port traffic among them. Vessel schedule disturbances, which include surges of up to 45 percent in the ratio of cargo rollovers, longer passage, as well as more void sailings, are triggering shipment disruptions and global supply chain disturbances. Furthermore, yard inventory for import containers at Penang Port was 45 percent prior to MCO, and it increased to roughly 58 percent to 60 percent during the first week. The usual yard occupancy for imports at Penang Port was around 40%, but this has recently been increased to 50%. Most of the recent vessel purchases were in the middle of 2023, with an estimated 60,000- 70,000 containers entering service around mid-2022 (Shah, 2020).

1.2. Background of Ports.

This chapter aims to review the related literature of the research through the major ports in Malaysia.

1.2.1. Background of Port Klang.

Port of Klang is situated in Peninsular Malaysia which is about 40 kilometers from the country's capital, Kuala Lumpur (Britannica, 2020). A government decision made in 1993 enabled the development of the Port of Klang into the National Load Centre and eventually a center for the area. Port of Klang has used a variety of load-centering and hubbing techniques, and as a result, its amenities and services are now considered to be on par with those of top-tier ports. The port conducts business with more than 120 countries and has connections with more than 500 ports worldwide (Port Klang Authority, 2018).

From January to November 2019, the Port of Klang handled 12.32 million TEUs containers. With a cumulative cargo volume of 12.32 million TEU containers, the Port of Klang ranked 13th in terms of container port traffic behind Rotterdam. More than half of the cargoes handled in the Port of Klang are transshipments, although the port currently handles 2.39 million TEUs of all Malaysian container-based sea-borne imports and 2.35 million TEUs of all Malaysian container-based maritime (Murugiah, 2021). Over the past 5 years, the throughput of cargo has climbed by 3.6%, with a major decline of 9% in 2017 as a result of restructuring in sea freight alliances that led some large clients to move their business to another country. Westports aims to increase throughput by 50% in the next twenty years achieving 30 million TEUs (Donnelly, 2017). After getting preliminary approval from the Malaysian government, a preliminary design for the construction of the container terminal is expected to be finished by 2019. Westports is looking into novel designs and automation solutions for the new terminals.

1.2.2. Background of Port Tanjung Pelepas.

PTP had excellent terminal growth after achieving a record-breaking total throughput of 9.8 million TEUs in 2020, marking an increase of more than 8% above the 9.1 million TEUs recorded in 2019. Port of Tanjung Pelepas (PTP) remains operational under some limitations as a sector that provides crucial services and strategic assets to Malaysia. This port is responsible to ensure that trade and the flow of logistics are running smoothly without any interruption (Bakar, 2021). On the other hand, PTP has expanded its port expansion plans and is now building another berth for RM750 million to increase capacity by 2022 (Donnelly, 2017). PTP has secured more additional property in Tanjung Bin in front of terminals to transform into the area of the seaport. In the future, the Port of Tanjung Pelepas will become a desirable port with a high level of efficiency among industrial businesses (Heide, 2019).

1.2.3. Background of Johor Port.

Overall, Johor Port operates in three phases:

- Phase I: When the port first opened in 1977, it carried break bulk and liquid edibles.
- Phase II: In 1986, with the addition of dry bulk and liquid to the activities.
- Phase III: In the year of 1993, the operation began when the port installed a container terminal.

The container dealt at Pasir Gudang is mostly imported and exported, owing to the large industry that surrounds the seaport, which isn't present at PTP. The seaport's free trade zone houses the biggest palm oil terminal, with a storage capacity of nearly 460,000 metric tonnes. It is also one of the main ports in the region for non-ferrous metals hubbing, and was designated known as a London Metal Exchange (LME). Currently, it is rated 6th in the world for LME freight, out of 35 countries (Keetrax, 2018). Johor Port has gained a stable client base of significant multinational businesses including Pacorini Metals, Henry Bath, and Metro International Trade Services as a result of its efficiency and capacity. Among the other international clients are Shell and Chevron.

1.2.4. Background of Penang Port.

Port of Penang, Malaysia's oldest and longest- established port, has carved out a niche for itself by serving as the main entryway to Malaysia's northern region and south of Thailand, covering the basins of the Straits of Malacca (Penang Port, 2022). Port of Penang's core operations including the operation of cargo together with North Butterworth Container Terminal (NBCT) serves as the pivot. The first container discharged at this wharf is in 1974 marking the beginning of Port of Penang's relationship with containers. The Port of Penang has grown from a single dedicated berth in a multi-purpose terminal to a sophisticated dedicated container terminal that caters to the region's ever-increasing volume of container commerce (Penang Port, 2022).

