Structural Problem on the Indonesian Interregional Input-Output (IRIO) Table

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Abstract

Reliability and validity of the Interregional Input-Output (IRIO) table is important to extract a correct intersectoral linkage across space. However, we find that the Indonesian IRIO table has a fundamental structural problem, and it affects the validity of the analysis derived from the table. We prove this problem by reversing the process of generating the matrices in the IRIO table structure. We call this process as a structural check process. We use Indonesian IRIO table of 52 subsectors from the Indonesian Central Bureau of Statistics (BPS). We find that the output and final demand vectors from our structural check process are not the same as the original output and final demand vectors provided in the BPS IRIO table. We check the validity of our structural check process (robustness check) by conducting the same process to the Japan IRIO table and the Indonesian Input-Output (IO) table. We prove that our structural check process is robust and consistent. We also explain our recommendations to the data provider, BPS, in correcting the existing Indonesian IRIO table.

Keywords: Regional Analysis; Input-Output Model; Interregional Input Output Model; Structural Problem.

Introduction

The main contribution of this study is to emphasize the importance of checking the structure of the Interregional Input-Output (IRIO) table. We show that the IRIO table published by the Indonesian BPS (Central Bureau of Statistics) does not have the correct structure based on the theoretical background of the IRIO table. The structure of an IRIO table has a significant role in the analyses that can be derived from an IRIO table such as multiplier, linkage, and the inter-region analysis. When the structure of the IRIO table suffers from errors, the analysis derived from the table becomes invalid. For example, if we try to estimate the impact of building new infrastructures in one region to another, we can use the IRIO table to generate multipliers (the impact) using the inverse Leontief matrix. However, we can't use the multiplier from the inverse Leontief matrix if the structure of the table suffers from the validity problem. We, as

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IRIO table users, need to make sure that the table has a valid structure before we use the table to generate the multiplier/linkage analysis.

It is important to obtain a valid IRIO table because there have been many precedent studies for regional studies, especially in Indonesia, that depends on the information from IRIO table. Some of these studies are included in Table 1. Most of these studies were published from 2021 as the first publicly available IRIO table from BPS were published in 2021. These studies did not conduct a structural check on the IRIO table, and they directly used the IRIO table to answer the research questions.

Table 1. List of Studies in Indonesia that use the Indonesian IRIO table

Number	Authors	Year
1	Hirawan & Nurkholis	2008
2	Pribadi, Putra & Rustiadi	2015
3	Hadi, Fauzi & Achsani	2017
4	Faturay, Lenzen & Nugraha	2017
5	Subanti, Hakim, Riani, Hakim & Irawan	2020
6	Oktaviani, Triwibowo, & Susiyanti	2021
7	Kumara, Prasetyo, & Rahayu	2021
8	Rahmawan & Anggraini	2021
9	Hidayah & Sunarjo	2021
10	Ronalia	2021
11	Syahnur, Dawood & Diantimala	2021
12	Puspita & Ningsih	2021
13	Kustaman & Budiarty	2021
14	Handayani	2022
15	Indryani & Mun'im	2022
16	Tohari	2022
17	Meilaningsih & Yuniartuti	2022
18	Ariutama, Saputra, Muis & Nugroho	2022
19	Allo, Dwiputri & Maspaitella	2022
20	Kamil et al.	2023

Source: Author. Note: The readers can read the details reference in the References section.

Considering that the IRIO table has significant advantages for the researchers, such as the completeness of inter- and intra-regional, and inter- and intra-sectoral information, this study provides a mechanism for validating the IRIO table structures. We call this mechanism as the structural check process. The structural check process is a reverse engineering process for generating the vector output and vector final demand. If there are discrepancies from our structural check results with the original vector output and vector final demand, we identify the discrepancies as errors. Our structural check process is based on simple matrix identity equations. Therefore, we expect to have zero discrepancies if the IRIO table has a correct structure. We explain the details of our structural check process in theoretical background and results & discussion sections.

We present the results of this study straightforwardly; we have a focus on proving the structural errors of the IRIO table and providing a checking mechanism that can be used by other researchers in using the IRIO table. We also provide the recommendations for the BPS, as the data provider, in correcting the Indonesian IRIO table. We show the recommendations in the discussion section.

Using the Indonesian IRIO table, we find that the structure of the IRIO published by the Indonesian Central Bureau of Statistics (BPS) has structural errors. By using the structural check mechanism that we develop, we hope that the future studies based on Indonesian IRIO data can check the validity of the existing data. On the other hand, we also propose that BPS as the provider of the IRIO table conduct adjustment on the table as we propose in the discussion section. In producing these findings, we conduct robustness check (validity check) of our structural check process by using the 53 sectors Japan IRIO table and 185 sectors Indonesian Input-Output (IO) table. We show that our structural process passes the robustness check, so our structural process is valid to use.

Data and Methodology: Theoretical Background of the Interregional Input-Output Table

In this section, we present the basic structure of the Interregional Input-Output (IRIO) table. This section serves as a theoretical background in preparing the structural check process that we develop. The fundamental structure of the IRIO matrix mathematical equations refers to Miller & Blair (2009). In this section, we start by using a simple table of 2 regions and 3 sectors in each region to simplify the illustration of the IRIO structure (see Table 2). From this simple table, it will generally apply to the larger IRIO table.

Table 2. The basic example of IRIO table

			Selling Sector						Final Demand	Final Output
			Region 1			Region 2				
			Sector 1	Sector 2	Sector 3	Sector 1	Sector 2	Sector 3		
	Region 1	Sector 1	z_{11}^{11}	z_{12}^{11}	z_{13}^{11}	z_{11}^{12}	z_{12}^{12}	z_{13}^{12}	f_{11}	x_{11}

Purchasing Sector		Sector 2	z_{21}^{11}	z_{22}^{11}	z_{23}^{11}	z_{21}^{12}	z_{22}^{12}	z_{23}^{12}	f_{12}	x_{12}
		Sector 3	z_{31}^{11}	z_{32}^{11}	z_{33}^{11}	z_{31}^{12}	z_{32}^{12}	z_{33}^{12}	f_{13}	x_{13}
	Region 2	Sector 1	z_{11}^{21}	z_{12}^{21}	z_{13}^{21}	z_{11}^{22}	z_{12}^{22}	z_{13}^{22}	f_{21}	x_{21}
		Sector 2	z_{21}^{21}	z_{22}^{21}	z_{23}^{21}	z_{21}^{22}	z_{22}^{22}	z_{23}^{22}	f_{22}	x_{22}
		Sector 3	z_{31}^{21}	z_{32}^{21}	z_{33}^{21}	z_{31}^{22}	z_{32}^{22}	z_{33}^{22}	f_{23}	x_{23}
Value Added			v_{11}	v_{12}	v_{13}	v_{21}	v_{22}	v_{23}		
Final Output			x_{11}	x_{12}	x_{13}	x_{21}	x_{22}	x_{23}		

Source: Author.

We follow Miller & Blair (2009) in defining the structure of IRIO table. r and s show two different regions. z_{ij}^{rr} shows the intraregional flows and z_{ij}^{sr} shows the interregional flows. We can write the structure of the intraregional and interregional table as follows.

$$Z = [Z^{rr}\ Z^{rs}\ Z^{sr}\ Z^{ss}\ ] \tag{1}$$

We use the capital letters to denote the matrix, while we use the small letters to denote the vectors. We can write the equation that shows the distribution of sector i product as follows.

$$x_i = z_{i1} + z_{i2} + \cdots + z_{ij} + \cdots + z_{in} + f_i \tag{2}$$

x_i is the output for sector i and f_i is the final demand for sector i. One of the components in final demand is the export of the sector i goods. In the interregional input-output table with two regions, part of f_i that show the product sale of sector i to the productive sector in other regions (not for the consumer in other regions) is removed from the final demand and we may define it explicitly. We express the output of sector 1 in region r as:

$$x_1^r = z_{11}^{rr} + z_{12}^{rr} + z_{13}^{rr} + z_{11}^{rs} + z_{12}^{rs} + f_1^r \tag{3}$$

Or we can rewrite in the matrix form as $Zi + f = x$. i is the row vector with the elements of 1, $i = [1, \ldots, 1]'$.

