Applying input-output model to estimate the broader economic benefits of Cipularang Tollroad Investment to Bandung District

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Abstract

This paper aims to estimate the potential economic benefits of an individual transportation project (Cipularang Tollroad) investment to the regional economy of Bandung district by using input-output analysis. The linkage between transportation investment and economic growth has been widely researched in the past 25 years. Most research confirm that the improvement of transportation performance through transportation investment can reduce logistic cost of the production sectors and thus reducing their marginal cost. Consequently, the increase of the output in the production sectors is expected to develop the regional economy. Compared to other Asian countries, logistics cost in Indonesia is much higher than that of other nations in the region. Reaching up to 25% of the Gross Domestic Product (GDP), this cost causes the production sectors to become inefficient and less competitive (LPEM- UI, year). The purpose of this study was to estimate the broader economic benefits of the new infrastructure investment of Cipularang Tollroad to Bandung region that region connected to the tollway. Specifically, this study mapped out the indirect benefits received by the production sector (key sectors) in relation to the associated decrease of freight transportation costs. This study found that industrial served as the key sectors in Bandung district region. Using the regional input-output simulation model, the regional GDP increases 1% after the operation of Cipularang Tollroad. This increase was estimated due to reduce of inter-regional freight transportation costs. This study has implications for the stakeholders involved in the development of Indonesian transportation infrastructure, by highlighting the broader economic benefits received by the regions (especially key sector) in which the transportation project investment occurs.

Keywords: Infrastructure investment; production sector; economic growth.

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1. Introduction

Transportation is an activity that is derived demand, where the need for transportation cannot be separated from the development of the region, activity patterns, population and economic growth. New investment of road infrastructure will provide potential economic benefits to a region, and improvement of the road infrastructure performance is believed to be one way to increase the economic growth of that region. Road infrastructure improvements such as additional road capacity will reduce travel time and transportation cost, which has a major impact on improving productivity, distribution of goods and competition in the production sector. Therefore, transportation sector cannot be separated from the regional economy. At its most basic level, transportation must be able to provide benefits by providing access to people and serving as a logistic function (Taking Raw Materials; manufacture to consumer).

The macroeconomic models argue that there are externalities to investments in infrastructure which are not captured in microeconomic studies. The utility of such a result is open to question in view of two serious drawbacks of this macroeconomic modeling stream: first, the sharp differences and conflicts among these models on the magnitudes and direction of economic impacts of infrastructure, and second, these macroeconomic models offer little clue to the mechanisms linking transport improvements and the broader economy (T.R. Lakshmanan, 2008).

In order to estimate the total economic implications of road infrastructure investment, the estimates of the microeconomics analysis, the project effects in direct user or toll revenue compare to total cost of project, however, do not represent a full economic analysis. Changes in costs and productivity affecting an industry at the project level have broader economic repercussions for the locality or region (Glen W., 1998).

From a regional economic point of view, the benefits of transportation infrastructure investment, are: opening a production area, creating a new market, opening up an isolated area and connecting it to the nearest city. Yet, the benefits might not necessarily be the same for each region, whether it is a city or a newly developed area; a developed country or developing country.

The economic benefits of the investment of Cipularang tollroad will give a significant impact on production sector especially the transportation sector for the province of West Java or region connected with the toll road, and microanalysis results in the feasibility study of Cipularang tollroad indicates that it is financially viable.

This research aims to: (1) estimate the broader economic benefits of new tollroad infrastructure investments (Cipularang toll road) to the production sector of Bandung District that region connected to Cipularang tollroad, especially in terms of cost reduction of freight transportation, and (2) assess the influence of these key sectors on other economic sectors in the Bandung district, where the value of the investment is not suitable to be included as part of the value invested by Bandung region and that’s not captured microeconomic analysis.

2. Literature Review

2.1. Linkage between Transport Infrastructure Investments towards Economic Growth

Economic income (GDP) is one of the factors that drive the economic growth of a region. Besides, the economic development of an area will also be reflected in infrastructure performance. In turn, good infrastructure will support economic activity in the region. More specifically, the increase in transportation infrastructure will affect economic sectors, with the assumption that this increase would serve to encourage the production sector activity, and also can be a stimulus for economic growth in a region or as a fulfilment the demand of the region's economic growth itself (infrastructure may follow growth as well).

There are several aspects of the productivity of economic sectors that could be affected by transportation infrastructure investment. Overall, productivity can be defined as the ratio of output per unit from input number of factors (including labour, capital, and technology). Productivity level can be affected by many factors, such as the levels of capital, the amount of labour, technology, and quality of supporting infrastructure.