1.2.5. Background of Bintulu Port.

A multi-purpose port, Bintulu Port has 3 general cargo wharves, a bulk cargo wharf, a container terminal, and numerous LNG jetties. Currently, there are about 400TEUs and 70 million tonnes of annual capacity. In 1981, Bintulu Port Holding Bhd was given operational control when the Port of Bintulu Authority was founded (Heide, 2019). Port of Bintulu serves as the import and export gateway for Sarawak and Brunei, which includes Brunei, Indonesia, Malaysia, and the Philippines. It served as East Malaysia's largest cargo port, the only Liquefied Natural Gas (LNG) export gateway in the country, and one of the world's largest Liquefied Natural Gas (LNG) export facilities. The number of containers obtained from the countryside will rise as the Sarawak Corridor for Renewable Energy (SCORE) initiatives are put into action, with more shipments of downstream timber, agro produce and product, fertilizer, manganese, silicon, pulp and paper, aluminum and other commodities arriving at the dock (Idris, 2019). In anticipation of this rise in freight, Bintulu Port has property south of its current port that is planned to be extended into a port area. A business that specializes in bulking facilities for raw and refined palm oil, edible oils, vegetable oils, fats, and their by-products is called Biport Bulkers Sdn Bhd.

1.2.6. Background of Kuantan Port.

Port of Kuantan is a cargo deep seaport that faces the South China Sea. Port of Kuantan has grown into an important cargo terminal supplying the east coast of Peninsular Malaysia due to its advantageous location on the country's eastern shore and close to the petrochemical industry's center. Port of Kuantan is known as an outstanding seaport of its facilities and services, extensive market reach, and robust network of global shipping links, and will serve as an agitator for the fast-growing n of industrial and manufacturing enterprises along the East Coast Industrial Corridor. After the New Deep-Water Terminal (NDWT) is finished, the Port of Kuantan is anticipated to serve as both the main entryway to China and the Far East as well as a transshipment hub for smaller ports in the area.

1.2.7. Multiple Linear Regression Analysis.

Based on the research paper Studying the Determinants of University Student Success Through Multiple Linear Regression and Factor Analysis (Abuhassan et. al., 2020). This study uses data from a random sample of students at a Palestinian institution to analyze the factors that contribute to academic performance. To forecast the association between the variables and compare these models across staff groups and student seniority in the school, this study used multivariate inferential data analysis methodologies, such as factor analysis and multiple linear regression. The findings indicate a connection between high school and college success. The findings also indicate that "getting scholarships," "English language skills," and "school attendance" are the next most significant predictors of university success, with variables measuring psychological well-being, gender, type of residence, and smoking habits having a minor influence. Additionally, it has been demonstrated that there are significant differences between faculties and student seniority levels in the relationship between the majority of these predictor variables and academic success. While these same variables are not consistently connected with academic achievement in other fields of study, they are in some areas. Based on research into multiple linear regression analysis (Uyanik & Guler, 2013). The purpose of the study is to determine whether or not the KPSS score, the dependent variable, was significantly predicted by the five independent variables in the conventional model, specifically, the academic psychologist, curriculum development, guidelines, and methods of teaching. The main goal of the research is to illustrate the stages of multiple linear regression. In this research, the 2012-KPSS score and the lesson (assessment and evaluation, developmental psychology, program development, consultation, and teaching methodologies) scores of Sakarya University Education and Faculty students are used as the data sources for multiple linear regression analysis. The regularity, linear, lack of absolute values, and analysis of missing value assumptions of multilinear regression analysis were looked. Multiple regression was used to check the data that supported the hypotheses, and the KPSS was estimated for each of the following categories: instructional methods, counseling, program development, and educational psychology.

2. Methodology.

This chapter discuss the techniques and methodologies needed to gather and analyze data in order to predict the analysis model of major ports in Malaysia. Sections of the chapter include the area of study, collection of data, and methods for analysis and presentation.

2.1. Area of Study.

This research is conducted on 10 major seaports in Malaysia which are Port of Klang, Port of Penang, Port of Johor, Port of Kuantan, Port of Bintulu, Port of Kuching, Port of Miri, Port of Rajang, Port of Sabah and Port of Tanjung Pelepas. These seaports give a general overview of the capacity of Malaysia's seaports to determine port efficiency indicators, such as the number of containers (export, import, transshipment, ship calling).

2.2. Data Collection.

Secondary data is collected in order to predict the number of containers in the future, which is the goal of this work. The information was gathered from credible secondary sources. For use in their own research, researchers might use material already obtained via original documents as secondary data. It is a type of information that has already been obtained. A researcher may have gathered data for a particular study and then made it accessible for use by other researchers.

