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Supply and Demand Model of Construction Materials in Mamminasata Metropolitan Area, South Sulawesi

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Abstract

Mamminasata Metropolitan Area is the urban area which consists of Makassar City, Takalar Regency, Gowa Regency, and Maros Regency. The acceleration of economic growth and economic structural changing in Mamminasata Metropolitan Area will affect intensity of construction materials supply and demand. The concept of supply and demand is the important concept of modern economy. Construction materials have many application as the major raw material in making up road-building and construction industries. Some dependent variables affect the trend level of supply and demand, so this research aims to (1) determine dependent variables of construction materialssupply and demand, (2) establish supply and demand model. Data were obtained from Central Bureau Statistics of Gowa Regency, Maros Regency, Takalar Regency, and Makassar City, and Department of Energy and Mineral Resources of South Sulawesi Province for twelve years (2004 – 2015). In this research, correlation among construction materials supplyand demand and dependent variables were modelled using multiple regression analysis. The results showed that supply and demand of construction materials have weak relationships with their dependent variables.

Keywords: *supply-demand; multiple regression; construction materials; dependent variables; independent variables*

1. Introduction

A. Background

Construction materials are the most familiar minerals and the largest nonfuel mineral commodity comprise of sand, gravel, stone aggregates and rock The materials are fundamental for human development and wellbeing and used mostly by construction industry such as road-building, portland cement concrete asphaltic concrete, rail ballast, mortar, plaster and filter media for sewage and other water treatment [1-4].They are widely exploited as naturally sorted aggregates or as mixed aggregatesand used either in their natural state of after crushing, washing, and sizing [5-6].

The construction materials are generated by weathering of rocks and by topsoil erosion which is occur most commonly in the stream channels of active or historically active river system and directly removed from their natural configuration on riverbeds, quarries and pits. The composition varies depending on the source rocks which supplied the sediment [3]. Principal activities in the materials mining are extraction, processing, and transportation [5-6].Processing can be as simple as portable crusher and screens or can be a highly automated. After processing commonly is transported to market location by haul truck [2].

Construction materials mining have become a world phenomenon, particularly intense in industrial growth especially construction industry and countries subject to rapid urban. One of the rapid urban city is

Mamminasata Metropolitan Area includes 14 districts in Makassar City, 9 districts in Takalar Regency, 11 districts in Gowa Regency, and 12 districts in Maros Regency. Economic growth in Mamminasata Metropolitan Area affects the construction materials supply and demand in this area.

Construction materials supply and demand was affected by some variables, but not all variables have a significant relationship. The relationship between supply and demand with the variables consist of positive and negative correlations. A negative correlation occurs between supply and demand because construction materials production has declining since 2013 [7].The dependent variables of supply consistof price, number of trucks, number of companies and mining permit area, meanwhile the demand was influenced by price, length of road, number of buildings, GDP, income per capita, and economic growth [8-10].Therefore, this research the focus is to make the regression model of construction materials supply and demand.

Changes in supply and demand of construction materials occur because of changes in the economic factors so it would be expected that there is a relationship between increasing and decreasing of construction materials supply and demand, and some parameters of economic activity. Consequently, the purposes of this research are (1) to determine dependent variables of construction materials supply and demand, (2) to establishsupply and demand model by using multiple regression analysis.

B. Supply and Demand

Supply and demand are the central concept of modern economy and the most analyzed concepts. When price increase the production rate will increase and consumption rate will decrease, and vice versa Supplyis willingness and ability to supply goods or services at varying price points and demand is defined as the quantityof a good or servicepeople are willing and able to buy at different prices.Supply and demand jointly determined the market price of good and the quantity of it that is sold [11].

Demand for minerals generally affected by three factors, namely uses for mineral commodities, level of population, and standard of living [12]. Economic growth and population have a bigger impact on the construction materials market. In general, the mine production is directly related to the amount of construction activities in any area [2].

Construction materials supply and demand could be estimate by using multiple regression analysisas a statistical technique for estimating relationship between a dependent (criterion) variable and more than one independent (predictor) variables.This method measures the degree of influence of the independent variables on a dependent variable [13,14]. The general model of multiple regression look like following:

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \quad (1)$$

Where y is the predicted trend, $x_1, x_2, \ldots, x_n$ are the influence factor of predicted trend, $\beta_0, \beta_1 \ldots, \beta_n$ are the regression coefficients that shows slope of regression line, and ε is the residual variable.