$z_{11}^{rr} + z_{12}^{rr} + z_{13}^{rr}$ show the interindustry sale for intraregional sector 1, while $z_{11}^{rs} + z_{12}^{rs}$ show interindustry sale for interregional sector 1. f_1^r shows intraregional sale sector 1 to the final demand. Equation (3) also applies for x_2^r, x_3^r, x_1^s, dan x_2^s. We write the input coefficients for region r and s as follows.

$$a_{ij}^{rr} = \frac{z_{ij}^{rr}}{x_j^r} \quad and \quad a_{ij}^{ss} = \frac{z_{ij}^{ss}}{x_j^s} \tag{4}$$

We denote the interregional trade coefficients as:

$$a_{ij}^{rs} = \frac{z_{ij}^{rs}}{x_j^s} \quad and \quad a_{ij}^{sr} = \frac{z_{ij}^{sr}}{x_j^r} \tag{5}$$

By using the definition of input coefficients and regional trade, we define the equation (3) as follows.

$$x_1^r = a_{11}^{rr}x_1^r + a_{12}^{rr}x_2^r + a_{13}^{rr}x_3^r + a_{11}^{rs}x_1^s + a_{12}^{rs}x_2^s + f_1^r \tag{6}$$

By using the equation (6) we may define the equations for x_2^r, x_3^r, x_1^s, dan x_2^s. Then, we define A^{rr} as follows.

$$A^{rr} = [a_{11}^{rr}\ a_{12}^{rr}\ a_{13}^{rr}\ a_{21}^{rr}\ a_{22}^{rr}\ a_{23}^{rr}\ a_{31}^{rr}\ a_{32}^{rr}\ a_{33}^{rr}\ ]$$

Using the same method, we define $A^{ss} = Z^{ss}(\hat{x}^s)^{-1}$ and coefficients matrices as $A^{rs} = Z^{rs}(\hat{x}^s)^{-1}$ and $A^{sr} = Z^{sr}(\hat{x}^r)^{-1}$. By using the 4 matrices, we define the new equations, as we did in the equation (6), as follows.

$$(I - A^{rr})x^r - A^{rs}x^s = f^r \tag{7}$$

$$-A^{sr}x^r + (I - A^{ss})x^s = f^s \tag{8}$$

f^r is the three-element vector of final demands for region r goods and f^s is the two-element vector of final demands for region s goods.

We define the complete coefficients matrix for the two-region interregional table as submatrices:

$$A = [A^{rr}\ A^{rs}\ A^{sr}\ A^{ss}\ ]$$

Then we define x, f, and I as:

$$x = [x^r\ x^s\ ], \qquad f = [f^r\ f^s\ ], \qquad I = \left[I_{(3\times3)}\ 0_{(3\times2)}\ 0_{(2\times3)}\ I_{(2\times2)}\ \right]$$

We define equation (7) and (8) as:

$$(I - A)x = f \tag{9}$$

We can write the structure of equation (9) as:

$$\{[I\ 0\ 0\ I\ ] - [A^{rr}\ A^{rs}\ A^{sr}\ A^{ss}\ ]\}[x^r\ x^s\ ] = [f^r\ f^s\ ]$$

We may develop the IRIO table for more than two regions. For instance, the complete coefficients matrix for the three-region table is:

$$A = [A^{11}\ A^{12}\ A^{13}\ A^{21}\ A^{22}\ A^{23}\ A^{31}\ A^{32}\ A^{33}\ ] \qquad (10)$$

$$(I - A^{11})x^1 - A^{12}x^2 - A^{13}x^3 = f^1$$

$$-A^{21}x^1 - A^{12}x^2 - A^{13}x^3 = f^1$$

$$-A^{31}x^1 - A^{32}x^2 + (I - A^{33})x^3 = f^3$$

$$x = [x^1\ x^2\ x^3\ ], \qquad f = [f^1\ f^2\ f^3\ ], \qquad I = [I\ 0\ 0\ 0\ I\ 0\ 0\ 0\ I\ ]$$

The three-region interregional input-output table can be represented by $(I - A)x = f$. By using the same logic, we may develop the simple table into p-regions table as follows.

$$(I - A^{11})x^1 - A^{12}x^2 - \cdots - A^{1p}x^p = f^1$$

$$\vdots$$

$$-A^{p1}x^1 - A^{p2}x^2 - \cdots + (I - A^{pp})x^p = f^p$$

$$A = [A^{11}\ \cdots\ A^{1p}\ \vdots \ddots \vdots\ A^{p1}\ \cdots\ A^{pp}\ ], \qquad I = [I^{11}\ \cdots\ 0\ \vdots \ddots \vdots\ 0\ \cdots\ I^{pp}\ ], \qquad x = [x^1\ \vdots\ x^p\ ],$$
$$f = [f^1\ \vdots\ f^p\ ]$$

Results and Discussion

Structural Check on the Indonesian IRIO Table

In demonstrating the structural check process, we use the Indonesian IRIO table. We get the table from BPS website. The table is publicly available, and the table is the pioneer for the first publicly available Indonesian IRIO table. We use the IRIO table from 2021 BPS publication (BPS, 2021), which is the 2016 IRIO table. There are two types of Indonesian IRIO table, 17 sectors and 52 subsectors. The 17 sectors table is the aggregate of the 52 subsectors, or in other words, the 52 subsectors table provide more details than the 17 sectors table[2]. We show the result in this section by using the 52 subsectors table as the table provide more details than the 17 sectors table. In addition, we also conduct robustness check (validation process) of all the findings in this section by doing the same structural check process for the 185 sectors

[2] We show the details of sectors and subsectors in the Appendix section.

Indonesian IO table and 53 sectors Japan IRIO table. The robustness check is the crucial part of our study since we want to show the validity of our structural check process that we develop.

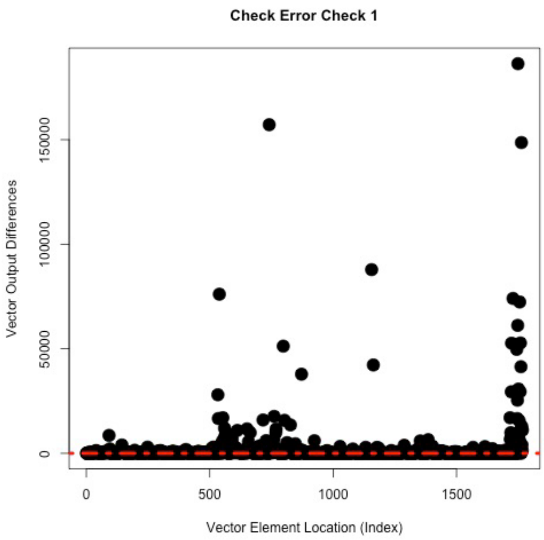
We use the Indonesian IRIO table with 52 subsectors and 34 provinces. We use the matrix Z with the dimension of 1767×1767, vector f with the dimension 1767×1, vector output with the dimension 1767×1. Our structural check process is based on the equation (3) and (9). In general, we develop the structural check process for checking the vector output and vector final demand. In details, we develop the process as follows.

- **Check 1 (check on vector output)**: $Zi + f = x$
- **Check 2 (check on vector final demand)**: $(X - AX) = f$
- **Check 3 (check on vector final demand)**: $(I - A)x = f$
- **Check 4 (check on vector output)**: $(I - A)^{-1} f = x$

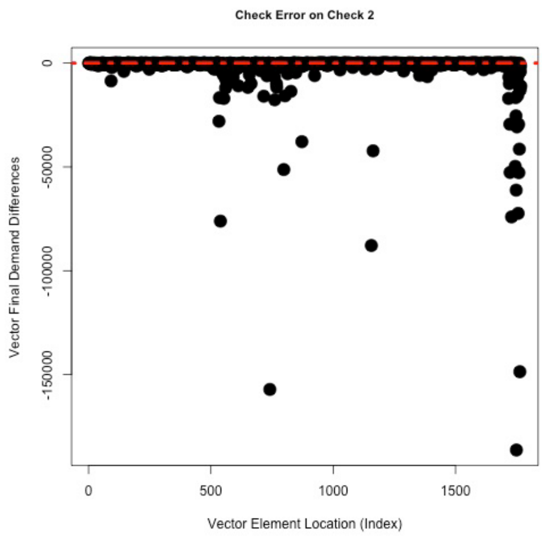
The readers might notice that the check 1-4 are simple matrix identity equations. We expect to have zero discrepancies from the LHS (left hand side) and RHS (right hand side) of check 1-4 equations if the IRIO table doesn't suffer from the structural problem. Figure 1 shows the error check results on the vector output and vector final demand by using check 1-4. Based on our estimation, we find that the original vector output and vector final demand (from the BPS) are not in line with the theoretical background of IRIO table.

