Constructing Input-Output (I-O) models from less than perfect datasets: an economic impact analysis of garage construction project in Gresik, East Java Province, Indonesia

A Irawan¹ and P R Satiawan¹

¹ Urban and Regional Planning Department, Institut Teknologi Sepuluh Nopember

Email: hicakandi@gmail.com

Abstract. This paper demonstrates techniques to construct input-output (I-O) models to perform impact analysis under a situation of data limitation. Of policy makers’ main interests regarding project proposals is to have some idea on the economic impact of the projects. I-O based model is an useful analytical tool to do impact analysis. However, the I-O table from which the analysis is based on is often not available for the region of interest, in this case, Gresik, a municipal in East Java. This paper shows how to derive the I-O table for Gresik out of the East Java’s I-O table with four approaches, namely: 1) location quotient (LQ); 2) cross-industry location quotient (CIQ); 3) Flegg location quotient (FLQ); and 4) augmented Flegg location quotient (AFLQ). We suggest that these approaches are suitable for a situation facing time and cost constraints, which is a typical one in city/municipal-level policy domain.

Keywords: input-output, impact analysis, transportation garage

1. Introduction
In real public policy setting, a situation where impact analysis is urgently needed under imperfect information is not uncommon. Neither an action of doing nothing nor an attitude unrealistically expecting all information would be perfectly available is wise. There are indeed methods to deal with imperfect information can be utilized [1]. In the case of impact analysis based on I-O modeling framework, this paper aims at showing that we could still conduct impact analysis in the absence of the study region’s I-O table by deriving the I-O table for the study region from the I-O table of the supra region where the study region is part of.

This paper uses a real case study where the municipal government of Gresik needs to assess the economy-wide impact of a construction of large garage for road transportation fleet. However, the Indonesian statistical agency (Badan Pusat Statistik, BPS) only makes the I-O table available at national and provincial level. It is not made available at city or municipal level. Therefore, there is no such thing as the I-O table of Gresik. This situation of imperfect data poses a challenge to the policy need. The main contribution of this paper is to provide a methodological solution to overcome the challenge.

The main approach for the impact analysis in this paper is based on the I-O framework. The main information in the I-O modeling is the I-O table which is a comprehensive measure to give an aggregate (macro) economic picture of a region in a given year in aggregate. Based on the data
contained in the I-O table, we can carry out various economic analyzes that are useful as a basis in the development planning process.

The analysis produced by I-O modeling is practical and quantitative. Descriptive analysis of table I-O provides a general overview of the economy of a region that is the focus of the study. Descriptive analysis can show the role of goods and services of domestic and imported production in fulfilling domestic and foreign demand, describing the role of each sector in the economy and the linkages between sectors (backward-forward linkages), and identifying leading sectors. In addition to descriptive analysis, another type of analysis that can be derived from table I-O is impact analysis. Impact analysis calculates the effect of a final change in demand on the output of the economy. Changes in final demand occur because of a shock in the economy. Surprises can be positive (for example: bridge construction projects, factories, and various other infrastructure) or negative (e.g. natural disasters, factory closures, or divestments). Impact analysis is used in this study and is the main focus in this section.

Impact analysis firstly requires the calculation of multiplier coefficient. The transportation and warehousing sector (which the fleet garage project belongs to) has a positive multiplier coefficient and is greater than one (1). This means that every Rp. 1 planted will have an impact greater than Rp. 1 for the economy as a whole. Based on the various methods used, the range of the output and multiplier of the transportation and warehousing sector is 1.11 - 1.33. Investment injection for the construction of a truck garage valued at around Rp. 23.55 billion will produce an additional output of Rp. 31.98 to Rp. 45.51 billion for the economy of Gresik Regency.

In succession, after the introduction section, this section will display the basic concept sections of the I-O model, the construction of the Gresik I-O table, the results section, and the conclusion section.