The debate on the contribution of transportation in improving the region's economic growth is not new. Economists have done many research in this regard, where the focus of research in general is to assess the benefits derived from a value of investment in transportation to the economy of an area within a certain time frame. Auscher (1988) for example conducted a study on the influence of capital and government spending on the public sector
towards the level of productivity. This study found that the decline in the growth rate of investment in the public sector during the period of the 1970s and 1980s in the United States of America was a major factor in the decline in the productivity of the private sector.

The description above explains that economic growth is the process of increasing the output of the production capacity of an area that continues over time. The success of the economic development of an area measured by the level of the economic growth achieved. In conventional macroeconomic growth is calculated based on the percentage improvement of the GDP for the regional or national level.

Table 1. Impact of Transportation Infrastructure Investment on Economic Growth.

| Study / Year | Type of Model       | Location                  | Effect of transportation investment                                    | Elasticity |
|--------------|---------------------|----------------------------|-------------------------------------------------------------------------|------------|
| Auscher 1991| Production Growth Model | United state              | Total transport capital effect on growth                               | 0.166      |
|             |                     |                            | Transit capital effect on growth                                       | 0.384      |
|             |                     |                            | highway capital effect on growth                                       | 0.231      |
| Seitz 1993  | Leontif Cost Function | Germany (highway data)    | Change in average private cost                                         | 0.05       |
| Garcia-Mila and McGuire 1992 | Production Function | United state (48 contiguous data) | Elasticity of GSP with respect to highway capital                      | 0.04       |
| Munnel 1990 | Production Function | United state (48 contiguous data) | Elasticity of GSP with respect to highway capital                      | 0.06       |
| McGuire 1992 | Production Function | United state (48 contiguous data) | Elasticity of output with respect to highway capital                  | 0.121-0.37 |
| Deno 1988   | Profit function model | United state              | Elasticity of output with respect to highway capital                   | 0.31       |
| Haughwout 1996 | Equilibrium model | United state              | Elasticity of output with respect to highway capital                   | 0.08       |

Table 1 shows several results of macroeconomic studies in estimating the effects on productivity of public capital in general, and of transportation infrastructure in particular. In order to understand this disparate results, the mechanisms that generate the economic impacts need to be uncovered (especially in an individual project). Transport infrastructure investment must be identified relations with the economic growth, which it will be able to open production areas, creating new markets and open up an isolated area and connect it to the nearest area/region.

The common approach in analyzing the economic benefits in transportation infrastructure investment (an individual project) is done micro-economically. Commonly, the scope of microeconomic analysis is limited to the individual projects reviewed and exclude the infrastructure investments of the production sector/economy of a region. Some believe this approach to be less objective; therefore it is necessary to develop another model that can analyze the benefits of transportation investment to the economic growth of a region.

To understand the relevance of the measurement of infrastructure to the production sector, the study focus its analysis on: (1) how an investment in an individual road infrastructure project can increase the output of each of the key sectors of the region connected with the road infrastructure, and (2) how much reduction of the cost of transporting goods towards the marginal cost of the production sector. The increase in the production sector will affect other production sectors, which in this study will be analyzed using Input-Output Analysis method.

From the diagram below show that the effect of road transport will provide accessibility for the region so that the current movement of people and goods will be more smoothly and reduce the transportation cost, it should be a stimulus for the economy of the region to develop.
2.2 Review of Input - Output Analysis on Transportation Infrastructure Investment

The I-O model could be a good research methodology to explore the influence of the transportation industry on the other sectors. However, there have been few studies that use the I-O model directly for analyzing the transportation industry. The use of input-output table serves as a basis for planning and macro-economic analysis, especially with regard to the production sector, the analysis of impacts, and the connections between sectors and economic projections (GDP).

Input-Output (I-O) Table is a statistical description that describes the transaction between the production sectors as a whole in a given year (shows the connection between sectors). Presentation of the Input-Output tables is in the form of a matrix, where each row shows how the output of a sector achieving the intermediate demand and final demand, including inter-industry linkage effect analysis, the demand-driven model, the supply-driven model, and the Leontief price model, to investigate.

The role of marine sector in the. To get a brief picture of how an I-O tables are arranged, the example presented in Table 2. And for the examples, it will describe how the I-O table for the economic system which consists of three production sectors.