Figure 1. Structural Check on Indonesian IRIO table

Check Error 1 IRIO Indonesia

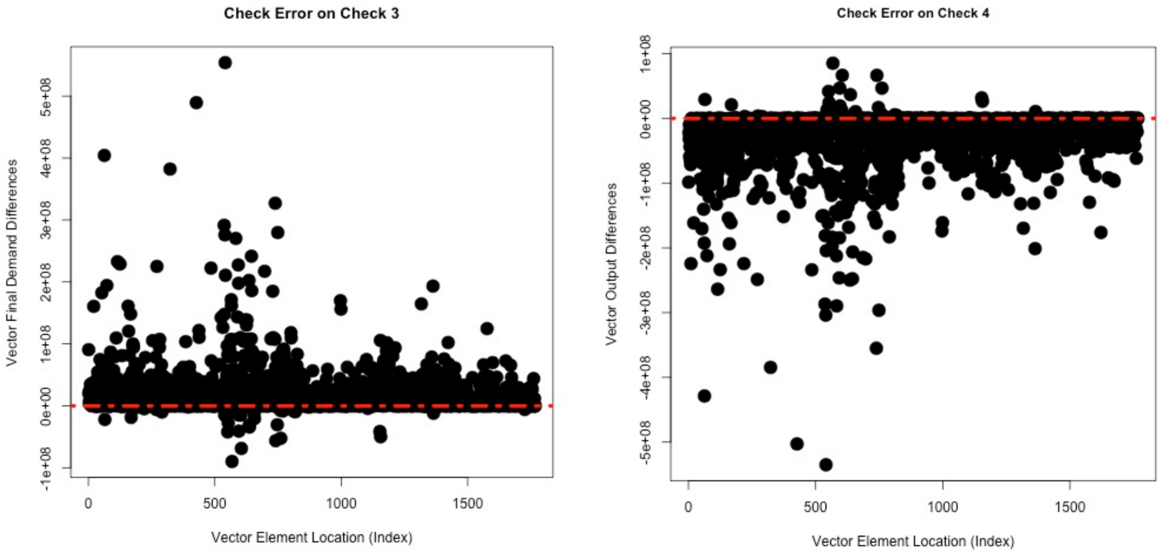


Check Error 2 IRIO Indonesia



Check Error 3 IRIO Indonesia

Check Error 4 IRIO Indonesia



Source: Author's Estimation. Notes: Vertical axis shows the differences between vector output or vector final demand from the structural check process, with the original vector output dan vector final demand from BPS. The red dashed line shows the zero differences. 1e+08 means 1×10^8.

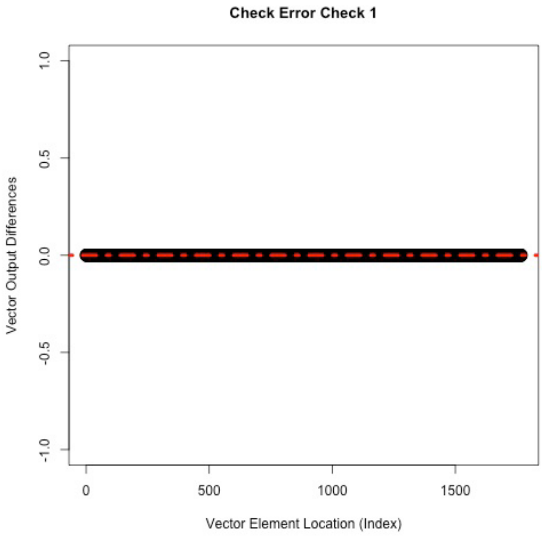
Based on the correct IRIO table structure, we should expect to see zero differences in each figure in figure 1. In other words, check 1-4 equations should generate the same vector output and final demand with the original vector output and vector final demand from BPS. However, we find the gap between the result of structural check process and the original IRIO table.

The readers might think that if we adjust the vector output by the difference shown in check 1 errors figure 1, we might get the correct structure of IRIO. This adjustment means that we eliminate the check 1 and check 2 errors. We show that after adjusting the vector output, or eliminating the check 1 and check 2 errors, we still don't have the correct structure of IRIO. We find the result by checking the vector final demand and vector output using the same procedure in this section. We show the result in figure 2.

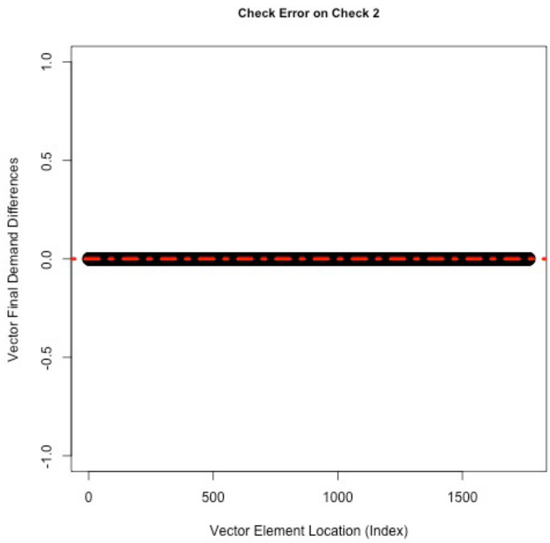
Notice that the result of check 1 and check 2 are zero. The reason is that our new vector output (vector output after adjustment) is confirmable with row sum of matrix Z. Row sum refers to the mathematical operation of adding up the elements within a row of a matrix. It involves summing the values horizontally within a specific row, resulting in a single value that represents the total sum of all the elements in that row. The result of check 1 and check 2 must be the vector output and vector final demand themselves. The figure 2 shows that, even after we adjust the vector output, we still have the incorrect IRIO structure. In other words, if we eliminate the check 1 and check 2 errors, we still have the problem in check 3 and check 4. We provide our recommendations in eliminating check 3 and check 4 errors in the discussion section. It also serves as our recommendation for the data provider.

Figure 2. Structural Check on Indonesian IRIO Table after adjustment

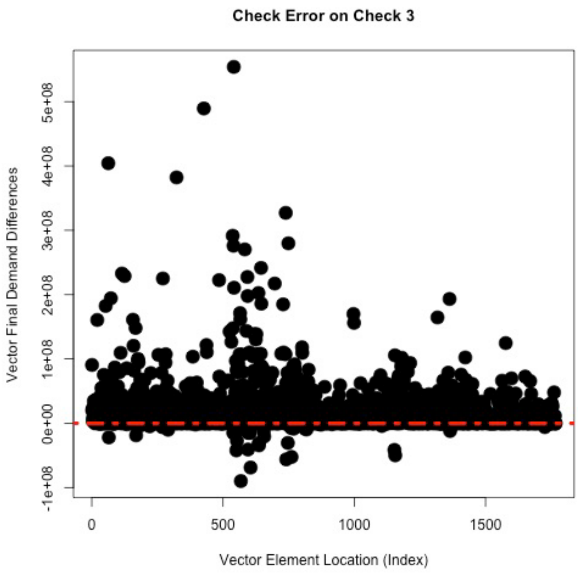
Check Error 1 IRIO Indonesia after adjustment



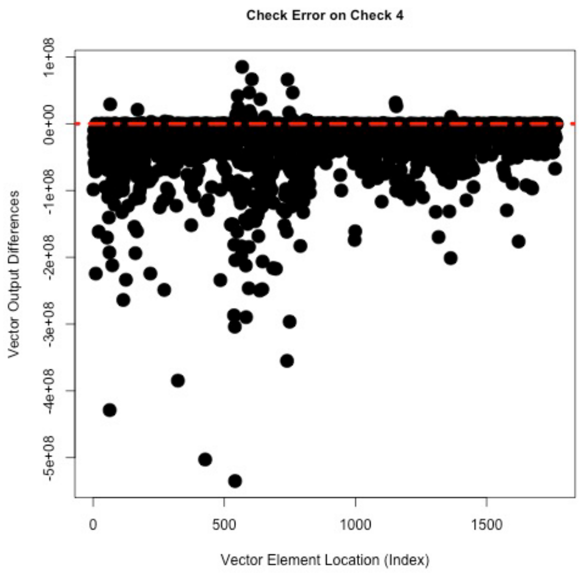
Check Error 2 IRIO Indonesia after adjustment



Check Error 3 IRIO Indonesia after adjustment



Check Error 4 IRIO Indonesia after adjustment



Source: Author's Estimation. Notes: Vertical axis shows the differences between vector output or vector final demand from the structural check process, with the original vector output dan vector final demand from BPS. The red dashed line shows the zero differences. 1e+08 means 1×10^8.

In validating the structural check process in our study, we conduct robustness check by using Indonesian IO (Input-Output) table and Japan METI (Ministry of Economy, Trade, Industry)

IRIO table. Based on the robustness check, we prove that our structural check process is robust, consistent, and valid.

Structural Check on the Japan IRIO Table

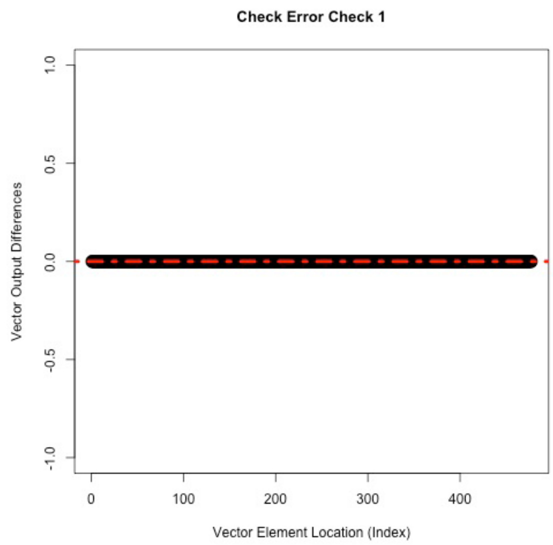
In proofing the validation of our structural check process, we use the same process as we did in Indonesian IRIO table, to the Japan IRIO table. The reason on why we use the Japan IRIO table is straightforward, it is because both the tables have the same structure. If we can prove that our structural check process generates zero discrepancies using the Japan IRIO table, then we can validate our structural check process that we develop.

