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# REVIEW ARTICLE

# A COMPARATIVE STUDY OF FORECASTING CONTAINER THROUGHPUT THROUGH TIME SERIES ANALYSIS

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**ABSTRACT**

This paper shows different techniques used in the operational research to encounter with forecasting the total container throughput handling. Each techniques approached has its objective and constraints regarding to the research problem. The container throughput is responsible for large investments in port infrastructure development as the aims is to established a sufficiently accurate forecasting decision support system since they try to follow the global trends in the optimization of port operations and facilities.



## INTRODUCTION

Containerization is extremely plays important characters in the rapid growth of international trade, especially for the container portswhichacts as roles in the trade and economic activities of a country.The growth of container throughput is also one of the most important elements of the large and irreversible investment in port infrastructure development. The need for accuracy in forecasting the container throughput is not surprising since it can influence the port development strategy, investment in infrastructure and daily operations management (Zhang *et al*, 2013). Therefore, the inability to have accurate forecasting of future container throughput may cause great effect especially from the financial point of view, for example the financial will losses in port construction or facility enhancement projects. The managerial decisions relying on inaccurate forecasts can lead to inappropriate future port strategy, inadequate infrastructure investments and also improper of upgrading or redesigning the decisions making for the ports (Peng and Chu, 2009). For cargo throughput forecasts, the techniques of forecasting approaches related to statistical methods and mathematical models generally may results the most reliable prediction results.

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This is because, the future of time series by means of historical data observations can be predicted as the techniques used provide a systematic apparatus based on the statistical principles (Zhang *et al*, 2013).

### Literature Review

A review of the literature of the last 20 years reveals the whole spectrum of scientific papers about forecasting the container throughput. Predicting container throughput at ports is very significant as such predictions influence the development and efficiency of a container port. The prediction techniques which are well-known forecasting approaches include the model based on classical decomposition method, Holts-Winters exponential smoothing method, regression analysis, Grey forecasting model, Hybrid Grey model and also the seasonal autoregressive integrated moving average model (SARIMA).

### Classical decomposition model

In this model, the time series is decomposed into four separate components: trend, cyclical, seasonal and irrelagular component. The model is more on intuition instead of theory. There are two types of models: the multiplicative model and additive model. These models have no theoretical basis, but the models have been useful when the parameters describing a time series are not changing over time (Bowerman and O'Connel, 1993).

**Table 1. Summary of Previous Study on Forecasting the Container Throughput**

| Author | Year | Title | Technique | Objective |
|---|---|---|---|---|
| Ismael, H. M., &Vandyck, G. K. | 2015 | Forecasting Container Throughput at the Doraleh Port in Djibouti through Time Series Analysis | Triple Exponential Smoothing<br>Grey Model<br>Linear Regression | To forecast container throughput through the Doraleh Port in Djibouti through Time Series Analysis |
| J. Jeevan*et al.* | 2015 | The Implications of the Growth of Port Throughput on the Port Capacity: the Case of Malaysian Major Container Seaports | Regression Analysis<br>3-Period Moving Average Method | To identifying the development of Malaysian container seaports by analysing the growth of container volumes |
| J.Y.Chung*et al.* | 2014 | Univariate Throughput Forecasting Model on Container Terminal Equipment Planning | Holt-Winter's Exponential Smoothing<br>SARIMA | To enhance the empirical approach of the equipment planning at the end of planning time horizon |
| Xie, G., *et al.* | 2013 | Hybrid approaches based on LSSVR model for container throughput forecasting: A Comparative Study | X-12 ARIMA Model<br>SARIMA Model<br>Classical Decomposition Model | To forecast the container throughput by Hybrid Approaches |
| Gosasang, V., *et al.* | 2011 | A Comparison of Traditional and Neural Networks Forecasting Techniques for Container Throughput at Bangkok Port | Neural Network<br>Linear Regression | To forecast container throughput at Bangkok Port by using MLP and Linear Regression |
| W.Y.Peng&C.W.Chu | 2009 | A Comparison of Univariate Methods for Forecasting Container Throughput Volumes | Classical Decomposition<br>Trigonometric Regression<br>Regression Model with Seasonal Dummy Variables<br>Grey Foorecast<br>Hybrid Grey Model<br>SARIMA | To search the model that can provide the most accurate prediction of container throughput |
| Chou, C. C., *et al.* | 2008 | A modified regression model for forecasting the volumes of Taiwan's import containers | Regression | To forecast the volumes of Taiwan's import containers by modified regression model |
| Mostafa, M. M. | 2004 | Forecasting the Suez Canal traffic: a neural network analysis | ARIMA<br>Neural Network | To forecast the maritime traffic flows in the Suez Canal |

### *Multiplicative model*

Assume a multiplicative if appears that $y_t$ has greater amplitude at higher levels of the series:

$$y_t = T_t * S_t * C_t * I_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where $y_t$represents the measured value of the time series at time $t$, $T_t$ indicates the trend component, $S_t$ is the seasonal component, $C_t$ indicates the cyclical component and $I_t$ indicates the random irregular component at time $t$ (Peng and Chu, 2009).