Table 2. Input – Output Table (3 Production Sector).

| Input Structure | Output Allocation | Intermediate demand | Final Demand | Total Output |
|-----------------|-------------------|---------------------|--------------|--------------|
| Primary Input   | V₁, V₂, V₃        |                     |              |              |
| Intermediate    |                   |                     |              |              |
| Input           |                   |                     |              |              |
| Production's    |                   |                     |              |              |
| Sector          |                   |                     |              |              |
| 1               | X₁₁, X₁₂, X₁₃     |                     | F₁           | X₁           |
| 2               | X₂₁, X₂₂, X₂₃     |                     | F₂           | X₂           |
| 3               | X₃₁, X₃₂, X₃₃     |                     | F₃           | X₃           |

From table 2, it can be seen that the I-O tables consists of 3 quadrants, each associated with intermediate demand, final demand, and primary inputs. Then, the supply and demand equation in sectors above can be used in the form of notation:

\[ \sum_{j=1}^{n} x_{ij} + F_i = X_i - M_i \]  (1)
where:
\[ x_{ij} = \text{the amount of output in sector } i \text{ used as input in sector } j \]
\[ F_i = \text{Final demand towards output sector } i \]
\[ X_i = \text{total output of sector } i \]
\[ M_i = \text{total output imported} \]

and for the total input of a sector can be formed equation;

\[
\sum_{j=1}^{n} x_{ij} + V_j = X_j
\]  

(2)

where:
\[ x_{ij} = \text{the amount of output in sector } i \text{ used as input in sector } j \]
\[ V_j = \text{primary input (adding value) in sector } j \]
\[ X_j = \text{total input of sector } j \]

The use of input-output table serves as a basis for planning and macroeconomic analysis, especially with regard to the production sector, the analysis of impacts, and the connections between sectors and economic projections (GDP). However, there is a slight difference between this study and other studies that use traditional I-O analysis.

Due to the provision of new transport infrastructure investment (Cipularang Tollroad), is assumed to reduce the marginal cost of Production sector or the key sector. This reduction is assumed as a reduced the marginal cost or an additional profit surplus of the key sectors.

I-O models can be used as a tool to help the decisions maker in planning of a region development. In the I-O models, it is figured which sector is becoming a key sector in the economic structure of the region. A sector can be said to be a key sector is a sector that is spread in various economic activities so as to move the production sector as a whole. Beside that this model can be used to see what sectors are biased into key sectors in a region. These sectors can be identified with the event (Daryanto, Arif and Yundy H, 2013):
1. Backward linkages and forward linkages are relatively high (>1)
2. High Level of the sector’s output
3. Demand driven relatively high
4. Creating jobs is high

3. Research Methodology

3.1. General Framework

The framework of this research is the development of a model that can estimate the broader economic benefits of an individual road infrastructure investment to the production sector in terms of reduction of freight transportation cost (distribution cost). There is a connection between road infrastructure investments (individual project) that provides the benefits of a reduction of the cost of transportation of goods that can have a positive impact on the production sector. Macro-economically this will increase the region's economic performance.

The research methodology is structured as a series of flow chart that shows the relationship between road infrastructure investment on the production sector, as well as the added value generated as a result of economic improvement in the measured region Gross Domestic Product (GDP). Illustration of the work frame of the research can be seen in the Figure 3 below.

To figure out about the key sectors of the economy, the region should measure backward linkage (demand-driven) for boosting other sector and forwards linkage (supply-driven) for supporting others. The backward linkage effect is represented as the power of dispersion (POD), which is the average of n elements in column j divided by the average of all n2 elements in the Leontief inverse matrix. Similarly, the forward linkage effect is expressed as the
sensitivity of dispersion (SOD), which is the average of n elements in row i divided by the average of all n^2 elements in the Leontief inverse matrix.

\[
BL_i = \frac{\sum_{j=1}^{n} X_{ij}}{X_i} = \sum_{j=1}^{n} a_{ij} \\
FL_i = \frac{\sum_{j=1}^{n} X_{ij}}{X_i} = \sum_{j=1}^{n} b_{ij}
\]

Where:
BL = backward linkage
FL = forward linkage
Xij = the amount of output in sector i used to sector j
Xi = total output in sector i
aij = coeff matrix
bij = coeff matrix

4. Result

Cipularang Tollway is an extended towards the outer ring road of Cikampek, Jakarta, and an alternative short road from Jakarta to Bandung and vice versa. Cipularang Toll construction along 58 km has cost + 1.6 trillion rupiahs. The operation if the toll that connects Jakarta – Bandung makes a short latency time thus increasing significantly the number of trips to and from Bandung Region.