We use the 2005 Japan IRIO table with 53 sectors, notice that we use the nearest number of sectors as we did in checking the Indonesian IRIO table (53 sectors vs 52 sectors) [3]. The difference of the number of provinces in Indonesia and Japan is not a problem to our results since our structural check process is not sensitive to the dimension of the matrix. We use the 2005 data because the latest publicly available data is 2005 data.

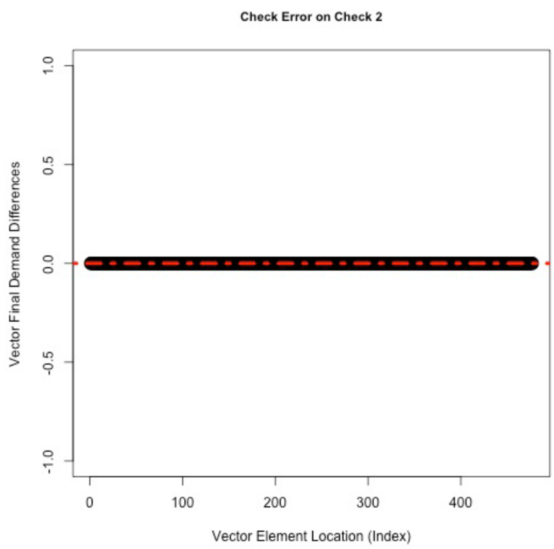
We conduct the structural check process on vector output and vector final demand to the Japan IRIO table by using check 1-4 equations. Notice that we use the same checking equations in this section as we did for the Indonesian IRIO table.

Figure 3. Structural Check on Japan IRIO Table

Check Error 1 IRIO Japan



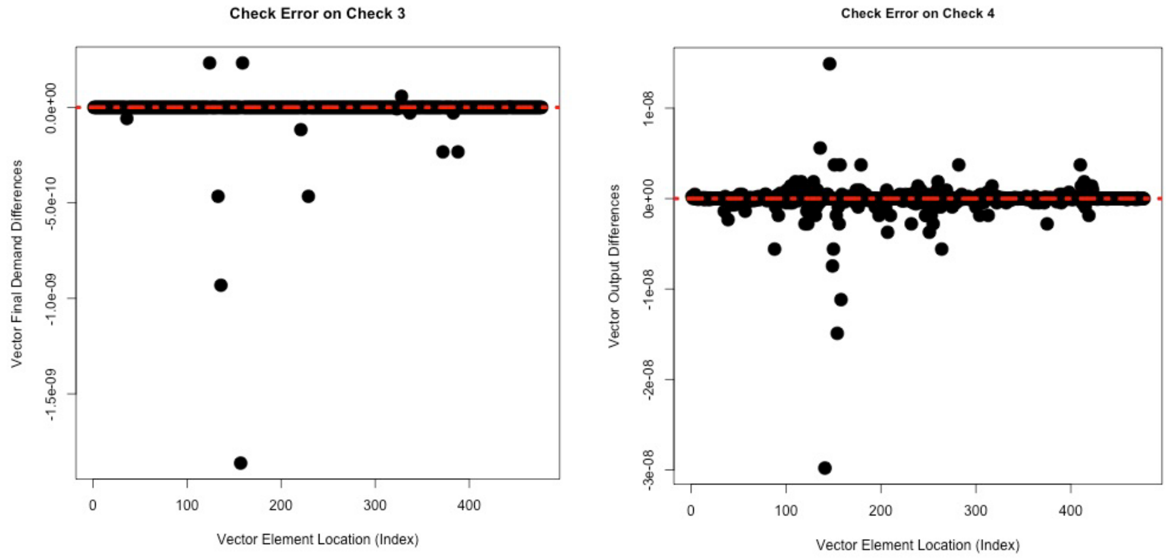
Check Error 2 IRIO Japan



Check Error 3 IRIO Japan

Check Error 4 IRIO Japan

[3] The readers can access the Japan IRIO table by using this link: https://www.meti.go.jp/english/statistics/tyo/tiikiio/index.html



Source: Author's Estimation. Notes: Vertical axis shows the differences between vector output or vector final demand from the structural check process, with the original vector output dan vector final demand from METI Japan. The red dashed line shows the zero differences. 1e-08 means 1×10^{-8}.

By looking at the figure 3, we can see that the errors from the structural check process are zero. There is no difference between the vector output and the vector final demand from the process, with the original vectors from METI Japan. Thus, we may conclude that our structural check process in this study is valid, so that our findings in the Indonesian IRIO table section are valid.

Structural Check on the Indonesian Input-Output (IO) Table

In this section, we try to strengthen the validity of our structural check process by applying the same process to the Indonesian IO table. We show that if the IO table has a correct structure, our structural check process generates the same vector output and vector final demand as BPS provides. The reason on why we use the Indonesian IO table is due to the similar (not the same) structure of Indonesian IO table and Indonesian IRIO table. This section is part of the robustness check of our structural check process.

We follow Miller & Blair (2009) the structure of Input-Output (IO) table. In general, we write the Input Output table as follows.

$$x = Zi + f \qquad (11)$$

Where x is the vector output, Z is the matrix where the matrix has elements that show the *interindustry* sale. f is the vector final demand. Based on equation11, we can get the matrix technical coefficient A which contains the elements showing the ratio between elements in matrix Z and elements in vector x.

In specific, we can write the equation (11) as:

$$x_1 = a_{11}x_1 + \ ... + a_{1i}x_i + \cdots + a_{1n}x_n + f_1$$

$$\vdots$$

$$x_i = a_{i1}x_1 + \cdots + a_{ii}x_i + \cdots + a_{in}x_n + f_i$$

$$\vdots$$

$$x_n = a_{n1}x_1 + \cdots + a_{ni}x_i + \cdots + a_{nn}x_n + f_n$$

We transform the above equations into:

$$A = Z\hat{x}^{-1}$$

Where $\hat{x}^{-1} = \left[\frac{1}{x_1} \ \cdots \ 0 \ \vdots \ddots \vdots \ 0 \ \cdots \ \frac{1}{x_n}\right]$, we also define the vector output (x) equation as follows.

$$x = Ax + f \qquad (12)$$

Multiplier from the demand side depends on the inverse Leontief matrix. In defining the inverse Leontief matrix, we need to define the identity matrix I with dimension $n \times n$ as follows.

$I = [1 \ \cdots \ 0 \ \vdots \ddots \vdots \ 0 \ \cdots \ 1\ ]$ and $(I - A) = [(1 - a_{11}) \ - a_{12} \ \cdots - a_{1n} \ - a_{21} \ (1 - a_{22}) \ \cdots - a_{2n} \ \vdots \vdots \ddots \vdots \ -a_{n1} \ - a_{n2} \ \cdots \ (1 - a_{nn})\ ]$ (13)

We can write the equation (12) as:

$$(I - A)x = f$$

We define the inverse Leontief as:

$$x = (I - A)^{-1}f = Lf \qquad (14)$$

Where $(I - A)^{-1} = L$. L is the Leontief inverse matrix or total requirement matrix. We define the demand side multiplier as the system of equations as follows.

$$x_1 = l_{11}f_1 + \ ... + l_{1i}f_i + \cdots + l_{1n}f_n$$

$$\vdots$$

$$x_i = l_{i1}f_1 + \cdots + l_{ii}f_i + \cdots + l_{in}f_n$$

$$\vdots$$

$$x_n = l_{n1}f_1 + \cdots + l_{ni}f_i + \cdots + l_{nn}f_n$$

We define the multiplier as $l_{ij} = \frac{\partial x_i}{\partial f_j}$. In addition, we also conduct the structural check process for the supply side. In defining the multiplier from the supply side, we rotate or transpose the vertical columns into horizontal columns in the IO table. We can generate B matrix, the direct-output coefficient matrix, from the transpose result. We define the 2 sectors matrix B as:

$$B = [b_{11}\ b_{12}\ b_{21}\ b_{22}\ ] = \left[\frac{z_{11}}{x_1}\ \frac{z_{12}}{x_1}\ \frac{z_{21}}{x_2}\ \frac{z_{22}}{x_2}\right] = \left[\frac{1}{x_1}\ 0\ 0\ \frac{1}{x_2}\right][z_{11}\ z_{12}\ z_{21}\ z_{22}\ ] = \hat{x}^{-1}Z$$

b_{ij} shows the output distribution sector i for sector j which buy input interindustry from sector i, or we may define the elements as allocation coefficient. We can write the equation from above explanations as:

$$x' = i'Z + v' \qquad (15)$$

Where $v' = [v_1, \dots, v_n]$ and $Z = \hat{x}B$. We can write equation (15) as:

$$x' = i'\hat{x}B + v' = x'B + v'$$

Since $i'\hat{x} = x'$, from the equation: $x' = v'(I - B)^{-1}$ (16), we can define this equation:

$$G = (I - B)^{-1}$$

Matrix G has the same characteristics with the inverse Leontief matrix, where each element in matrix G is the partial derivative of output with respect to value add.

