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Supply and Demand of Jeneberang River Aggregate Using Multiple Regression Model

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ABSTRACT: Aggregate plays an important role in developing infrastructure because it is the major raw materials used in construction such as roads, hospitals, schools, factories, homes and other buildings. Sand and gravel are essential sources of aggregate and exploited often from the active channels of river systems. Jeneberang River is one of the main rivers in South Sulawesi Province which is located at Gowa Regency and mined in order to fulfill the aggregate demand of Gowa Regency and Makassar City. Supply and demand are economic occurrences that affected by several factors, so this research aims to (1) determine influencing factors to aggregate supply and demand, (2) develop supply and demand model. Data was obtained from Central Bureau Statistics of Gowa Regency and Makassar City, and Department of Mines and Energy, Gowa Regency for eleven years (2001 – 2011). In this research, aggregate supply and demand were modeled using multiple regression method. First, relationship among supply and influencing factors were established, followed by demand and its factors. Second, supply and demand model was established using SPSS. The result of this research showed that the model can be used to estimate accurately supply and demand of aggregate using the established relationship among the influencing factors. Supply of aggregate was affected by several factors including price, number of trucks, number of mining companies and mining permit area meanwhile the price, GDP, income per capita, length of road, number of buildings and economic growth had high influence on demand rate.

KEYWORDS: Jeneberang River, infrastructure, aggregate mining, sand and gravel, supply and demand, influencing factors.

1 INTRODUCTION

1.1 JENEBERANG RIVER

Jeneberang River is one of the main rivers in South Sulawesi Province. It is located at Gowa Regency and flows east to west across the province to Makassar City. The river is 85.5 km long with a catchment area of 762.01 km^2, originating from Mt. Bawakaraeng (2,833 m) which is located 90 km from Makassar. In the midstream area of the Jeneberang River, the

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multipurpose Bili-bili Dam provides some benefits to the community such as flood control, water supply, irrigation and power plant [1].

On 26 March 2004, gigantic caldera wall collapsed at the east ridge of caldera of Mt. Bawakaraeng. The volume of the collapsed mass was estimated at about 235 million m^3 (originally) and based on more detailed survey the collapse was estimated to be 231 million m^3. Small to middle scale collapsed deposits were estimated at 1.6 million m^3. Surface erosion (2004-2009) was estimated at 11.7 million m^3. In 2009, the remains of the collapsed deposit in the caldera were estimated at 82.7 million m^3 and sediment volume flowing into the Jeneberang River was estimated at 162.2 million m^3 [1]. After the collapse, the Jeneberang River was supplied with a large amount of sediment that are mined conveniently and economically to supply aggregates demand of Gowa Regency and Makassar City. Mining activities become a part of sediment control plan to mitigate the potential debris flow resulted from the Mt. Bawakaraeng collapse.

1.2 AGGREGATE MINING

The most common natural aggregates of mineral origin are sand, gravel, and crushed rock. Aggregate is basic raw material required for all construction activities. It is impossible to construct a city without using natural aggregate. Aggregate is used in many different applications such as road-building, rail ballast, mass concrete for foundation or major structures, concrete blocks, steel reinforced beams, flooring and walls, mortar, plaster and filter media for sewage and other water treatment [2]. The aggregate produced from natural sources extracted from quarries and gravel pits and used either in their natural state or after crushing, washing, and sizing [3]-[4].

Throughout the history, the Jeneberang River mining started during the development of the Gowa Kingdom Forts under the reign of Karaeng Tumapa'risi Kallonna in 1525. The Forts were built from stones that are presumed to have been taken from the river [5]. Currently, there are eighteen active mining sites in midstream of the Jeneberang River which mining permit area varies between 5 – 60 hectares. A permit for the extraction of sand and gravel is given by Department of Mines and Energy, Gowa Regency. The permit is typically effective for 1-5 years, at which time the applicant has the option to apply for a renewal permit.

1.3 SUPPLY AND DEMAND

Supply in economic term essentially measures quantity of a product or service to be offered at varying price points, meanwhile demand measures quantity of a product or service to be purchased at varying price points [6]. Aggregate demand modeled generally fall under three main methods [7]: (1) historical trend: using such simple assumptions as recent per capita consumption or recent average annual levels; (2) regression models: using either macroeconomic indicators (such as GDP, population, unemployment rate, etc.), and (3) construction input factors: these may be either space based (i.e. tons per sq. ft. of different types of construction).