2. Basic concepts of the I-O model
The structure of the I-O table is briefly explained in figure 1 below. This figure is taken from Blair and Miller [2].

| Interindustry Sales (Z) | Sales to Final Demand (f) | Total Sales (x) |
|------------------------|--------------------------|----------------|
| z_{11} z_{12} ... z_{1n} | c_{11} c_{12} ... c_{1n} | x_1 |
| z_{21} z_{22} ... z_{2n} | c_{21} c_{22} ... c_{2n} | x_2 |
| ... | ... | ... |
| z_{n1} z_{n2} ... z_{nn} | c_{n1} c_{n2} ... c_{nn} | x_n |

| Value Added |
|-------------|
| \( v_1 \) | \( v_2 \) | ... | \( v_n \) |

| Imports |
|---------|
| \( m_1 \) | \( m_2 \) | ... | \( m_n \) |

| Total Outlays (x) |
|------------------|
| \( x_1 \) | \( x_2 \) | ... | \( x_n \) |

| Transactions between the payments sectors (including imports) and final demand |
|---------------------------|
| L | OV |
| M |

**Figure 1.** I-O table structure.

Basically, I-O tables are a combination of several matrices. The main matrix in the I-O table is the Z matrix (top left corner) which records transactions between sectors. From the Z matrix, we can produce an Matrix A or commonly referred to as the technology coefficient matrix. Matrix A is also commonly referred to as the ‘production recipe’ matrix because it shows the composition of the use of inputs in the production of a sector. Each element in matrix A, namely \( a_{ij} \), shows how much (in monetary value, for example in rupiah) the sector buys input from sector \( i \) for each monetary unit of
output produced by sector \( j \). So, the matrix A element gives a kind of recipe, how much input from sector \( i \) is needed for each monetary unit of sector output \( j \).

This Matrix A is needed to calculate matrix multipliers or also commonly referred to as Leontief Inverse or B matrix. Mathematically, the Matrix B is formulated as follows: \((I - A)^{-1}\), where matrix \( I \) is the identity matrix, that is a symmetrical matrix where the diagonal element is one (1) and the other element is zero (0). This Matrix B is very important in impact analysis, which is to see changes in output in the economy, \( \Delta X \), if there is a change in the final demand, \( \Delta f \), due to an economic shock. The impact calculation formula is as follows:

\[
\Delta X = (I - A)^{-1} \Delta f
\]

The change in the final request is Rp 23.55 billion, which is worth the investment in the construction of a truck garage, in the transportation and warehousing sector, assuming other sectors have not experienced a change in final demand. So changes in output in the economy will depend on the matrix A.

As will be explained in the next section, I-O tables are derived or constructed from East Java I-O tables through four different ways and two parameters of the location quotient (LQ). So we will get several types of matrix A. The difference in this method, besides functioning as a robustness check model, will also provide a range of estimated impacts, not just one estimated impact. This is useful for decision making because we minimize the situation of over/under estimation.

3. Construction of table I-O Gresik

Table I-O of Gresik Regency is not available. Due to time and cost constraints, construction of survey-based I-O tables for Gresik is not possible. Following Flegg, Webber, and Elliot \[3,4,5\], therefore the construction of the Gresik I-O table must be done with a non-survey approach, which is derived from the East Java I-O table through four methods, namely: 1) location quotient (LQ); 2) cross-industry location quotient (CIQ); 3) Flegg location quotient (FLQ); and 4) augmented Flegg location quotient (AFLQ). Following are the stages of construction of the Gresik I-O table:

1. Reclassification of sectors in the East Java I-O table and Gresik Gross Regional Domestic Product (GRDP).
2. Calculating LQ) output of Gresik's economic sectors relative to the same sectors in East Java's economy.
3. Calculating matrix A for Gresik based on the four methods above.

3.1 Sector Reclassification

The East Java I-O Table in 2015 consisted of 110 x 110 sectors, while the Gresik GRDP in 2015 consisted of 46 sectors which could be integrated into 17 sectors. Therefore, both data must be reclassified so that they have the same number and sector nomenclature. This process is called crosswalk. Figure 2 below describes the process briefly. Table 1 shows the crosswalk sector results.