We check the Indonesian IO table (demand side) by using the same procedure as we did in Indonesian IRIO table section. From the supply side, we use the following procedure:

- **Check 1**: $x' = i'Z + v'$
- **Check 2**: $v' = x' - x'B$
- **Check 3**: $v' = x'(I - B)$
- **Check 4**: $x' = v'(I - B)^{-1}$

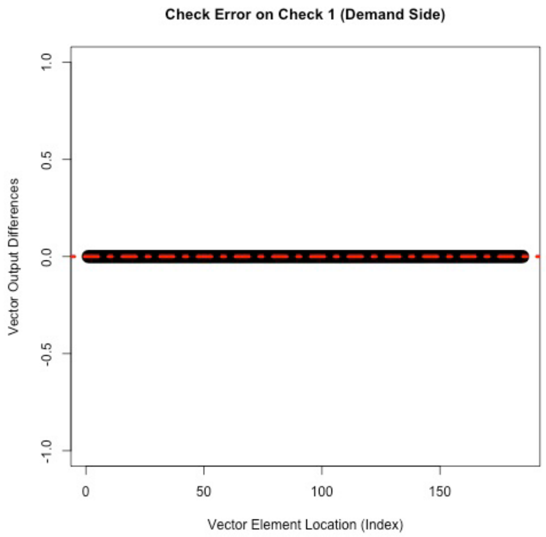
We show the result of structural check from the supply side in the appendix section. We conduct the structural check process on 3 types of 185 sectors Indonesian IO table.

a. The total transaction based on the buyer's price. (Type A)
b. The total transaction based on the constant price. (Type B)
c. The domestic transaction based on domestic price. (Type C)

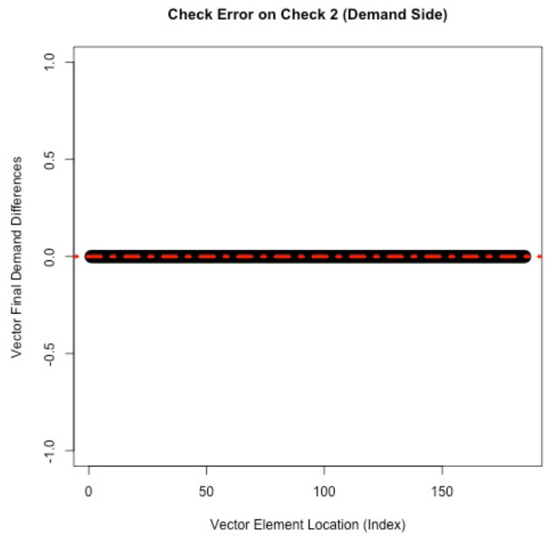
The type A IO table includes profit margin and delivery cost transactions. Type B IO table includes import transaction, while the type C IO table only includes domestic transactions.

Figure 4. Structural Check on Indonesian IO Table type A (Demand Side)

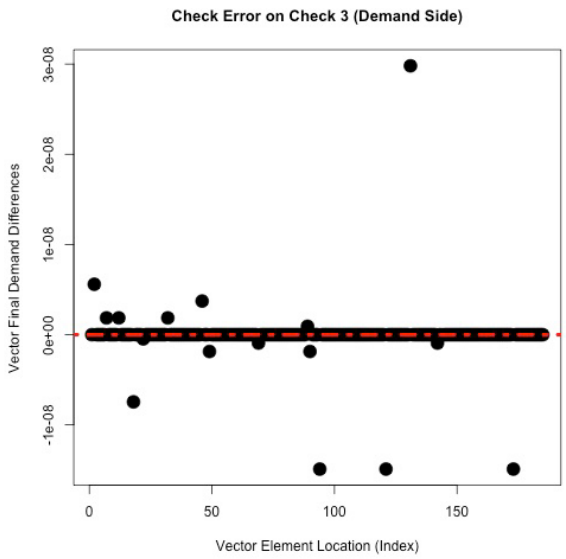
Check Error 1 IO Indonesia



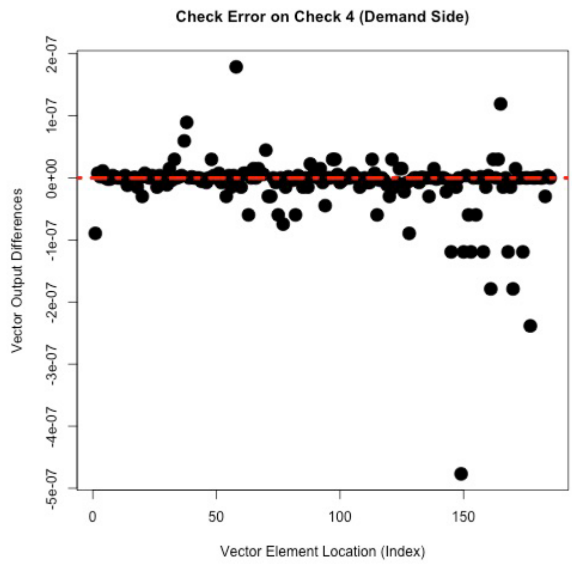
Check Error 2 IO Indonesia



Check Error 3 IO Indonesia



Check Error 4 IO Indonesia

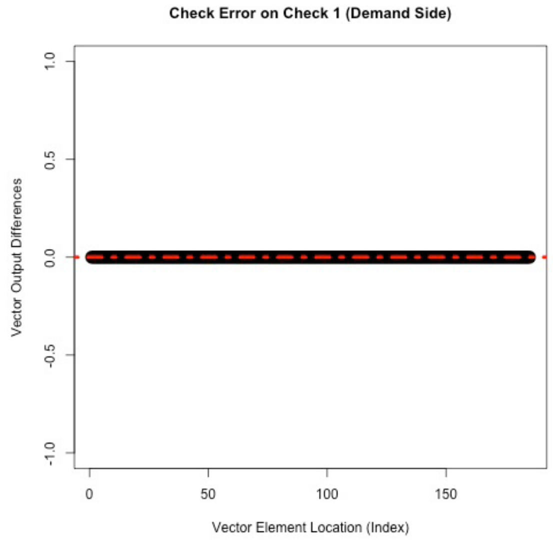


Source: Author's Estimation. Notes: Vertical axis shows the differences between vector output or vector final demand from the structural check process, with the original vector output dan vector final demand from BPS. The red dashed line shows the zero differences. 2e-07 means 2×10^{-7}.

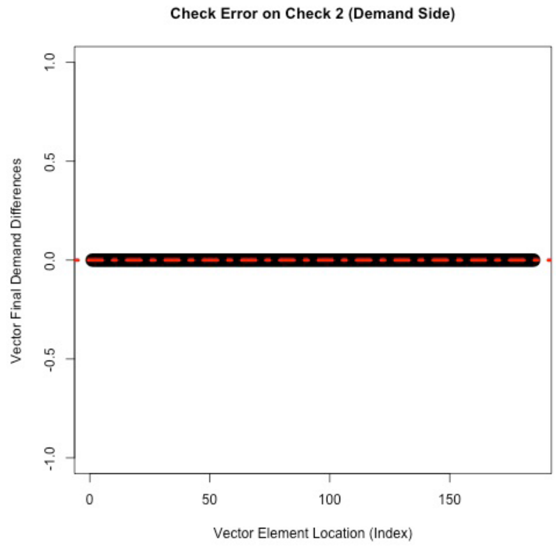
We show the result of our structural check process from the demand side type A, type B, type C in figure 4, figure 5, and figure 6, respectively. The result in each figure shows that our structural check process generates the same vector output and vector final demand, compared to the original vector output and vector final demand. We show the result for each check equation. The results also show that the Indonesian IO table type A, B, dan C has the correct structure, based on the theoretical background, and we can analyse and interpret the result of multiplier from the tables. We show the same findings both in the demand and supply side[4].

Figure 5. Structural Check on Indonesian IO Table type B (Demand Side)