It is important in aggregate resources to forecast demand because the forecast facilitates an evaluation of the sufficiency of the resource supply to meet the expected demands. In order to forecast aggregate supply and demand we developed an economic model using multiple regression method. Regression method is a tool that widely used in many study areas, because it can be easily modeled using simple assumptions. This method measures the degree of influence of the independent variables on a dependent variable. A regression with two or more explanatory variables is called a multiple regression. Multiple regression is used to test the effects of n independent (predictor) variables on a single dependent (criterion) variable (Supranto, 2005). The general model of multiple regression is given:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + \varepsilon$$

Where y is the predicted trend, x_1, x_2, …, x_n are the influence factors of predicted trend, β_0, β_1 …, β_n are the regression coefficients, and ε is the residual variable.

1.4 AIMS OF RESEARCH

In general, changes in supply and demand level for aggregate occur because of previous or present changes in the characteristics of the overall economy. Thus, it would be expected that a relationship exists between trends in the level of aggregate supply and demand, and various indicators of the general economic activity. Consequently, the aims of this research are (1) to determine influencing factors to aggregate supply and demand, (2) to develop supply and demand model.

2 METHODOLOGY

In this research aggregate is considered as total sand and gravel. Data were collected primarily from Department of Mines and Energy, Gowa Regency and was also obtained from Central Bureau Statistics of Gowa Regency and Makassar City from 2001 to 2011.

The data obtained were subjected to multiple linear regression method using Statistical Product and Service Solutions (SPSS) Version 18.0 from which multiple regression model parameters were estimated and all graphs in this paper were drawn using Microsoft Excel 2010.

3 RESULTS AND DISCUSSIONS

Historical annual aggregate production data were obtained from Department of Mines and Energy, Gowa Regency but the demand for aggregate was determined using the rates of production. This is because there is no accurate source of information to compile the quantities of aggregate actually delivered to consumers. The assumption made, in order to substitute production rates for demand rates. Because only legal mining report their figures to the Department of Mines and Energy, so the figures do not account for the contribution of illegal operators in meeting the demands of the area. Using the Department of Mines and Energy's figures as a basis for projecting supply and demand will, therefore, provide a supply and demand estimation which is lower than the actual.

According to the Department of Mines and Energy, the greatest volume is produced by nine mining sites and the other ones have relatively small operation. There are some sand and gravel illegal mining that take place frequently in several locations but the number and quantity of production is unknown [8].

In this research, dependent variable for supply model was total supply meanwhile potential independent variables considered for supply model here included price, number of trucks, number of mining companies and mining permit area (Table 1).

Table 1. Total supply of aggregate and influencing factors of supply model

Year	Price (Rp/m^3)	Number of trucks (unit)	Number of mining companies (unit)	Mining permit area (ha)	Total supply (m^3)
2001	16,667.00	582	9	38.00	508,528.00
2002	20,833.00	633	9	38.00	602,709.00
2003	29,583.00	430	9	38.00	459,807.00
2004	35,000.00	501	9	38.00	289,078.56
2005	35,416.67	528	9	38.00	363,244.78
2006	44,412.00	522	9	38.00	377,610.57
2007	63,750.00	607	19	105.30	498,403.86
2008	70,062.50	790	25	138.26	555,243.00
2009	76,167.00	891	25	138.26	1,847,896.53
2010	79,375.00	919	12	93.42	1,162,553.79
2011	80,000.00	1164	15	144.42	503,453.92

The supply of aggregate was modeled as:

$$Q_s = -2{,}088{,}760.888 + 15.052\ x_1 + 3667.876\ x_2 + 171{,}417.766\ x_3 - 37{,}302.661\ x_4$$

Where:

Q_s = quantity of aggregate supplied (in metric cubic), annually

X_1 = price of aggregate

X_2 = numbers of trucks

X_3 = number of mining companies

X_4 = mining permit area

The dependent variable for demand model was total demand meanwhile the independent variables were price, GDP, income per capita, length of road, number of buildings and economic growth as shown in Table 2, Table 3 and Table 4.

