Demand Estimating Model to Forecast the Building Material Requirements for the Construction and Allied Industries in Sri Lanka

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Abstract

Over the past few years, there has been a high level of interest in modelling demand estimation for the construction and allied industries in Sri Lanka. Demand estimation is a process that involves coming up with an estimate of the level of demand for a product or service and, typically confined to a particular period of time, a month, quarter or year. Demand estimation methods can be categorized into two main categories according to the technique applied to analyse data. Different approaches are survey methods and statistical methods. For a good quantitative analysis, statistical methods are more preferable. Regression analysis method which comes under econometric statistical method is more preferable to develop demand estimation models since it has high accuracy level. In the regression analysis, there are two methods to develop the model. These are Single Regression Analysis and Multiple Regression Analysis. The few steps to develop the estimation models are statement of a theory or hypothesis, model specification, data collection, estimation of parameters, checking goodness of it, hypothesis testing and forecasting. In this project, there are two models for sand and ABC materials each and the first model is for dust and ¾ particle size. Developed model for chip particles was rejected due to inaccuracy of the unavailability of required data. In validation, sand and ¾ particle size have shown very high accuracy when as dust and ABC has shown quite lower accuracy.

Keywords: Demand estimation, Regression Analysis, Time series Analysis

1. Introduction

With the construction boom in Sri Lanka, the demand for construction materials has highly increased. Over the past five years, there has been a high level of interest in modelling demand estimation for the construction and allied industry in Sri Lanka. In economic terms, the construction industry can be used as a proxy to measure the economic status of a nation. This is based on the principle that a nation with good economic health would keep upgrading its infrastructure through construction. Post conflict Sri Lanka's growth has been phenomenal where the construction proportion in GDP has grown to 8.7% (in the year 2013) from 6.6% (in year 2009).

The theory of demand and supply is a cornerstone of microeconomics. The idea that the price of a commodity lies at the intersection of its supply and demand curves is central to the teaching of managerial economics [1].Demand estimation is a process that involves coming up with an estimate of the amount of demand for a product or service. The estimate of demand is typically confined to a particular period of time, such as a month, quarter or a year. While this is definitely not a way to predict the future for business, it can be used to come up with fairly accurate estimates if the assumptions made are correct [2].

Demand estimation methods can be categorized into two main different categories according to technique which is applied to analysis the data. Those are survey methods and statistical methods. To obtain a good quantitative analysis, statistical methods are more preferable. For estimation of demand, most preferable way is regression analysis which comes under econometric statistical methods.

Good understanding about the demand of construction material is vital to improve construction industry. It provides benefits in many ways. To identify future demand of sand and other construction materials, government can issue exact amount of licenses. Not only that, but material providing companies also can produce aggregates for exact demand. There is no research for estimating the demand of concrete material in Sri Lanka. The reason is that it is very difficult to predict the exact future demand of construction materials by analysing past data. Except the quantitative variables, it depends on many qualitative variables which do not have any quantitative data. Best example is political changes of the country. However, in this research it is possible to do the analyses up to a significant extent by analysing all the quantitative data

Unregulated mining has the potential to release harmful substances into the soil, air, and water. Government enforces regulations on mining companies and use cutting-edge technology to reduce the damage from mining-related sources. However, unauthorized mining activities are on rise. Government cannot eliminate and regulate these illegal and unauthorized mining activities without knowing the real requirement of building materials for construction and allied industries. There is no proper mechanism to estimate the demand for each building material discussed above to use in construction and other allied industries. Therefore, development of a demand estimation model will help address this issue. Thus, this study attempts to investigate the demand for building materials for the construction industry in Sri Lanka and develop a demand estimation model to predict future demand by the sector.

2. Methodology

2.1 Process of Demand Estimation

Forecasting is essential for every business though it always does not follow as predicted due to the occurrence or non-occurrence of a certain event in the internal or external environment. Most of the time these are beyond the control of the entity and entity needs to be adjusting itself accordingly. Anyhow even with this risky business making predictions or forecasts is needed. Therefore, a systematic and logical method is required to make predictions. In

modern management, these predictions are widely used when it comes to making decisions and establishing strategies. In the process of estimating the demand for building materials, the industrial sector in Sri Lanka will follow the following steps.

2.1.1 Demand Function

By analysing independent variables of demand for sand and aggregates and the relationship with the dependent variables, demand function is developed. Analysing linear, loglinear and non-linear models, suitable model is selected to develop the demand estimation model.

2.1.2 Collecting Data

Primary data and Secondary data are used in this study. Primary data is taken from the field or by surveying and observing. Secondary data is the type of data which is taken from compiled data set, like reports, web sites, journals and magazines. In this case secondary data are used.

2.1.3 Regression Analysis

In this research study, the regression analysis method is selected to estimate and forecast the demand for sand and aggregates since it is the most accurate method for estimating the demand. It is explained under the econometric method.