Multiple regression methods are built using certain assumptions include [15]:

- The relationship between Y (predicted trend) and X (influence factor of predicted trend) is linear in the parameters.
- X variable is a non-stochastic variable that has a fixed value. The X value is fixed for various repeated observations.
- Expected value (E) or the average of the residual variable ε_i is zero.

$$E(\varepsilon_i|X_i) = 0 \quad (2)$$

- The variant (σ^2) of the residual variabel ε_i is the same (homoskedasticity).

$$Var(\varepsilon_i|X_i) = E[\varepsilon_i - E(\varepsilon_i|X_i)]^2_2 \quad (3)$$

$$= E(\varepsilon_i{}^2|X_i) \text{ refer to 3}^{\text{rd}} \text{ assumption}$$

$$= \sigma^2$$

- There is no serial correlation between residual variabel ε_i, it can be stated as follows:

$$Cov(\varepsilon_i, \varepsilon_j|X_i, X_j) = E[(\varepsilon_i - E(\varepsilon_i)|X_i)][(\varepsilon_j - E(\varepsilon_j)|X_j)] \quad (4)$$

$$= E(\varepsilon_i|X_i)(\varepsilon_j|X_j)$$

$$= 0$$

- Residual variabel $\varepsilon_i$are normally distributed

$$e \sim N(0, \sigma 2) \quad (5)$$

In terms of measuring how well the regression line fits the data or measures the percentage of the total Y variation explained by the regression line, the concept of coefficient of determination (R^2) can be used. R^2 can be defined as a proportion or percentage of the total variation of the dependent variable Y which is explained by the regression line (independent variable X). The value of coefficient determination is between 0 and 1 [15].

$$0 \leq R^2 \leq 1 \quad (6)$$

if the value of R^2 approaches 1 then it can be interpreted that the line is able to explain the actual data, and vice versa.

One of the stages in multiple linear regression analysis is evaluating the effect of all independent variables on the dependent variable using the F test [15]. The F test can be calculated using the following formulation:

$$F = \frac{R^2/(K-1)}{1-R^2/(n-k)} \quad (7)$$

Where$R^2$is coefficient determination, n is amount of data or observation, and k is number of estimation parameters, including intercepts or constants [15].The stages in the F test are as follows:

- Make a null hypothesis (H_0) and alternative hypothesis (H_1).

$$H_0 : \beta_1 = \beta_2 = \cdots = \beta_n = 0$$

$$H_0 : \beta_1 \neq \beta_2 \neq \cdots \neq \beta_n \neq 0 \quad (8)$$

- Count for the value of F with the formula in Equation 7 and compare it with the critical F value from the distribution table F.
- If the calculated F value is greater than the critical F value, then H_0 is rejected, but if the calculated F value is less than the critical F value then H_0 is accepted.

2. Research metodology

This researchobtained data of variables from Department of Energy and Mineral Resources of South Sulawesi Province and Central Bureau Statistics of Makassar City, Takalar Regency, Gowa Regency, and Maros Regency. The collected data in the form of annual time series for 12 years (2004-2015) that consist of dependent and independent variables. Dependent variables were the production of construction materials (sand, sand and gravel, *batukali*, crushed stone, and boulder), while independent variables were number of inhabitants, number of buildings, length of road, GDP, income per capita, economic growth, prices, number of trucks, number of companies, and mining permit.

In constructing the supply-demand model, we used two assumptions. First, demand rates of construction materials were same as the rates of production because there was no accurate data to compile the quantities of materials actually delivered to consumers. Second is only onetime series data of price available for all of construction materials product.

3. Results and Discussion

The main characteristic of construction mining industry is production geared more to fulfil the needs of local market. The study of construction materials market economy still very little done due to the limited data so that the analysis becomes difficult [16].

This study analysed historical data of supply and demand. Dependent variables of supply were price, number of trucks, mining permit area, and number of companies. Dependent variables of demand were price, length of road, number of inhabitants, number of buildings, economic growth, GDP, and income per capita.

The equations of relations of several independent variables to both supply (Qs) and demand (Qd) are:

$$Q_s = f\,(P, NT, MPA, NC) \quad (9)$$

where:

P = price
NT = number of trucks
MPA = mining permit area
NC = number of company

$$Q_d = f\,(P, LR, NI, NB, EG, GDP, IC) \quad (10)$$

where:

P = price
LR = length of road
NI = number of inhabitants
NB = number of buildings
EC = economic growth
GDP = Gross Domestic Product
IC = income per capita

3.1. Supply of Construction Materials

3.1.1. Supply of Sand

The following equations show relations of several independent variables to supply of sand (Qs):

$$Q_{s_1} = -444{,}582.165 + 12{,}086\ P - 3{,}241.247\ MPA + 49.024{,}247\ NC - 355{,}641\ NT \quad (11)$$

$$Q_{s_2} = 78{,}874.298 + 0.843\ P + 25{,}910.003\ NC (12)$$

$$Q_{s_3} = 26{,}420.968 + 25{,}410.730\ NC - 355.641 NT \quad (13)$$

Statistical test shows that fit of goodness (R^2) of sand supply for Equation 8, 9, and 10 are 0.151, 0.004, and 0.151. Range value of $F_{cal}$is 1.019-2.241 and α > 0.05, namely 0.303, 0.399, and 0.165.