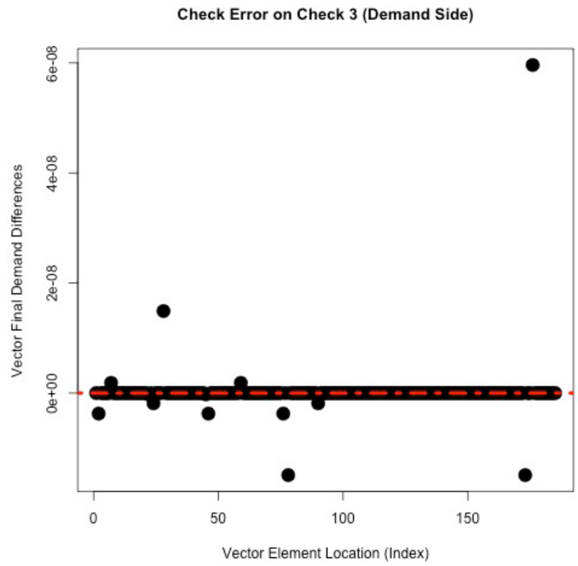
Check Error 1 IO Indonesia



Check Error 2 IO Indonesia



Check Error 3 IO Indonesia



Check Error 4 IO Indonesia

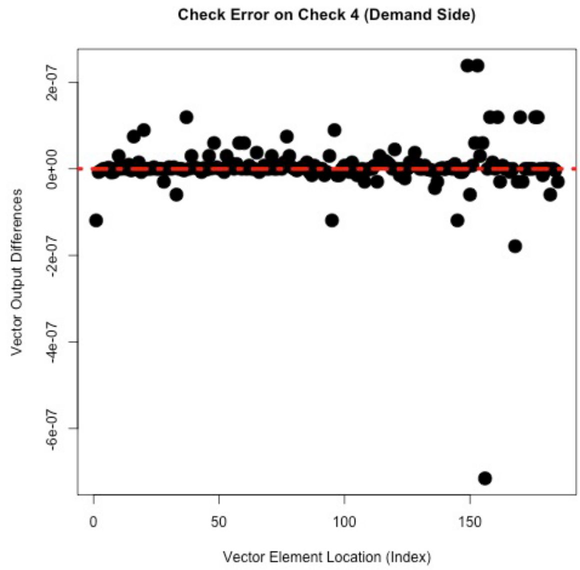
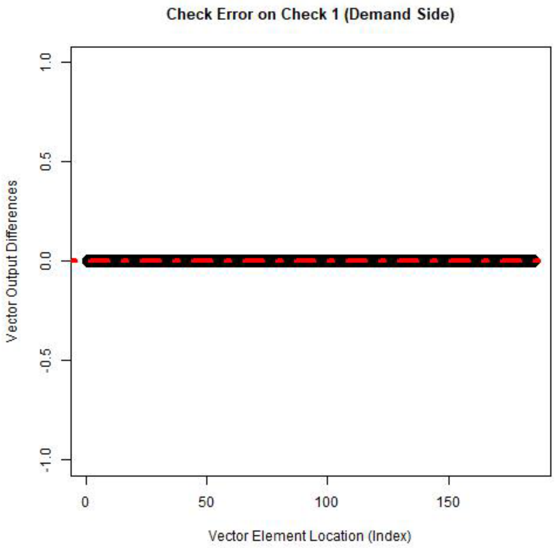


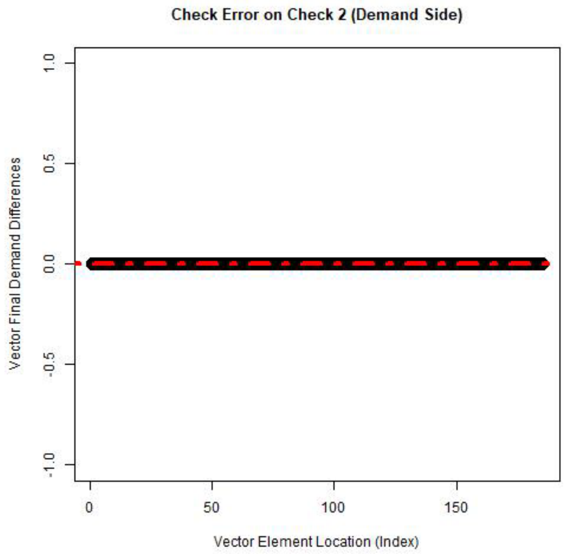
Figure 6. Structural Check on Indonesian IO Table type C (Demand Side)

Check Error 1 IO Indonesia

Check Error 2 IO Indonesia

[4] See the appendix for the results in supply side structural check process.





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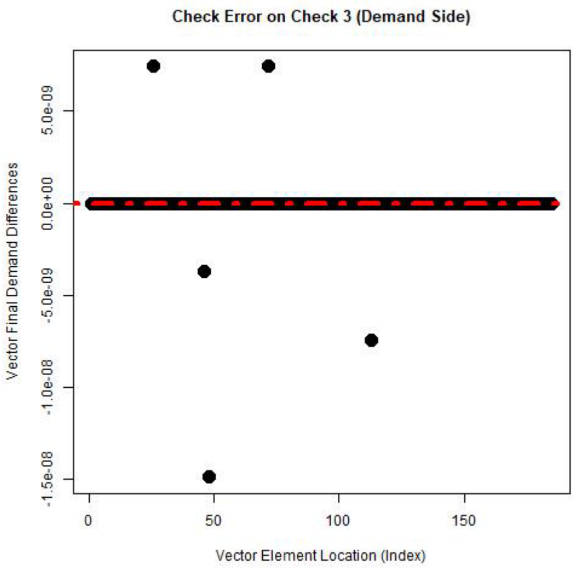
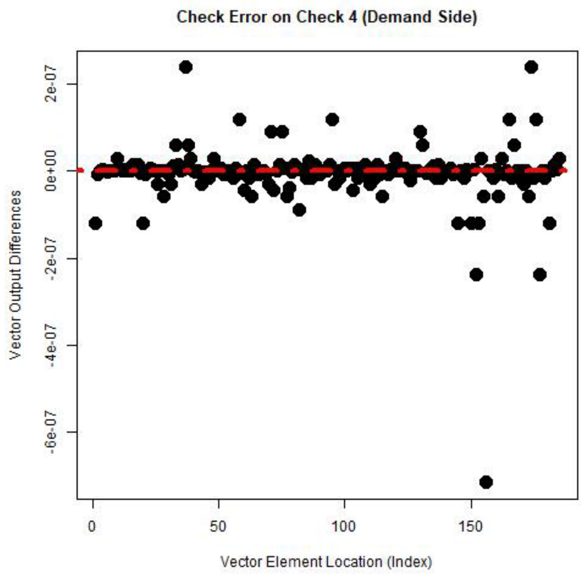


Check Error 4 IO Indonesia



Source: Author's Estimation. Notes: Vertical axis shows the differences between vector output or vector final demand from the structural check process, with the original vector output dan vector final demand from BPS. The red dashed line shows the zero differences. 2e-07 means 2×10^{-7}.

Discussion

Our results suggest that the Indonesian IRIO table has structural problem, so we can't generate the multiplier/linkage analysis using the existing table. We proof our structural check process by using the robustness check. The robustness check includes the structural check process on Japan IRIO table and Indonesian IO table. We show that our structural check process is applicable in both the tables, and we show there is no discrepancies between the result of the checking process with the original vectors from BPS.

The readers might think that the IRIO and IO tables are different tables, so the IO table cannot be used as our robustness check. Based on the theoretical background that we provide in this study, we show that the basic structure of the two tables is the same. The difference between the two tables lies in the relationship between regions in the IRIO table. In addition, we also validate our structural check on the 2005 Japan IRIO table of 53 sectors released by METI Japan. We show that the Japan IRIO table has the correct structure, so we prove that the structural check process in this study has strong validation.

We also show that if we eliminate the check 1 and check 2 errors, we still have the check 3 and check 4 errors in Indonesian IRIO table section. The possible reason of this finding is the zero elements in vector output. The Indonesian IRIO table has numerous zero elements in vector output (119 elements) , compared to the Japan IRIO table (19 elements) and Indonesia IO table (0 element). To confirm this hypothesis, we use a simple simulation-based test by increasing the number of zero elements inside **X** vector (vector output). The simulation is based on the following condition.

$z_{ij} \in Z \sim U\{0, u_b^Z\};\ f_i \in F \sim U\{0, u_b^F\}$, under the constraint that $z_{ij}, f_i \in Z_+$

where, $u_b^Z = 10^3$ and $u_b^F = 10^5$. Both are the upper bounds for simulating Z and F. This process is then followed by including R_i^0 in the rows of X vector, creating X_m^0 and X_n^+ groups randomly and separately, given that $m \neq n \in i, i = 1, \dots, R \times S$.

Setup: Given $\triangle_p = |X_m^0|/|X|$ where $|\cdot|$ is the total elements in a set, then the iterative process is

$\triangle_p = (\triangle_1, \triangle_1 + \varepsilon, \dots, 0.9 - \varepsilon, 0.9)$, $\triangle_1 = 0$, and $\varepsilon = 0.01$.