As a result, this study relies on secondary data gathered from reputable sources, such as the Ministry of Transportation Reports from 2018. Because government records are an actual source of reliable data, this source is considered trustworthy. They contain a wide range of information that can be applied to study in the humanities, administration, social sciences, and advertising. The majority of secondary data sources are publicly accessible to academics and can be obtained via online devices. The number of containers in Malaysia's major ports is calculated using data from the Ministry of Transportation's 2018 reports. Port of Klang, Port of Penang, Port of Johor, Port of Kuantan, Port of Bintulu, Port of Kuching, Port of Rajang, Port of Sabah, and Port of Tanjung Pelepas are the ten seaports that participated in this study.

2.3. Data Analysis.

The data were evaluated using multiple linear regression. The total number of containers at major ports in Malaysia was first predicted using multiple linear regression for the ten ports. The data for the multiple linear regression was gathered from dependable secondary sources, including official data statistics from the Ministry of Transportation (2018). As a result, this strategy is appropriate for this study because it forecasts the model based on historical trends.

If Malaysia follows a growth pattern dictated by the government's port infrastructure strategy, the overall seaport capacity of the seven major seaports will increase. The total cargo throughput of the ten major seaports was forecasted during a 10-year period from 2009 to 2018 and was matched to port capacity increase. In order to anticipate the number of containers that major Malaysian seaports will need to predict the number of containers in the long term, this study will use a multiple linear regression method. Furthermore, the outcomes of these assessments will identify the further steps are needed for these seaports to remain competitive in the shipping industry.

The relationship between the dependent variable (Gross Register Tonnage (GRT)) and the independent variable (Import, Export, Transshipment, Ship calling) is represented by the below equation in multiple linear regression, where there are p acts as independent variables:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_nX_n \quad (1)$$

Where:

Y = the predicted value of the dependent variable.

B_0 = the y-intercept (value of y when all other parameters are set to 0).

B_1X_1 = the regression coefficient (B_1) of the first independent variable.

(X_1) BnXn = the regression coefficient of the last independent variable.

Simple Linear Regression (SLR) can be considered as an extension of multiple linear regression when p predictor variables are present, or multiple linear regression can be considered as a particular example of simple linear regression when p=1. In Multiple Linear Regression (MLR), the term "linear" refers to the assumption that the dependent variable (Gross Register Tonnage (GRT)) is linearly connected and related to a linear combination of the explanatory variables. Analysis such as simple linear regression and correlation prevents us from making conclusions about the cause of an incident, but it does allow us to look at the relationship between a dependent variable (Gross Register Tonnage (GRT)) and independent variables (Import, Export, Transshipment, Ship calling). The null hypothesis or H0, states that there is no correlation between the independent variables (x) and dependent variable (y) in a simple linear regression. In other words, the independent variable and the dependent variable have no relationship. The

B_2 = -428,

X_2 = Export,

B_3 = 12.1,

X_3 = Transshipment,

B_4 = 4226,

X_4 = Ship calling.

Alternative hypothesis H1 states that the x variable and y variable are not equal to zero or there might be some relationship between x and y. Therefore, the null and alternative hypotheses can be expressed as follows:

Null hypothesis: There is no correlation between the congestion factors (Import, Export, Transshipment, and Ship Calling) and Gross Register Tonnage (GRT) at a major port in Malaysia. Alternative hypothesis: There is a relationship between the congestion factors (Import, Export, Transshipment, and Ship Calling) and Gross Register Tonnage (GRT) at a major port in Malaysia.

3. Results and Discussion.

The regression equation of regression analysis is as follows:

$$GRT = -13206340 + 548\ (Import) - 428\ (Export) + 12.1\ (Transshipment) + 4226\ (Shipcalling) \quad (2)$$

Where:

Y = Gross Register Tonnage.

B_0 = -13206340.

B_1 = 548, X_1 = Import.

B_2 = -428, X_2 = Export.

B_3 = 12.1, X_3 = Transshipment.

B_4 = 4226, X_4 = Ship calling.

Table 1: Output for Multiple Linear Regression.

Predictor	Coef	SE Coef	T	P
Constant	-13206340	3750502	-3.52	0.001
Import	548.47	86.84	6.32	0.000
Export	-427.91	94.15	-4.55	0.000
Transshipment	12.150	2.050	5.93	0.000
Ship Calling	4225.7	683.4	6.18	0.000

Source: Authors.

