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Multiplier Effects Analysis of Development on The High Speed Train Industry on Indonesia National Economic Growth

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Abstract: Improvement high speed train in Java is one of Indonesia's national development priorities, aiming to reduce carbon emissions compared to conventional trains to stimulate growth and development in other economic sectors. This research aims to understand the influence of high-speed train industry development on other economic sectors The multiplier effect was calculated using input-output method. It found that producing 1 train set escalates economic output by IDR 1,16 Trillion; raises total income by IDR 180 Billion and generates 2.800 laborers. The results suggest that the participation of manufacturing industry in producing trains will impact the country's overall economic progress.

Keywords: high-speed train; multiplier effect; output; income; labor

1. Introduction

Transport has a vital function in many other economic sectors[1]. Transportation sector has time utility and place utility benefits[2]. Time utility is benefit value that arise if a product was utilized at the right time. Place utility is defined as an increase in benefit value when a product is used elsewhere. People are doing their daily activities to fulfill their needs. In order to fulfill their needs, people need support from transportation sector since the activities centre are spread in different areas. Transportation integrates various sectors and positively impact on economic growth[3]. The determining factor in boosting the Gross Regional Domestic Product/GRDP is development of adequate transportation infrastructure. GRDP's economic growth rate is becoming greater from year to year[4]. Economic growth can be modeled as capital, labor and technology function. One way to measure the economic growth is by measuring percent rate of increase of Gross Domestic Product/GDP[5].

In the Attachment of President Regulation Republic of Indonesia (Perpres RI) No. 18 of 2020 regarding the National Medium-Term Development (RPJMN) for 2020-2024[6], it is stated that the average growth of the Indonesian economy is 5.0% per year, based on the calculation of financial advancement amid the usage of the National Medium-Term Development (RPJMN) for 2015 – 2019. The economic growth was driven by growth in various sectors, including the manufacturing/processing industry growing at an average of 4.2% per year, the agricultural industry growing at an average of 3.7% per year, the transportation industry growing at 8.9% per year, and the warehousing industry grew by 7.1% per year. The transportation and warehousing industry has a relatively large growth value compared to other industrial sectors. The processing industry which includes the processing of various materials into finished goods, including the manufacture of transportation facilities such as motor vehicles, ships, planes, and trains has a fairly high average growth rate. The growth in the processing industry will impact the growth of the transportation and warehousing industry.

Train as one of the modes of transportation has advantages in carrying capacity compared to other modes. Train has the advantage of larger load capacity compared to other modes of transport. In addition, the advancement of railway technology makes trains a faster, safer, more energy efficient, and eco-friendly mode of transport. The energy consumption and greenhouse gas (GHG) emissions produced by trains are lower than those of passenger cars using gasoline or diesel fuel. The energy consumption of gasoline cars is 70% higher than railway vehicles, while energy consumption of diesel cars is 50% higher. The difference (in energy consumption and GHG emissions) increases between road vehicles and trains as vehicle occupancy decreases[7]. Compared to high-tech trains and conventional trains, the amount of GHG emissions produced by high-tech trains with new renewable energy is significantly lower[8]. Using new rail lines with high-speed technology in China reduces GHG emissions by 1.75% in China's transport division. It

demonstrates the effect of high-speed rail on traffic and GHG outflows[9]. Alternative fuels significantly contribute to the energy mix in electricity power generation and as fuel in the transport sector among the targeted renewable energies. In the transportation sector, particularly motorist transport, the use of alternative fuels will have a significant impact, considering that the transportation division is the fastest-growing source of greenhouse gases outflows[10]. The NRE (new renewable energy) also offers benefits in social and economic aspects, including improving the quality of life in a rural area [11]. Energy use in developing countries tends to increase rapidly, so policies are needed to streamline energy, one of which is rail based transport sector with high speed technology policy on the island of Java[12].

One of targets for developing economic infrastructure to improve connectivity is prioritizing high-speed trains on the island of Java. In the President Regulation Republic of Indonesia (Perpres RI) No. 18 of 2020 regarding the 2020-2024 RPJMN, it is stated that goals of infrastructure development include connecting between production areas and distribution areas, increasing accessibility to tourist areas, creating new job chances, and gain the contributed value growth to the national economy.

The development of the railway sector can influence the growth and development of other economic sectors. The activities from the railway sector will induce the activities in other sectors and drive the other supporting industries. The growth can be in the form of increasing the production quantity and developing the quality of railway facilities and infrastructure. Improving innovation for high-speed rail facilities and infrastructure will affect the development of other financial divisions[13]. Regarding economic impact, the research found that HSR's infrastructure projects result in changes in land prices[14], an increase in economic diffusion of cities along the railroad, and changes in industrial structure[15]. It also indirectly affects regional innovation through accessibility[16] in rural areas[17].