### *Additive model*

Assume an additive model if it appears that $y_t$ has constant amplitude at all levels of the series:

$$y_t = T_t + S_t + C_t + I_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where the meaning of the symbols is the same as in multiplicative case. All the steps of the procedure presented in the multiplicative case can also be used in the additive approach. The only difference is that we now deal with addition operations instead of the multiplication operations before.

### Holts-Winter's exponential smoothing model

Exponential smoothing techniques are simple tools for smoothing and forecasting a time series. Smoothing time series targets for eliminating the irrelevant noise and extracting the general path followed by the series. All the exponential models are good as long as they only deal with non-seasonal data, but when the seasonality exists; Holt-Winter's is more suitable model. Holt-Winters method can appear in two forms which differ in the seasonal component: multiplicative component and additive component (Bowerman and O'Connel, 1993). The multiplicative method is used when the seasonal variations are increasing to the level of the series while the additive method is used when there is roughly constant seasonal variation through the series (Fried and George, 2011).

### Regression model

Regression analysis is a statistical method that is used to summarize and study the relationship between a dependent variable (also called response variable or measurement) and one or more of the independent variables (also known as exploratory variables or predictors).

The dependent variable in the regression equation is modeled as a function for the independent variables, corresponding parameters (constant) and an error part. The error part is treated as a random variable which represents as an unexplained variation in the dependent variable (Weisberg, 2005). To give the ''best fit" of data analyze, the parameters are estimated. Usually, the best fit is evaluated by using the least squares method, results in predicted values is close to the observed data values.

**Seasonal ARIMA model**

The general ARIMA formulation for time series with seasonal component present is called SARIMA model. Then the additional differencing is necessary to be performed in order to eliminate the seasonality effect (Lazim, 2005). The general equation can be specified as *SARIMA(p,d,q)(P,D,Q)s*, where *p* denotes to the order of autocorrelations, *d* denotes as the number of differencing required to make the series stationary and *q* denotes as the order of the moving average, while capital letters refers to their counterparts for the seasonal model. The vital step of identifying the order of *(p,d,q)* and *(P,D,Q)* if seasonal ARIMA is used must be done with good attention as the order will affect the model.

**Grey forecast model**

The grey forecasting model (GM) is a basis of the grey theory developed by (Deng, 1989). Usually it is suitable and effective when the number of observations is insufficient and also for forecasting in the areas of studies where incomplete information or uncertain behaviors are common problems. The grey theory has three basis operations: (1) accumulated generation, (2) inverse accumulated generation, and (3) grey modeling. The characteristics of grey model are that it requires less data to make a prediction. Grey models are characterized by the order of the differential equation associated with the model and the number of variables included. For instance, a first order and single variable grey model is usually denoted by GM(1, 1).

**Hybrid grey model**

(Tzeng *et al*, 2001) shown that the grey forecast of GM (1,1) model will always generate an increasing or a decreasing series. Thus, grey model is insufficient to forecasting time series with seasonality. So, they suggested to combining the GM (1,1) model with the ratio-to-moving-average deseasonalised method called as hybrid grey model. (Peng and Chu, 2009) proposed a hybrid grey model by combining the grey model with the classical decomposition model. They also continue the analysis by varying the size of the initial sequence in grey forecast and search for the one that has lowest prediction errors.

## DISCUSSION

This section will discuss on the previous study and the strength or weakness of each technique approached. Next, we will discuss the proposed for each forecasting method used regarding the container throughput volume handling at ports terminal. Table 1 shows the comparison of previously study and there are different method approached with different objective and constraints.

**Conclusion**

There are many different industries with different characteristics, in a similar way there are many forecasting methods with their own strengths and weakness available. As every forecasting method applied by the industry can be affected by various economic, social, political and other factor. It is very important to find the good and right forecasting method for the particular industry.We recommend that in the finding of a good method of forecasting must be carefully examine the pattern in data, so that the most suitable model can be chosen among the others method for prediction. Forthcoming, it may be advantageous to explore the other forecasting methods which apply the latest technologies such as advanced data mining techniques or artificial intelligence to predict the container throughput handling.

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