A p-value is a numerical representation of the likelihood that the data occurred by chance (i.e., The null hypothesis is true). The statistical significance level is usually expressed using the p- value, which has a range of zero to one. The null hypothesis should be rejected if the p-value is higher. Statistical significance can be interpreted as a p- value below 0.05(usually ≤ 0.05). This implies strong evidence against the null hypothesis and that the outcomes are random because there is only around a 5% chance that it is accurate. Therefore, the null hypothesis is rejected, and accept the alternative hypothesis.

Interpretation of Standardized Regression Coefficients (Beta):

1. For every one-unit increase in Gross Register Tonnage (GRT), the total cargo that was imported was predicted to increase by 548.47 in the raw score unit.
2. For every one-unit increase in Gross Register Tonnage (GRT), the total cargo that was exported was predicted to decrease by 5427.91 in the raw score unit.
3. For every one-unit increase in Gross Register Tonnage (GRT), the total cargo that was transshipment was predicted to increase by 12.150 in the raw score unit.
4. For every one-unit increase in Gross Register Tonnage (GRT), the number of ships calling was predicted to increase by 4225.7 in the raw score unit.

Table 2: Model Summary.

S=	R-Sq =	R-Sq(adj) =
24439512	95.8%	95.6%

Source: Authors.

The Multiple Correlation, known as Multiple R, between the Independent Variables (Import, Export, Transshipment, Ship calling), and the Dependent Variable (Gross Register Tonnage (GRT)), is shown in the Model Summary in the Table. (It is the relationship between the fitted Y (i.e., *Y*) values and the actual Y values): *corr (Y, Y)* The proportion of variance in Y that is accounted for by fitting (i.e., **Y**) is shown by the coefficient of determination known as R-square, which is the square of the multiple correlations. Values of R and R-square range from zero to one. R- Square (coefficient of determination) = 95.8% / .958 R- Square (adj) = 95.6% / .956 The model explains 95.8% of the variation in the dependent variable (Gross Register Tonnage (GRT)). When the sample size is lower and there are more predictors, R-square is positively skewed (as a population R-square estimator). Based on the sample group and the number of Independent Variables (Export, Import, Transshipment, Ship calling) in the model, the adjusted R-square offers an adjustment to the R-square. The gap between R-square (95.8%) and the Adjusted R-square (95.6%) in this output is really small. Shrinkage is the gap between the R-square and the adjusted R-square.

Table 3: Analysis of Variance, ANOVA.

Source	DF	SS	MS	F	P
Regression	4	1.55967E + 18	3.89917E + 17	652.81	0
Residual Error	115	6.86883E + 16	5.67290E + 14		
Total	119	1.62836E + 18			

Source: Authors.

The level of significance of the R-squared value in the Model Summary Table is analyzed using the analysis of variance. The population R-square is equal to zero, which is the null hypothesis. According to the ANOVA results, the entire model is significantly effective in describing Gross Register Tonnage (GRT) [F(A,115) = 3.89917, P < .000].

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)} \quad (3)$$

Or alternately based on ANOVA summary table:

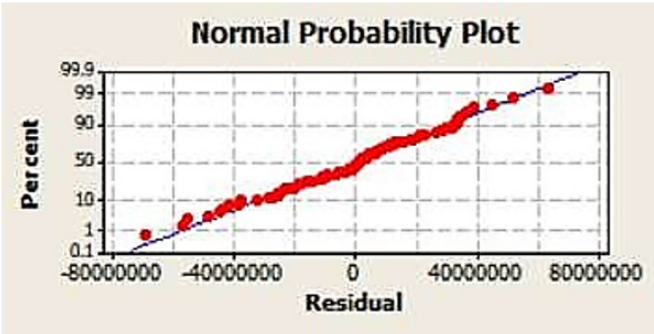
$$F = \frac{SS_{reg}/df_{reg}}{SS_{res}/(n-k-1)} \quad (4)$$

Where k = number of predictors, n= sample size.

3.1. Normality of residuals values.

A graph of residual normality was generated to assess the regression model's normality (Fig.1). It makes it possible to visually inspect the residuals' compliance with the normal distribution. If there are any points along the straight line that means it supports the residual distribution's normality. The first and last findings may be subject to some objection because they deviate somewhat from the line, but the normality of the residual values is unaffected by this deviation. The same details are provided by the histogram of the residuals (Fig.2). It is clear that things are going well because the normal line (the black line on the graph) crosses the top edge centers of the columns.