As the area which connected to Cipularang Tollway, each of the production sector in Bandung’s district regional economy will have an input-output structure difference. The following Table 3 shows the structure of the IO Bandung on the price buyers in 2008, with 9 sector classification.

From the table below, it is seen that the Bandung District has the industry’s sector was the biggest share to GDP. The Industry sector needs 9.7% of the total output to freight transportation cost (Ratio of the transportation sector and margin in industry sector).
Table 3. Bandung District’s I-O table based on Buyer’s Price in 2008 (million rupiah).

| SEKTOR                      | 1  | 2  | 3   | 4  | 5  | 6   | 7 | 8   | 9 | 180         | TOTAL DEMAND | OUTPUT |
|-----------------------------|----|----|-----|----|----|-----|----|-----|---|--------------|-------------|--------|
| 1 Agriculture, Forestry & Fishery | 749,439.0 | 1.0 | 7,490,002.0 | -  | - | 298,978.0 | - | - | 189,859.0 | 8,728,279.0 | 6,453,112 | 4,423,160 |
| 2 Mining                    | 182,233.0 | 41.857.0 | 691,856.0 | 524,529.0 | 54,822.0 | - | - | 1,980.0 | 1,497,277.0 | 335,725 | 476,258 |
| 3 Processing Industry       | 527,371.0 | 2,985.0 | 23,201,551.0 | 274,868.0 | 817,278.0 | 642,597.0 | 589,719.0 | 45,441.0 | 279,162.0 | 26,380,972.0 | 50,706,776 | 56,337,192 |
| 4 Electricity, Gas & Water | 144,083.0 | 654.0 | 2,783,794.0 | 241,133.0 | 24,571.0 | 6,716.0 | 30,921.0 | 3,399,716.0 | 875,973 | 1,605,653 |
| 5 Construction              | 7,058.0 | 2,110.0 | 75,629.0 | 96.0 | 706.0 | 8,009.0 | 134,151.0 | 85,350.0 | 314,479.0 | 2,163,727 | 1,832,043 |
| 6 Trade                     | 904.0 | 0.0 | 100,783.0 | 662.0 | 18,867.0 | 25,201.0 | 4,707.0 | 66,558.0 | 344,944.0 | 1,698,468 | 7,260,119 |
| 7 Transportation & Communication | 134,386.0 | 1,627.0 | 470,899.0 | 21,952.0 | 14,615.0 | 37,972.0 | 74,466.0 | 1,498,240.0 | 1,711,258 | 2,834,015 |
| 8 Finance, rental & services company | 122,372.0 | 7,789.0 | 11,793.0 | 11,215.0 | 30,499.0 | 11,001.0 | 181,606.0 | 88,098.0 | 2,303,644.0 | 508,889 | 1,206,081 |
| 9 Services                  | 89,982.0 | 42.0 | 191,232.0 | 17,348.0 | 244,571.0 | 73,918.0 | 9,968.0 | 827,201.0 | 4,753,786 | 2,640,060 |

Source: BPS Bandung District

4.1. Industry’s sector Linkage Analysis

Analysis of the leading sectors (key sectors) performed after the obtained analytical linkages between sectors using the input-output analysis. Total impact of changes in final demand for a sector of the economy-wide output is further used to determine how far the level of linkages between sectors of production, can be seen from two sides, namely backward linkages and forward linkages.

Table 4. Forward Linkage, Backward Linkage, and Share to GDP of Bandung District’s Input Output.

| SECTOR                                      | Backward linkage | Forward Linkage | Share to GDP (%) |
|---------------------------------------------|-----------------|-----------------|------------------|
| 1 Agriculture, forestry & fishery           | 0.92            | 1.22            | 5.63             |
| 2 Mining                                    | 0.52            | 0.84            | 0.61             |
| 3 Processing Industry                       | 1.19            | 2.38            | 71.66            |
| 4 Electricity, Gas & water                  | 0.93            | 0.85            | 2.04             |
| 5 Construction                              | 0.73            | 0.61            | 2.33             |
| 6 Trade                                     | 2.01            | 0.59            | 9.24             |
| 7 Transportation & communication            | 0.94            | 0.79            | 3.60             |
| 8 Finance, rental & services company        | 0.73            | 0.99            | 1.53             |
| 9 Services                                  | 1.04            | 0.72            | 3.36             |

Based on table above, it can be seen that the key sector of Bandung district is the industrial sector with a forward linkage value 2.38 and backward linkage value 1.19 and share to GDP 71.66 %. As indicated in Table 4, the forward linkage and backward linkage effects of the processing industry sector are higher than those of other sectors, and be the key sector of Bandung District’s production sectors.
4.2. Broader Economic Impact by Reduce Freight Transportation of Industry’s sector

It can simply be formulated that industrial sector output multiplier is the total value of production output due to a change of 1 unit of final demand from the industrial sector due to a reduction in freight transport costs.