![Figure 2. Crosswalk between two data](image-url)
Table 1. 17 sectors crosswalk result

| Code | Sectors                                                                 |
|------|-------------------------------------------------------------------------|
| 1    | Agriculture, Forestry and Fisheries                                    |
| 2    | Mining and Excavation                                                  |
| 3    | Processing industry                                                    |
| 4    | Procurement of Electricity and Gas                                     |
| 5    | Procurement of Water, Waste Management, Waste and Recycling            |
| 6    | Construction                                                           |
| 7    | Large and Retail Trade; Car and Motorcycle Repair                       |
| 8    | Transportation and Warehousing                                          |
| 9    | Provision of Accommodation, Food and Beverage                          |
| 10   | Information and Communication                                          |
| 11   | Financial and Insurance Services                                       |
| 12   | Real Estate                                                            |
| 13   | Company Services                                                       |
| 14   | Government Administration, Defense and Mandatory Social Security       |
| 15   | Education Service                                                      |
| 16   | Health Service and Social Activity                                     |
| 17   | Other Services                                                         |

3.2. LQ calculation

LQ is basically the ratio between the proportion of a sector in the total economy of a region and the proportion of a sector that is the same in the total economy of a larger region where the first region is part of it. LQ is a measure to see the similarity of the economic structure of a region with a supra-region that surrounds it. In this case study, the area of concern is Gresik and the supra-region, East Java. LQ is calculated based on the following formula:

\[
LQ_{i,Gresik} = \frac{\sum_{i=1}^{17} s_i,Gresik}{\sum_{i=1}^{17} s_i,East Java}
\]  

(2)

The sector output for Gresik is taken from Gresik GRDP based on the 2015 sector, 17 sectors. While the output of the East Java sector is taken from the East Java 2015 I-O table, 17 x 17 sectors.

There are two values that will be used as denominators in the use of formula (2) above. First, the sector value is based on the total vector matrix as shown in figure 1 of the structure of the I-O table above. Second, sector value is based on intermediate demand. In figure 1 above, the temporary request vector matrix is not explicitly displayed. Temporary demand vector matrix elements can be easily calculated, i.e. summing of cross column lines per line (sector per sector) in matrix Z. In the end, we will get two groups of LQ parameter values.

3.3 Calculating matrix A Gresik

The Matrix A Gresik is derived from matrix A in the East Java I-O table through the four methods above (LQ, CIQ, FLQ, AFLQ) and two groups of LQ parameter values. This process is illustrated in figure 3 below.
The derivation through the LQ method is to use the value of \( LQ_{i,Gresik} \) obtained from formula (2) and further adjustments are made as follows:

\[
a_{i,j}^{Gresik} = \begin{cases} 
    a_{i,j}^{East \, Java} & \text{if } LQ_{i,Gresik} \geq 1 \ (\text{for } j = 1, 2, \ldots, n) \\
    (LQ_{i,Gresik})a_{i,j}^{East \, Java} & \text{if } LQ_{i,Gresik} < 1 \ (\text{for } j = 1, 2, \ldots, n)
\end{cases}
\]  

(3)

The derivation through the CIQ method requires first cross-industry LQ calculations, where:

\[
CIQ_{ij}^{Gresik} = \frac{LQ_{i,Gresik}}{LQ_{j,Gresik}}, i \neq j
\]  

(4)

and adjusting matrix A elements is done in the following way:

\[
a_{i,j}^{Gresik} = \begin{cases} 
    a_{i,j}^{East \, Java} & \text{if } CIQ_{ij}^{Gresik} \geq 1 \\
    (CIQ_{ij}^{Gresik})a_{i,j}^{East \, Java} & \text{if } CIQ_{ij}^{Gresik} < 1
\end{cases}
\]  

(5)

The derivation through the FFQ method based on the following criteria:

\[
a_{i,j}^{Gresik} = \begin{cases} 
    a_{i,j}^{East \, Java} & \text{if } FLQ_{ij}^{Gresik} \geq 1 \\
    (FLQ_{ij}^{Gresik})a_{i,j}^{East \, Java} & \text{if } FLQ_{ij}^{Gresik} < 1
\end{cases}
\]  

(6)

Where

\[
FLQ_{ij}^{Gresik} = (\lambda)CIQ_{ij}^{Gresik}, \lambda = \{log_2[1 + \left(\frac{\text{worker}_{Gresik}}{\text{worker}_{East \, Java}}\right)]\}^\delta
\]  