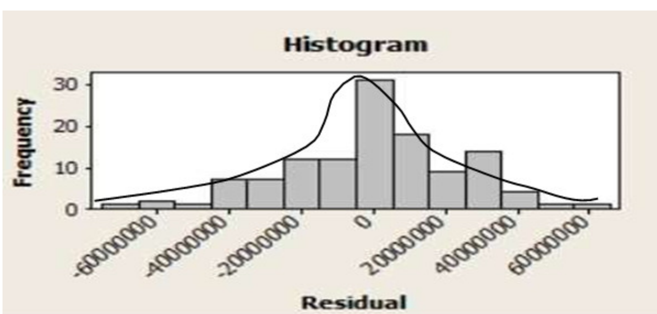
Figure 1: Normal P-P of Regression Typical Residual.



Source: Authors.

The standardized residuals' normality can also be evaluated using the normal P-P plot. This plot shows the disparity between the observed regression and those estimated under the assumption of normality. More evidence of normality is present when the observed residuals are closer to the regression line. This evidence of normally distributed residuals is well supported by this plot.

Figure 2: Regression Standardized Residual.



Source: Authors.

One of the assumptions of linear regression is that the residuals are normal in distribution. An automatic histogram of the standardized residuals will be generated by Statistical Package for Social Sciences (SPSS). A histogram of the standardized residuals is shown here. The mean of the unstandardized and standardized residuals is zero, and both have the same skewness and kurtosis shapes. Their standard deviations vary, which makes them different. In this case, there is only a slight deviation from normality in the residuals. Conceptual Point: The difference between Y and predicted Y is used to calculate unstandardized residuals. The ratio of the unstandardized residuals (above) to the standard deviation of those residuals is used to calculate the standardized residuals.

4. Recommendations.

Some of the recommendations for increasing seaport capacity is that these ten seaports need an operational approach to deal with this issue. By supplying more external capacity for seaports outside the region, the linkage of these seaports with external logistics centers like port terminals will provide produce an appropriate strategy. More parties will use these external amenities that are close to the manufacturing region because dry ports offer almost all of the services that a seaport provides. This will increase the seaport's capacity, which may subsequently be set aside for transshipment needs, particularly at the Port of Tanjung Pelepas and Port of Klang. Malaysian ports are more competitive than those of their opponents due to the growth of ports, which helps ports' capacity.

However, due to high port fees, if the government keeps rising capital expenditures for port improvement in Malaysia every 5 years, it will have a lower favorable effect on the attractiveness of Malaysian seaports among logistic lines. Considering increasing port charges is the most suitable course of action for the terminal authority to adopt when making up for the cost which has been spent previously, seaport fees will rise continuously with the amount of capital investment. An increase in port charges will be required since the significant capital expenditure in port infrastructure demands a longer repayment time, even though the high fleet frequency and continuous cargo traffic volume will help with cost reimbursement. This condition affects how appealing Malaysian seaports are to shipping lines, as well as providing several advantages to competitors. The nation benefits greatly from dry ports' support in terms of transportation.

In order to enhance seaport performance, the establishment of the seaport-dry port corridor must be put into action. By creating a port-dry port corridor, traffic might be less congested and the seaport will be more accessible. Both of these elements will increase the efficiency of Malaysian seaports, particularly in terms of enhanced access to the hinterland, quicker vessel response times, and longer freight stay times. From a regional perspective, the development of seaports within the port system increases local residents' employment. A wide range of alternatives is available for local business owners to deliver their goods to their various clientele on time due to the improvement of the infrastructure, a well-rounded transport system, and the introduction of numerous modes of transportation. In addition, because dry ports are supported, seaports may handle more containers and will not have to invest as much in expanding their capacity. These approaches have been put into practice in China, where seaports have been set up to relieve tension on port capacities and also provide cheaper port fees. The Malaysian government could therefore use the same amount of money to improve the efficiency of the transportation system, particularly the rail system by upgrading the connectivity of the seaports-dry ports-stakeholders corridor and increasing accessibility to and from the seaports, with the assurance of long-term profits.

Conclusions.

In order to determine the container ports' throughput performance, this study suggests a prediction analysis model of the major ports in Malaysia. The outcome of this application has been utilized to simulate the performance of Malaysian ports recently. The method is especially beneficial for policymakers and service providers in tracking competitiveness and organizing the expansion of container ports. The number of containers in Malaysian ports is predicted to rise, and this development is anticipated to exceed the seaport's actual capacities.

Nevertheless, if seaports are unable to increase their capacity, it will undoubtedly result in some additional negative effects of various kinds, particularly congestion, lengthy turnaround times for both vessels and containers, and a decrease in the effectiveness of the supply.

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