Table 2. Total demand of aggregate, price and length of road

Year	Price (Rp/m^3)	Length of road (km)	Total demand (m^3)
2001	16,667.00	3041.46	508,528.00
2002	20,833.00	3101.46	602,709.00
2003	29,583.00	3229.27	459,807.00
2004	35,000.00	3287.39	289,078.56
2005	35,416.67	3369.80	363,244.78
2006	44,412.00	3410.81	377,610.57
2007	63,750.00	3256.62	498,403.86
2008	70,062.50	3315.25	555,243.00
2009	76,167.00	3405.81	1,847,896.53
2010	79,375.00	3241.65	1,162,553.79
2011	80,000.00	3159.34	503,453.92

Table 3. GDP, income per capita, number of buildings and economic growth of Makassar City

Year	GDP (in million rupiahs)	Income per capita (Rp)	Number of buildings (unit)	Economic growth (%)
2001	3,621,006.70	13,657,321.80	272,125.00	7.30
2002	3,621,006.70	13,385,901.02	278,596.00	7.14
2003	8,882,254.69	36,262,833.46	253,153.00	8.60
2004	9,785,333.89	39,149,322.02	260,003.00	10.17
2005	10,492,540.67	36,051,885.20	297,398.00	7.16
2006	11,341,848.21	39,493,315.12	298,485.00	8.09
2007	12,261,538.92	42,130,081.50	297,283.00	8.11
2008	13,561,827.18	46,169,494.04	300,544.00	10.52
2009	14,798,187.68	49,930,789.07	303,372.00	9.20
2010	16,252,451.43	52,100,959.69	312,087.00	9.83
2011	17,820,000.00	57,673,075.87	316,030.00	9.65

Table 4. GDP, income per capita, number of buildings and economic growth of Gowa Regency

Year	GDP (in million rupiahs)	Income per capita (Rp)	Number of buildings (unit)	Economic growth (%)
2001	1,134,805.53	1,017,361.00	125,177.00	6.02
2002	1,180,965.05	1,041,973.00	126,797.00	4.60
2003	1,234,698.07	1,038,350.00	128,087.00	4.02
2004	1,294,783.37	2,000,000.00	133,371.00	4.87
2005	1,369,696.51	2,381,679.00	138,191.00	5.74
2006	1,453,592.57	2,480,241.00	142,903.00	6.17
2007	1,543,568.30	2,596,751.00	144,858.00	6.19
2008	1,650,323.75	2,723,864.00	145,757.00	6.92
2009	1,782,158.63	2,889,942.00	152,223.00	7.99
2010	1,890,032.59	2,897,361.00	158,203.00	6.05
2011	2,007,276.99	3,043,579.00	159,757.00	6.20

The demand of aggregate was modeled as:

$$Q_d = 11{,}523{,}838.83 + 19.535\ x_1 + 5981.368\ x_2 + 6.187\ x_3 + 1.348\ x_4 + 0.455\ x_5 - 0.476\ x_6$$
$$- 29.475\ x_7 - 110.561\ x_8 + 34{,}500.193\ x_9 - 250{,}471.053\ x_{10}$$

Where:

Q_d = quantity of material construction demanded (in metric cubic), annually

x_1 = price of aggregate

x_2 = total length of road in Gowa Regency and Makassar City

x_3 = GDP of Gowa Regency

x_4 = GDP of Makassar City

x_5 = income per capita of Gowa Regency

x_6 = income per capita of Makassar City

x_7 = number of buildings of Gowa Regency

x_8 = number of buildings of Makassar City

x_9 = economic growth of Gowa Regency

x_{10} = economic growth of Makassar City

The analysis confirmed that these factors were all correlated with aggregate supply and demand to some degree and had the expected positive or negative signs. The fit of supply model was good with correlation coefficient 0.836 (r) coefficient of determination (R^2) 0.698. The fit of demand model was very good because it had correlation coefficient (r) 1.000, coefficient of determination (R^2) 1.000. The values showed that there was strong relationship between dependent and independent variables. Therefore, the models were good predictors to estimate aggregate supply and demand (Table 5).