(7)

and \( 0 < \delta < 1 \) in empirical studies, commonly used \( \delta = 0.3 \)

Finally, the augmentation in AFLQ is as follows

\[
AFLQ_{ij}^{Gresik} = \begin{cases} 
    \left[log_2(1 + LQ_{i,Gresik})\right]FLQ_{ij}^{Gresik} & \text{if } LQ_{i,Gresik} > 1 \\
    FLQ_{ij}^{Gresik} & \text{if } LQ_{i,Gresik} \leq 1
\end{cases}
\]  

(8)

So that,
\[ a_{Gresik}^{\text{Gresik}} = \begin{cases} \alpha_{i,j}^{\text{East Java}} & \text{if } LQ_{i,Gresik} > 1 \\ \alpha_{i,j}^{\text{East Java}} & \text{if } LQ_{i,Gresik} \leq 1 \end{cases} \] (9)

4. Result

The results of the calculation of multiplier coefficients and changes in economic output due to investment injections in the construction of a truck garage worth Rp. 23.55 billion is shown in table 2 and table 3.

Table 2. Transportation and warehousing, multipliers

| Methods | Parameter | LQ1 | LQ2 |
|---------|-----------|-----|-----|
| LQ      | 1.31      | 1.33|
| CIQ     | 1.23      | 1.34|
| FLQ     | 1.11      | 1.11|
| AFLQ    | 1.16      | 1.12|

Table 3. Transportation and warehousing, impact (Rp. Billion)

| Methods | Parameter | LQ1  | LQ2  |
|---------|-----------|------|------|
| LQ      | 39.28     | 40.15|
| CIQ     | 43.33     | 45.51|
| FLQ     | 33.33     | 31.98|
| AFLQ    | 34.64     | 32.95|

Table 2 shows that the range of the output and multiplier of the transportation and warehousing sector is 1.11 - 1.33. The implication is that the investment injection for the construction of a truck garage worth around Rp. 23.55 billion will produce an additional output of Rp. 31.98 to Rp. 45.51 billion for the economy of Gresik Regency (see table 3).

As a percentage, the additional output is less than 1%, in the range (0.032% to 0.045%). The construction of this truck garage should also increase the regional revenue (PAD) of Gresik. If the change in regional income (PAD) of Gresik changes with the same growth rate as the output growth rate above, then PAD Gresik will increase in the range of Rp. 0.25 billion - Rp. 0.36 billion. Table 4 below lists the PES Gresik (delta) scenarios with the 2015 PAD Gresik baseline realization of around Rp. 799.78 billion.

Table 4: Transportation and warehousing, Additional Regional Original Income (Rp. Billion)

| Methods | Parameter | LQ1 | LQ2 |
|---------|-----------|-----|-----|
| LQ      | 0.312     | 0.319|
| CIQ     | 0.344     | 0.361|
| FLQ     | 0.265     | 0.254|
| AFLQ    | 0.275     | 0.262|

Conceptually, the impact of changes in output and PAD will occur in the same year as the project implementation or one (1) year ahead, assuming the project can be completed in a short time. This modeling is based on 2015 data. If the economic structure of Gresik and East Java in 2018 does not
change drastically, this modeling can still be used to estimate the impact of changes in output and PAD due to the construction of a garage truck.

5. Conclusion
Impact analysis based on the I-O model is practical and quantitative, because it is able to calculate the effect of a change in final demand on economic output. I-O modeling provides various methods for analyzing in less than perfect data. These methods allow us to construct an I-O table for a region as a derivative of a larger region of I-O tables that shelter it. This procedure is very useful in situations of limited resources, especially time and financial resources.

This concise study applies the above procedure to analyze the impact of the construction of a truck garage on the overall economy of Gresik. Impact analysis through various methods gives its own advantages, namely we will get a range of estimated values, not just one estimated value. As shown in the previous section, the construction of truck garages has a positive and greater multiplier effect on the transportation and warehousing sector. In the end, the construction of a truck garage worth Rp.23.55 billion will increase Gresik's economic output of Rp. 31.98 to Rp. 45.51 billion; and adding PAD of Rp. 0.25 billion - Rp. 0.36 billion.

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