3.1.2. Supply of Sand and Gravel

Relationship between independent variables and supply of sand and gravel is shown in Equations 14.

$$Q_s = 185{,}919.981 - 1.231P - 73.747\ MPA - 1{,}124.171\ NC - 15.152\ NT \ (14)$$

The fit of goodness (R^2) of model is 0.382, F_{cal}2.701 and α > 0.05, namely 0.119.

3.1.3. Supply of Batukali

Supply model of *batukali* are shown in Equation 15 and 16.

$$Q_{s_1} = 2{,}965.703 - 0.356\ P - 95.369\ MP + 1{,}584.476\ NC + 30.014\ NT \quad (15)$$

$$Q_{s_2} = 2{,}965.703 + 1{,}584.476\ NC \quad (16)$$

Statistical test showed that fit of goodness (R^2) of *batukali* supply is 0.101 for Equation 15 and 0.121 for Equation 16. Value of F_{cal} are 0.406 and 0.812, and α > 0.05, namely 0.799 and 0.389.

3.1.4. Supply of Crushed Stone

The relations of some independent variables to supply of crushed stone (Q_s) are shown in Equation 17 and 18.

$$Q_{s_1} = -101{,}132.244 - 1.157\ P - 786.101\ MPA + 12{,}110.500\ NC + 238.838\ NT \quad (17)$$

$$Q_{s_2} = 44{,}269.798 + 4{,}849.577\ NC \quad (18)$$

The model fit of goodness (R^2) of Equation 17 is 0.101, F_{cal}1.308, and α > 0.05, namely 0.354. The model fit of goodness(R^2) of Equation 18 is 0.121, F_{cal}2.513, and α > 0.05, namely 0.144.

3.1.5. Supply of Boulder

Relationship between independent variables and supply of boulder are shown in Equations 19 and 20.

$$Q_{s_1} = 28{,}890.559 - 0.3167\ P - 166.194\ MPA - 4{,}301.855\ NC + 30.014\ NT \quad (19)$$

$$Q_{s_2} = -8{,}604.843 + 1.313\ P - 68.724\ MPA \ (20)$$

Statistical test showed that fit of goodness (R^2) of boulder supply is 0.116, F_{cal} is1.360, and α is 0.338 for Equation 19. The fit of goodness (R^2) for Equation 20 is 0.095, $F_{cal}$is 0.525, and α is 0.609.

3.1.6. Supply of Total Amount of Construction Materials

In this analysis the production data is total amount of all construction materials product. Equation 21, 22, and 23 show relations of several independent variables to supply of total amount of construction materials (Q_s):

$$Q_{s_1} = -326{,}583.442 + 12.525\ P - 3{,}922.354\ MPA - 57.458{,}941\ NC - 307{,}701\ NT \quad (21)$$

$$Q_{s_2} = 297{,}111.707 - 1.285\ P + 28{,}770.494\ NC \quad (22)$$

$$Q_{s_3} = 217{,}145.328 + 27{,}948.359 NC \quad (23)$$

Statistical test shows that fit of goodness (R^2) of total amount of construction materials supply for Equation 21, 22, and 23 are 0.257, 0.020, and 0.114. Range value of F_{cal} is 1.110-2.415 and α > 0.05, namely 0.207, 0.371, and 0.151.

3.2. Demand of ConstructionMaterials

3.2.1. Demand of Sand

The following equations show relations of some independent variables to demand of sand (Q_d):

$$Q_{d_1} = 11{,}063{,}510.829 + 30.921\ P - 148.124\ LR + 5.191\ NI - 16.356\ NB + 20{,}988{,}755.740\ EG - 0{,}136\ GDP + 0{,}266\ IC \quad (24)$$

$Q_{d_2} = -1{,}514{,}065.646 - 17.521\ \mathrm{P} + 44{,}382{,}244.559\ \mathrm{EG}$ (25)

Statistical test shows that fit of goodness (R^2) of sand demand for Equation 24 and 25 are -0.478 and 0.135. Value of F_{cal} are 0.491 and 0.345, and $\alpha > 0.05$, namely 0.806 and 0.717.

3.2.2. Demand of Sand and Gravel

Relationship between independent variables and demand of sand and gravel is shown in Equation 26.