Table 5. Regression estimates of aggregate supply and demand

Year	Estimated supply (m^3)	Estimated demand (m^3)
2001	422,065.26	508,528.00
2002	671,831.54	602,709.00
2003	589,534.68	459,807.00
2004	400,906.71	289,078.56
2005	506,210.87	363,244.78
2006	619,596.95	377,610.57
2007	426,141.16	498,403.86
2008	991,386.02	555,243.00
2009	1,453,723.46	1,847,896.53
2010	1,048,929.60	1,162,553.79
2011	568,783.98	503,453.92

The results of the theoretical and estimated data from supply and demand models were plotted and shown in Figures (1) and (2), respectively.

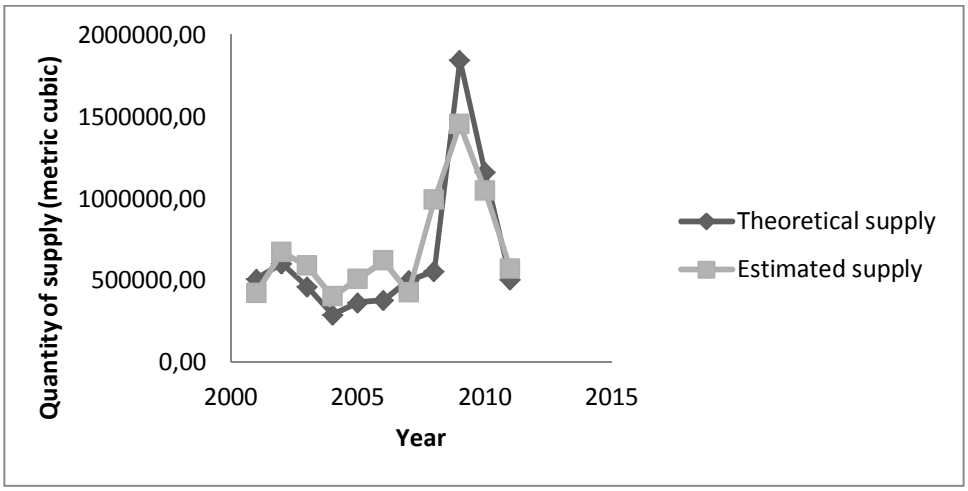

Fig. 1. Relationship between theoretical and estimated quantity of aggregate supply

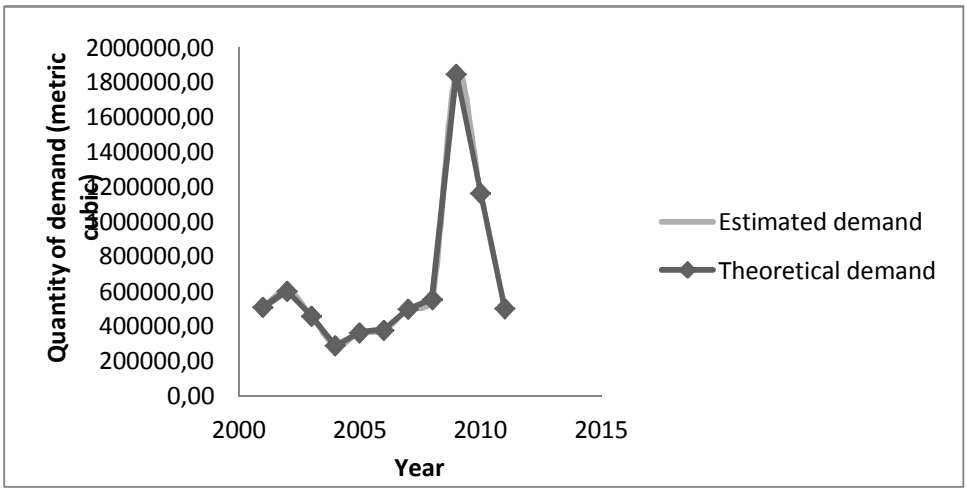

Fig. 2. Relationship between theoretical and estimated quantity of aggregate demand

4 CONCLUSION

It was established that aggregate supply and demand have been affected by number of factors ranging from price, number of trucks, number of mining companies, mining permit area, GDP, income per capita, length of road, number of buildings and economic growth. It was also established that the influencing factors can be effectively modeled using multiple linear regression approach and obtained a good relationship for supply and demand with their influencing factors.

It is recommended that the supply and demand of aggregate be monitored on a periodic basis (such as every year) to see how their trend, as well as to incorporate relevant updates of economic, population, and infrastructure growth.

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