Algorithm:

for $\triangle_p$: $\triangle_1 = 0, \triangle_1 + \varepsilon, \dots, ,0.9$

for $k = 1, \dots, 100$

$$z_{ij} \in Z \sim U\{0, u_b^Z\};\ f_i \in F \sim U\{0, u_b^F\};$$

$$X = Zi + F;$$

$\lfloor \triangle_p \rfloor = |X_m^0|/|X|$ implies that $|X_m^0| = \lfloor \triangle_p \rfloor |X|$

the $x_m \in X_m^0$ indices are randomly selected by $m \sim U\{1, |X_m^0|\}, m \in Z_+, X_m = 0$;

$A_m = 0$, where m is row index given by $m \in R_i^0$

check_3$[k] \leftarrow F - (I - A_m)X_m$

check_4$[k] \leftarrow X_m - (I - A_m)^{-1}F$

}

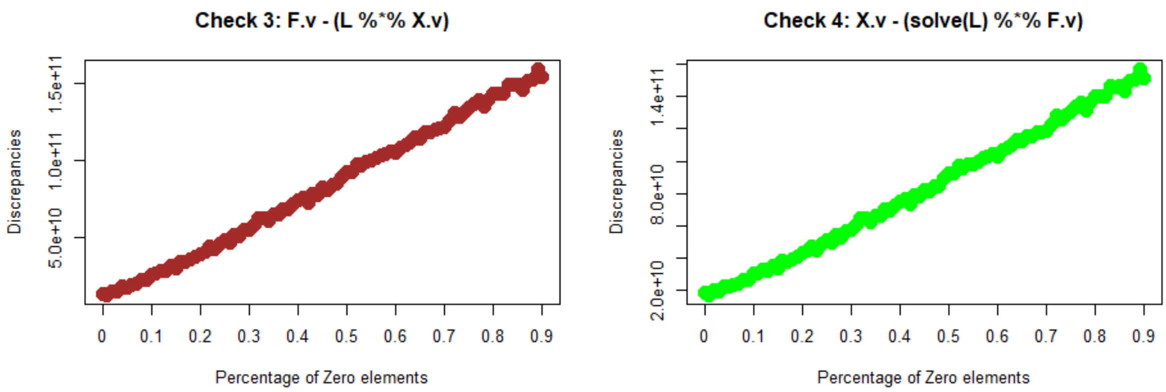
}

For each **check** (check 3 and 4), we then measure the mean value of discrepancies for all $\triangle_p$. The zero elements condition in vector output (**X** vector) will impact the computation result of several rows inside **A** matrix, which generate $a_{ij} = 1/0 = Inf$. The usual approach to overcome this situation is by doing the following elements:

Condition $\forall\, a_{ij} = 1/0, such\ that\ a_{ij} \in A, then\ those\ a_{ij} \leftarrow 0\ as\ \boldsymbol{replacement}$

However, as the number of replacement elements increase, we observe the discrepancy over all checks. Figure 7 shows the discrepancies after we increase the ratio of element $x_i = 0$ over total number of $R_x = R_i^0/x_i$, where R_i^0 is the number of $x_i = 0$.

Figure 7. Discrepancy Test under check 3 and 4.



Source: Author's Estimation.

It is clearly shown that check 3 and check 4 show the linear relationship between the R_i^0 and the mean of discrepancies for 100 iterations between each R_i^0. This trade-off affects the structural check results in our study. By using this finding, we find that our discrepancies found in Indonesian IRIO table (check 3 and check 4 errors) is due to this condition. We can eliminate the check 1 and check 2 errors by correction in the row sum of matrix Z. Therefore, the adjustment is crucial and important during the IRIO table formulation.

We can also validate the structural check process in this study based on the theoretical background of the IRIO table. The structural check process is a simple process by reverse engineering the matrix generated from the IRIO table, to get back the output vector and final demand vector originating from the IRIO table. Mathematically, the proof of our structural check process is trivial since the structural check process is a reverse engineering process.

The readers might also think that the reason for the discrepancy between the Indonesian IRIO tables and the structural check results is the precision of our data processing. In conducting structural check, we use python using two popular packages, pandas and numpy[5]. We created a virtual environment to isolate the packages, so that while we were working on this study, the versions of the two packages did not change. However, precision issues can arise when using numpy to perform inverse or row/column sum operations. We minimize the precision problem by increasing the number of digits that can be stored by each matrix element. We use float64 which refers to a floating-point data type with 64 bits of precision. It is commonly used to represent decimal numbers with high precision in numerical computations.

Conclusion

We prove that the Indonesian IRIO table does not have a structure in line with the theoretical background by using the structural check process that we present in this study. We also show the validation process (robustness check) of our structural check process. We prove that the structural check process in this study is valid to use.

This study has aims to emphasize the importance of checking the structure of the IRIO table, so that users of the IRIO table, in general, can be more careful in using the IRIO table. We also provide recommendations for data providers to make correct adjustments regarding zero elements in the vector output. We recommend that future studies that uses the IRIO table should check before using the IRIO table to produce correct analysis of the IRIO table.

[5] We publish our code online in github repo: https://github.com/fawdywahyu18/pyinputoutput

Disclaimer

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Data Availability

The authors are committed to transparency and scientific integrity. The research methodology and data sources have been clearly described to facilitate reproducibility and allow for a critical evaluation of the study's validity. All the codes and data in this study are published online in github repo: https://github.com/fawdywahyu18/pyinputoutput .

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Appendix

Table A1. List of Sectors and Sub-sectors in Indonesian IRIO Table

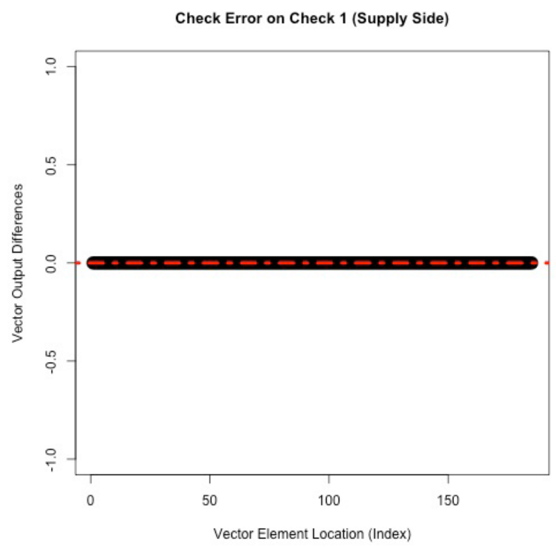
Indonesia's Sector and Subsectors	
Agriculture, Forestry and Fisheries	Food Crop Agriculture
	Seasonal Horticultural Plant Farming, Annual Horticulture, and Others
	Seasonal and Annual Plantations
	Livestock
	Agricultural and Hunting Services
	Forestry and Logging
	Fishery
Mining and excavation	Oil, Gas and Geothermal Mining
	Coal and Lignite Mining
	Metal Ore Mining
	Mining and Other Quarrying
Processing industry	Coal Industry and Oil and Gas Refining
	Food and Beverage Industry
	Tobacco Processing Industry
	Textile and Apparel Industry
	Leather Industry, Leather Goods and Footwear
	Wood Industry, Products from Wood & Cork and Woven Products from Bamboo & Rattan
	Paper and Paper Products Industry, Printing and Reproduction of Recorded Media
	Chemical, Pharmaceutical and Traditional Medicine Industries
	Rubber Industry, Rubber and Plastic Products
	Non-Metal Minerals Industry
	Basic Metal Industry
	Metal, Computer, Electronic Goods, Optical and Electrical Equipment Industries
	Machinery and Equipment Industry YTDL
	Transportation Equipment Industry
	Furniture Industry
	Other Processing Industry, Machinery and Equipment Repair and Installation Services
Gas and Electricity	Electricity
	Gas Supply and Ice Production
Water Supply, Waste and Recycling Management	Water Supply, Waste and Recycling Management
Constructions	Constructions

Wholesale and Retail Trade; Cars and Motorcycles Repair	Trade in Cars, Motorcycles and Their Repair
	Wholesale and Retail, Other than Autos and Motorcycles
Transportation and Warehouse	Rail Transportation
	Ground Transportation
	Sea Transportation
	River, Lake, and Crossing Transportation
	Air Transportation
	Warehousing and Transportation Support Services, Post and Courier
Accommodation services and Food & Beverage	Accommodation Services
	Food & Beverage
Information and Communication	Information and Communication Services
Financial Services and Insurance	Financial Intermediary Services other than the Central Bank
	Insurance and Pension Fund
	Other Financial Services
	Financial Support Services
Real Estate	Real Estate
Firm Services	Firm Services
Government Administration, Defence and Mandatory Social Security	Government Administration, Defence and Mandatory Social Security
Education Services	Education Services
Health Services and Social Activities	Health Services and Social Activities
Other Services	Other Services

Figure A1. Supply side structural check.

Structural Check on Indonesian IO Table type A (Supply Side)

Check Error 1 IO Indonesia



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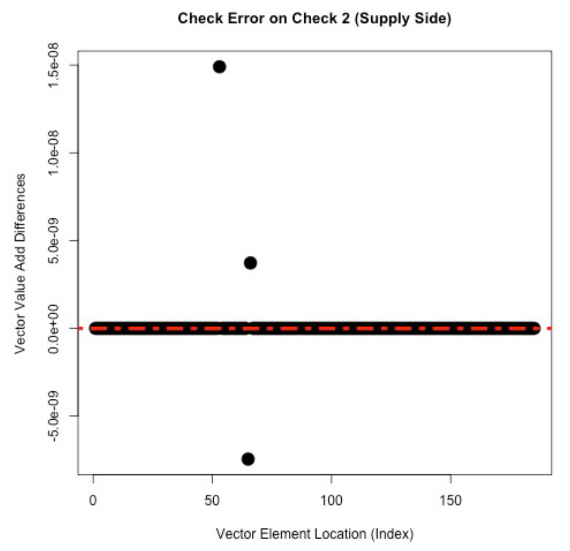
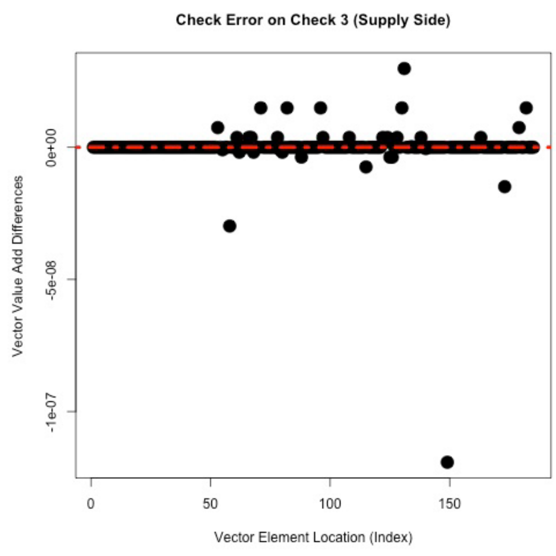