$Q_d = -138{,}043.059 - 0.730\ \mathrm{P} + 2.043\ \mathrm{LR} - 29.500\ \mathrm{NI} - 1.117\ \mathrm{NB} - 5{,}367{,}717.222\ \mathrm{EG} - 0.049\ \mathrm{GDP} + 0.272\ \mathrm{IC}$ (26)

The fit of goodness (R^2) of model is 0.591, F_{cal}3.275 and $\alpha > 0.05$, namely 0.134.

3.2.3. Demand of Batukali

Demand model of *batukali* is shown in Equation 27.

$Q_d = 396{,}289.745 + 0.564\ \mathrm{P} - 22.808\ \mathrm{LR} - 0.110\ \mathrm{NI} - 0.098\ \mathrm{NB} + 256{,}768.838\ \mathrm{EG} - 0{,}016\ \mathrm{GDP} + 0{,}036\ \mathrm{IC}$ (27)

Statistical test show that fit of goodness (R^2) of *batukali* demand is -0.717, F_{cal} is 0.344 and $\alpha > 0.05$, namely 0.897.

3.2.4. Demand of Crushed Stone

The equations of relationship of some independent variables to demand of crushed stone (Q_d) are shown below:

$Q_{d_1} = 1{,}312{,}917.954 - 1.431\ \mathrm{P} - 46.854\ \mathrm{LR} - 0.845\ \mathrm{NI} - 0.187\ \mathrm{NB} + 16{,}732{,}979.869\ \mathrm{EG} + 0.016\ \mathrm{GDP} + 0.033\ \mathrm{IC}$ (28)

$Q_{d_2} = 591{,}254.505 - 0.047\ \mathrm{P} - 0.370\ \mathrm{NI} - 0.360\mathrm{NB} + 13{,}784{,}813.747\ \mathrm{EG}$ (29)

$Q_{d_3} = -112{,}292.728 + 3{,}173{,}797.343\ \mathrm{EG}$ (30)

The model fit of goodness (R^2) of Equation 28 is0.146, F_{cal}0.799, and $\alpha > 0.05$, namely 0.628. The model fit of goodness (R^2) of Equation 29 is 0.240, F_{cal}1.866, and $\alpha > 0.05$, namely 0.221.

3.2.5. Demand of Boulder

Relationship between independent variables and demand of boulder are shown in Equations 31 and 32.

$Q_{d_1} = -611{,}994.201 + 1.043\ \mathrm{P} + 53.533\ \mathrm{LR} + 1.051\ \mathrm{NI} - 1.084\ \mathrm{NB} - 2{,}329{,}582.844\ \mathrm{EG} + 0.026\ \mathrm{GDP} - 0.079\ \mathrm{IC}$ (31)

$Q_{d_2} = 98{,}930.163 + 0.221\ \mathrm{P} + 0.640\ \mathrm{NI} - 1.009\mathrm{NB} + 635{,}198.468\ \mathrm{EG}$ (32)

Statistical test showed that fit of goodness (R^2) of boulder demand is -0.148, $F_{cal}$is 0.798, and α is 0.628 for Equation 31. The fit of goodness (R^2) for Equation 32 is -0.409, $F_{cal}$is 0.202 and α is 0.930.

3.2.6. Demand of Total Amount of Construction Materials

In this analysis demand is total amount of all construction materials product. Equation 33 and 34 showrelations of several independent variables to supply of total amount of construction materials (Q_d):

$Q_{d_1} = 11{,}974{,}074.918 + 30.343\ \mathrm{P} - 194.010\ \mathrm{LR} + 4.183\ \mathrm{NR} - 15.673\ \mathrm{NB} + 30{,}285{,}276.420\ \mathrm{EG} - 0.167\ \mathrm{GDP} + 0.037\ \mathrm{IC}$ (33)

$Q_{d_2} = -1{,}878{,}978.744 - 23{,}972\ \mathrm{P} + 59{,}205{,}998.665\ \mathrm{EG}$ (34)

Statistical test shows that fit of goodness (R^2) of total amount of construction materials demand for Equation 30 and 31 are -0.253 and -0.090. Value of F_{cal} is 0.682 and 0.547, and $\alpha > 0.05$, namely 0.691 and 0.597.

The analysis confirmed that those independent variables in each relation are all have weak correlation with dependent variables of supply (Q_s) and demand (Q_d). Fit of goodness (R^2) of supply (Q_s) have value range -0.276 - 0.382 and of demand (Q_d) have value range -0.717 – 0.591. Numerically, it could be assumed that level of correlations is low.

4. Conclusions

This research identified that construction materials supply and demand depend on some influencing variables. Supply influenced by price, number of trucks, mining permit area, and number of companies. Demand influenced by price, length of road, number of inhabitants, number of buildings, economic growth, GDP, and income per capita.

The developed model performs low relationship between supply and demand of construction materialsin Mamminasata Metropolitan Area with their influencing variables.

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