Regression is a statistical measure used in finance, investment and other disciplines that attempts to determine the strength of the relationship between one dependent variable (usually denoted by Y) and a series of other variables (known as independent variables). Regression helps investment and financial managers to value assets and understand the relationships between variables, such as commodity prices and the stocks of businesses dealing in those commodities. [3]

The reason for choosing Regression Analysis was, due to the fact that it provides the statistical support to justify the significance of variables and overall model's ability and the appropriateness to make predictions without bias. Following steps have been followed which are explained in econometric theory while making the estimation. In this study, two hypothesis called H_0 (Null hypothesis) and H_a (Alternative hypothesis) have been considered. If the T values of each variables are higher than table value of T (for 20 samples) then the alternative hypothesis is true. If not, Null hypothesis H_a is true. It has been planned to follow by to evaluate the quarterly demand for sand and aggregates, forecasting the futures sand and aggregate demand.

Let ρ be the true correlation between sand consumption and sand unit price. The null hypothesis (H_0) is that there is no relationship between these two variables and the alternative hypothesis (H_1) is that the two variables are positively correlated. These hypotheses are

H_0: $\rho = 0$

H_1: $\rho > 0$

The test statistic is r and the standardized t statistic for r is

$$t = r \sqrt{[(n-2)/(1-r^2)]} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

If the calculated t value is greater than t value relevant to 95% confident interval, result will be in the alternative hypothesis region. It follows that there exist a relationship between considered variables. If the result is in null hypothesis region then there is no relationship between variables under considered confident interval.

2.1.4 Specifying the mathematical model of the theory

To evaluate the future demand for sand and aggregates, mathematical formula are developed without paying attention to the precise and accuracy form of functional relationship between the variables. In this stage , it is only considered to develop mathematical models and get relationships between each variables

$Y = ß_0 + ß_1X_1 + ß_2X_2 + ….+ ß_nX_n$ .....(1)

Where;

Y – Demand for material

X_i – Quantities of each variable are affected the demand of material

ß – Coefficient of variables (Amount of change in Y produced by a unit change in X_i)

2.1.5 Specifying the econometric or statistical model

The deterministic mathematical formula should be modified to demonstrate the relationship between the variables as follows by introducing the error term or disturbance variables,to specify the demand estimation model.

$Y=ß_0 + ß_1X_1 + ß_2X_2 + ….+ ß_nX_n + ε$ …(2)

Where;

Y – Demand for material

X_i – Quantities of each variable affected by the demand of material

ß – Co efficient of variables (Amount of change in Y produced by a unit change in X_i)

ε - Residuals

2.1.6 Estimating the parameters of the econometric model

After collecting of data, the next step was to estimate the parameters of the econometric model developed. To estimate the parameters, the "Minitab" software was used for regression analysis.

Minitab is a statistics package developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner in 1972. It began as a light version of OMNITAB, a statistical analysis program by NIST; the documentation for OMNITAB was published in 1986, and there has been no significant development since then [3]. In regression analysis, draw a regression line which is best fitted line and satisfies all the plotted spots in the scatter diagram. Then we determine the coefficient of correlation (r) and determination of (r^2) which measures the strength of the linear relationship that exists.

2.1.7 Forecasting and Prediction

After developing the model, we should check whether that module exist in given confident interval. If the chosen model does not refuse the hypothesis or theory under given confident interval, it can be used to predict the future value of the dependent variable.

3. Results

3.1 Sand

Model 1:

Sand (m^3) = 3564096 - 269222 Unit Price of Sand + 361505 Unit price of offshore sand - 23642 Fuel price

Model 2:

Sand (m^3) = - 10817174 - 194630 Unit Price of Sand + 257469 Unit price of offshore sand + 854955 Population Data

3.2 ABC

Model 1:

ABC (m^3) = - 493875 - 25.7 ABC unit price + 37066 Population Data - 689 CCPI

Model 2:

ABC (m^3) = - 423063 - 39.0 ABC unit price + 30737 Population Data

3.3 Dust (0-5mm)

Model 1:

0-5mmt (m^3) = 3351649 - 144.90 Unit Price - 1776.6 Fuel Price - 216 CCPI- 160073 Population Data + 123.04 Per Capita GDP

3.4 12-20mm Material

Model 1:

Amount (m^3) = -17241665 + 1848.56 Unit Price (Rs) + 20235.0 Fuel Price+ 799848 Population Data - 722.76 Per Capita GDP

3.5 Prediction of quantities for 2016

Table 1- Sand

Quarter	Model-1 (m^3)	Model-2 (m^3)
Q1	2,944,289.24	3,043,114.95
Q2	3,177,947.92	3,228,775.73
Q3	3,424,884.59	3,423,094.61
Q4	3,680,637.64	3,622,807.40