Check Error 3 IO Indonesia



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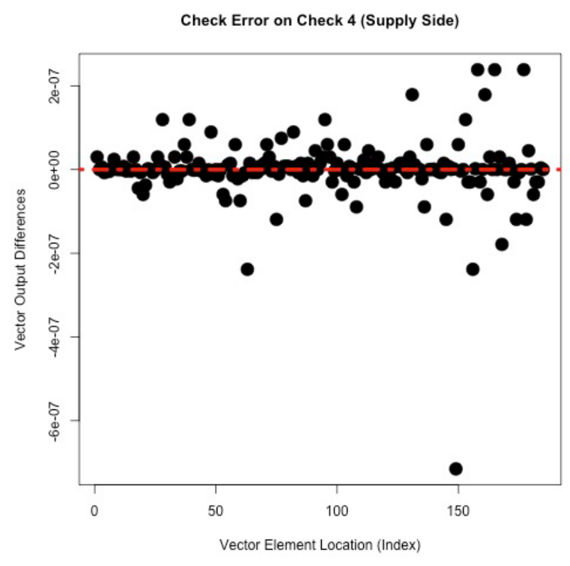

Structural Check on Indonesian IO Table type B (Supply Side)

Check Error 1 IO Indonesia	Check Error 2 IO Indonesia

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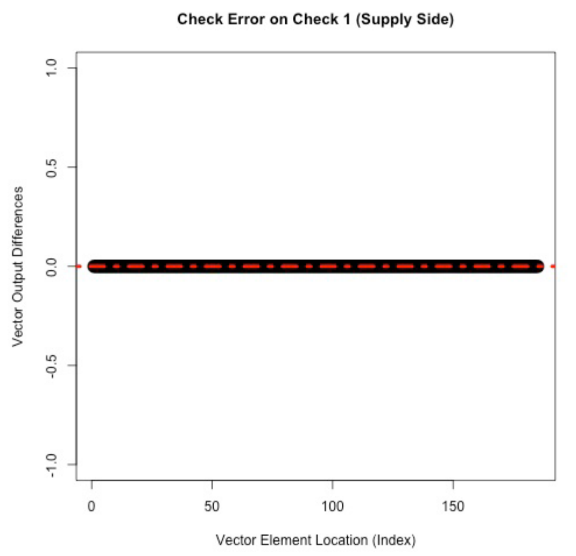
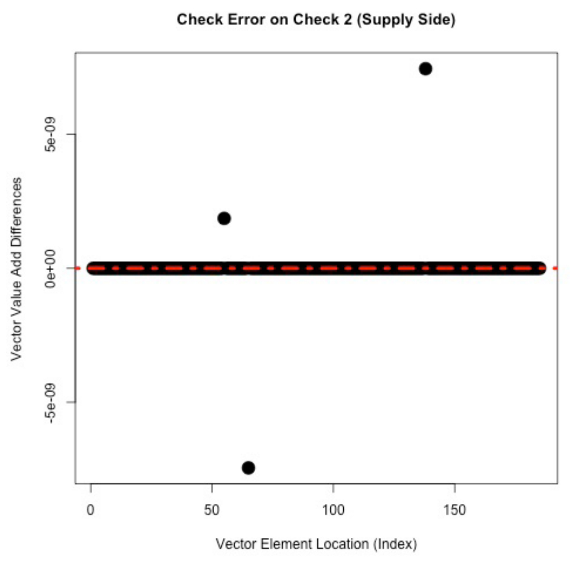
<tr><td>
</td><td>
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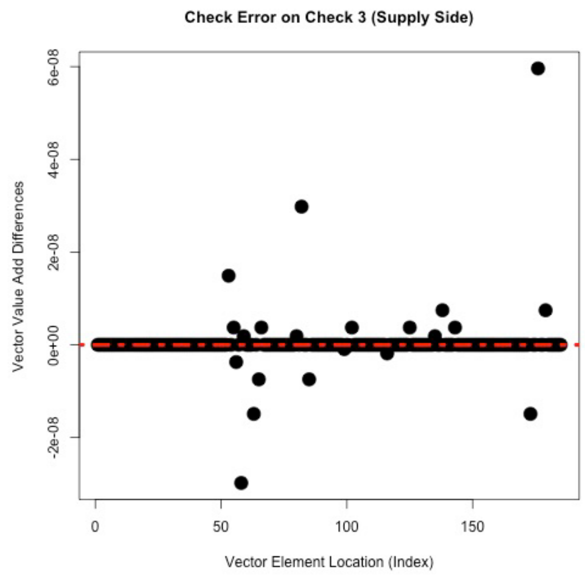
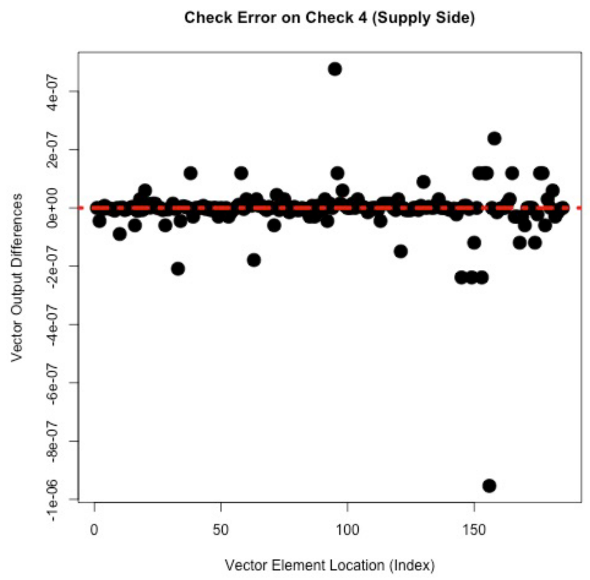
<tr><td>
</td><td>
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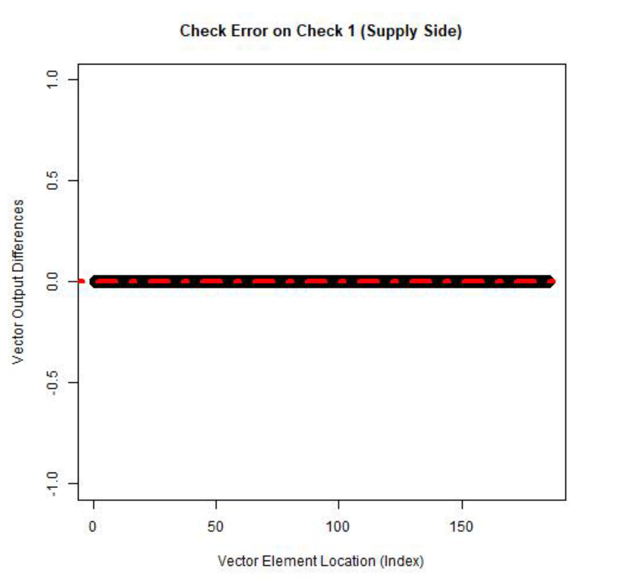
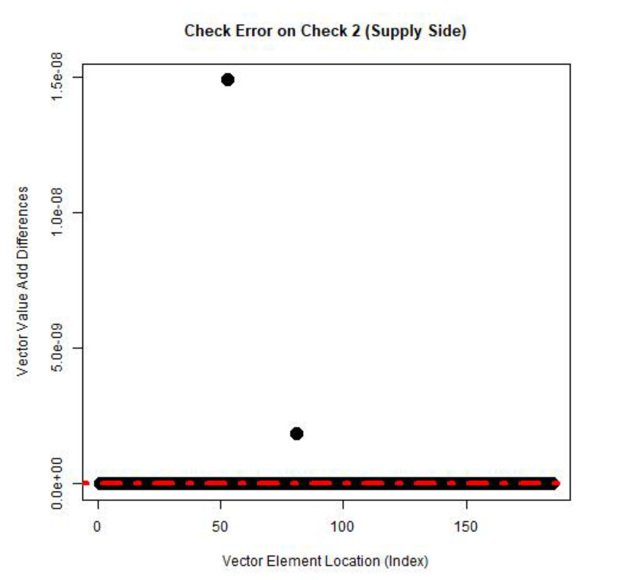
Structural Check on Indonesian IO Table type C (Supply Side)

Check Error 1 IO Indonesia	Check Error 2 IO Indonesia





Check Error 3 IO Indonesia	Check Error 4 IO Indonesia