The results will describe how the effects of an exogenous change (in this study reduced freight transportation costs) to the industrial sector output and other production sectors. The results will describe how the effects of an exogenous change (in this study reduced freight transportation costs) to the industrial sector output (as direct impact) and other production sectors (as indirect impact). Before the analysis, it is necessary to make the technology coefficient, this coefficient is calculated as follows:

\[ a_{ij} = \frac{z_{ij}}{x_j} \]  

(5)

Where:

- \( a_{ij} \) = input-output coefficient
- \( z_{ij} \) = intermediate demand for sector j from sector i
- \( x_j \) = Total input sector j

If there are n sectors in the production sector, then there will be \( n^2 \) coefficients. All coefficients can be expressed in a matrix (matrix A), in the form of:

\[
A = \begin{bmatrix}
    a_{11} & \cdots & a_{1n} \\
    \vdots & \ddots & \vdots \\
    a_{n1} & \cdots & a_{nn}
\end{bmatrix}
\]  

(6)

An additional output from the production sector means that require additional input from itself, and from other production sectors. Additional input from each production sector will create a new additional output for all sectors. An analysis of the total output can be calculated as follows with round-by-round effect analysis (Nazara, Suahasil, 2005).

Direct effect

\[ \Delta Y_1 = \begin{bmatrix}
    x_1 \\
    x_2
\end{bmatrix} \]

Indirect effect

\[
\begin{bmatrix}
    a_{11} & a_{1n} \\
    a_{n1} & a_{nn}
\end{bmatrix}
\begin{bmatrix}
    x_1 \\
    x_2
\end{bmatrix} =
\begin{bmatrix}
    x_3 \\
    x_4
\end{bmatrix}
\]

\[ \Delta Y_2 = \begin{bmatrix}
    x_3 \\
    x_4
\end{bmatrix} \]

\[
\begin{bmatrix}
    a_{11} & a_{1n} \\
    a_{n1} & a_{nn}
\end{bmatrix}
\begin{bmatrix}
    x_3 \\
    x_4
\end{bmatrix} =
\begin{bmatrix}
    x_5 \\
    x_6
\end{bmatrix}
\]

\[ \Delta Y_n = \begin{bmatrix}
    x_n \\
    x_{n+1}
\end{bmatrix} \]

Total output sector 1 = \( x_1 + x_2 + \ldots + x_n \)

Total output sector 2 = \( x_2 + x_4 + \ldots + x_{n+1} \)

Reduction of freight transportation cost due to the operation of Cipularang tollroad, assumed 10% of the existing transportation costs. Due to changes in the total demand, the total output of Bandung (GDP) overall increase of Rp. 76,975 million (7x iteration change in output) which is around 1% elasticity from the existing total Bandung District’s total output.
Direct changes felt by the industrial sector output is as big as the value of goods transportation cost savings which is Rp. 54.479 million. On the other hand, indirect changes by another production sector is Rp. 22.497 million.

5. Conclusion

Based on Bandung district’s Input Output table, the total primary input of Bandung’s region is the Industrial sector (+71.66 % of the total GDP of Bandung district). This reflects that these sectors provide the largest share of the total economy of the Bandung District’s region.

Based on the results in the linkage analysis, the industrial sector has the largest forward linkage value and with largest shares on GDP of Bandung district. Therefore, the industrial sector becomes the key sector of the economic system in Bandung. However, in the analysis of the economic potential that can be gained from the construction of Cipularang tollroad, it is more appropriate, for the industrial sectors to have the greatest impact compared to other sectors (based on the reduction of transportation cost) related to the movement of goods between cities/region. Therefore, it is the industrial sector that simulates the final demand changes (total output) which is 10% of the total reduction in cost of transporting goods.

The results towards the output changes performed based on the direct impact received by the industrial sector and the indirect impact received by another production sector in Bandung is ± 1% of the GDP total.

For further research, there should be an analysis of the percentage of freight from the total cost of production (marginal cost). It is also necessary to collect relevant data on how large the output of industry sectors that use the toll road infrastructure is.

This study has implications for the stakeholders involved in the development of Indonesian transportation infrastructure, by highlighting the broader economic benefits received by the regions (especially key sector) in which the transportation project investment occurs.

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