Table 2 - ABC

Quarter	Model -1 (m^3)	Model -2 (m^3)
Q1	37750.45	40867.56
Q2	32755.85	38484.66
Q3	30278.44	33972.36
Q4	19844.70	19717.86

Table 3 - Dust (0-5mm)

Quarter	Model 1 (m^3)
Q1	34775.8
Q2	34775.8
Q3	34775.8
Q4	34775.8

Table 4 - 12-22mm material

Quarter	Model 1 (m^3)
Q1	1548768
Q2	1548813
Q3	1549832
Q4	1549633

4. Validation of Models

4.1 Sand

Actual sand consumption for the first three quarters in 2016 is **9.66** million cubic meters. Predicted data for the first three quarters in 2016 according to Model 1 is **9.53** million of cubic meters and according to Model 2 it is **9.68** million of cubic meters. Since the results of the model are more realistic compared with the actual values, both models which have been developed for estimating sand demand in Sri Lanka are more accurate and acceptable.

4.2 ABC

Actual ABC amount for 2016 was calculated based on Road Development Authority data and it was 345,941 m^3. Predicted data for 2016 according to Model-1 is 120,629.44 m^3 and according to

Model-2 is 133,042.44 m^3. This is a high deviation of actual values from predicted value. This is possible due to limited and unreliability of secondary data collected for the study. In this study, researchers developed a model for ABC material based on 2011,2012,2013,2014 and 2015 data. Most of the construction works of mega projects were affected and stand stalled due to political changes that for a year after 2015 election. However, most of the projects have recommenced now after obtaining financial and technical assistance from the World Bank, IMF and other funding agencies. Therefore, secondary and primary data relevant to year 2015 shows an abnormal trend compared with the other years. However, after the political situation, stabilized few mega projects have recommenced. (Southern Highway Expansion Project (Matara-Hambanthota), Central Highway Project). Due to the recommencement of stalled mega projects, normal trend for building material demand has affected. However, developed model will be more reliable for normal situations to predict the ABC requirement for the country.

4.3 Quarry Dust

Actual quarry dust requirement for 2016 was calculated based on RDA data. It was 92,651.66 m^3. According to the developed model, estimated quarry dust material requirement for 2016 was 139,103.2 m^3. Predicted data and actual data show significant variance in this case. This may also be affected due to unreliability of collected secondary data and assumptions made in the study.

4.4. Size 12-22 mm material

Actual three quarter material consumption for 2016 was 3.96 million cubic meters. The predicted value for first 3 quarters was 4.64 million cubic meters. This indicates that the predicted and actual requirements do not show difference. This small difference took place due to the reliability of some secondary data and assumptions made in the study. However, the developed model to estimate the requirement of (12-22) mm material for construction industry is in acceptable limit and therefore the model is reliable to estimate future material requirements.

5. Discussion

Literature survey confirmed that annual permitted sand mining capacity is about 7 to 8 million cubic meters per annum. However, according to the developed model, sand requirement for 2016 is 13,227,759m^3 (in Model 1) and 13,317,792 m^3 (in Model 2). Reason for the variation is due to illegal sand mining. It is not add that many illegal and over extractions of sand and aggregate in mining locations in Sri Lanka. The research project shall help GSMB to formulate new policies for sand mining to eliminate illegal mining activities.

Analysing the 2016 ABC consumption, in the 4th quarter there shows a rapid reduction in the demand. Because ABC is mostly used for road construction purposes and most of the construction work is temporally stopped for Christmas and New Year celebration and year end vacations.

This study also developed an estimation model for chip material estimations.

Sqrt(Amount)=33.0+ 0.1004 Unit Price (Rs) + 0.662 Fuel Price - 1.276 CCPI

However, due to the unreliability of secondary data, this model provides predicted values which are lower than the actual data. Therefore, this model was not considered for material predictions and rejected even though it satisfies all the required statistical conditions.

6. Conclusion

According to the regression analysis method, some conditions are needed to be satisfied to develop accurate demand estimation models. They are:

- Hypothesis tests should be carried out to check the correlation of each independent variable with dependent variables and if the alternative hypothesis is true, independent variables have strong coefficient with dependent variables.
- Determination of coefficient value should exceed at least 0.5 to get a strong relationship with variables.
- P value of each variable should be less than 0.05 to lie on the 95% confident interval
- T distribution of each variable should be greater than 2.086 to lie on the 95% confident interval.

In these models, the above four factors are satisfied. Therefore, researches confirm that there may not be any technical defects in developing there models. But, there can be some inaccuracies due to inaccurate data since data were obtained from secondary sources. However, researchers have predicted the 2016 figures using the developed model. However, results realize that the Model for chip (5-12) mm material is not accurate because of unreliable secondary data. Therefore, the model should be rejected and other models be developed to predict the other material to satisfy the requirement are more accurate and within the 95% confidence limit.

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