A sector's contribution to the economy and the interrelationships between segments will portray the economic integration of a region. Comprehensive and sustainable economic integration between sectors is the key of economic development[18]. The interrelationships between economic sectors can be described through the Input-Output Table (Table I-O). The Input-Output table is a matrix that provides data related to exchanges of commodities and services and also the interrelationships between units of financial activity in a locale over a certain period. Statistical modeling for economic sector analysis can be done using the data presented in Table I-O. One of them is to measure the contribution of a sector in giving effect to other economic sectors or to calculate the multiplier effect[19].

Regression is another method than can be used to understand the relationship between variables. Hypothesis testing to measure the relationship/connection between dependent and independent variables can be conducted using multiple regressions[20]. In previous study, Agustin (2017) researched the influence of transportation sector on Gross Regional Domestic Product (GRDP), population, and the number of motor vehicles on the revenue from motor vehicle taxes in East Java Province. The analysis was performed using the multiple regressions method. The research findings revealed a significant positive relationship between the transportation sector on Gross Regional Domestic Product (GRDP), population, and the number of motor vehicles on the revenue from motor vehicle taxes in East Java Province[21].

In a previous study[22], Lee et al conducted an economic implications of four modes of transportation through input-output (I-O) analysis, particularly emphasizing their application in Korea. Using a model based on the Bank of Korea's I-O table from 2000-2010, Lee assessed the influence of transportation industries (including rail, road, water, and air) on the economy of Korea. Various impacts were measured quantitatively, such as the increase in production and the effects on prices within different sectors. For example, Transportation investment has a bigger impact on petroleum and equipment sectors. Next, the transport sector's rails and roads have a greater supply shortage effect than other transport sectors.

In this study, a multiplier effect was calculated using data from Indonesia Input Output Table 2016 to determine the contribution of the improvement of high-speed rail infrastructure has been identified as a critical factor contributing to the progress of diverse economic industries. Indonesia I-O Table 2016 data is compiled using Supply and Use Tables (SUT) 2016. The input-output data used is the Indonesia Input Output Table, because producing high-speed trains in Indonesia will involve numerous industrial sectors and other sectors across the country.

The geographical concentration of key railway-related industries such as assembly, bogie manufacturing, telecommunications, and propulsion in the Java region is notable. However, it is important to recognize that the railway industry's influence extends beyond these geographical boundaries. Sectors seemingly unrelated to railways, like education, play a significant role. It is particularly true for the developing skilled human resources in the railway domain, which often occurs outside Java. Institutions across various country regions provide the specialized education and training necessary for the railway industry.

Moreover, the connection between the railway industry and the coal mining sector is crucial. The generation of electricity, which powers trains and the entire transportation infrastructure, heavily relies on coal. Much of this coal supply comes from the Kalimantan and Sumatra regions. It highlights the intricate network of dependencies that comprise the railway industry's ecosystem.

Furthermore, the study's primary objective is to assess

the multiplier effects generated by the railway industry on the broader national economy. The multiplier effect is a concept in economics that describes how an initial injection of economic activity can lead to larger ripple effects through various sectors of the economy. By understanding the extent of this multiplier effect, policymakers and stakeholders can gain insights into the industry's role in driving economic growth.

The researchers use an Input-Output (I-O) table specifically designed for Indonesia's national economic structure to conduct this analysis. The I-O table provides a comprehensive framework to understand how different sectors of the economy are interconnected through the production and consumption of goods and services. This approach enables a holistic examination of the railway industry's economic impact and offers valuable insights into its contributions beyond geographical and industrial boundaries.

In previous study, Dwiatmoko (2020) investigated the effects of railway development on the national economy in Indonesia using input-output analysis. This study, which utilized data from Input-Output Data 2010, assessed the impact of investment in transportation service sector, broken down into railway, land, marine, river and crossing, and air transportation services[23]. Data for the transportation service sector were derived from national transportation operation data. However, in this current research, the multiplier effects was calculated using data from Input-Output Data 2016 for railway industry sector. Data for the railway industry sectors were based on the production of train vehicles manufactured in Indonesia. Table I-O Indonesia 2016[24]has data on Total Transactions based on Basic Prices from 185 products of the national economic sector, one of which is Railway products and their Repair Services. A total of 185 products are products from 17 economic sectors. Railway Products and Repair Services are included in the Processing Industry Sector. The current focus is to evaluate the impact of the highspeed rail industry on Indonesia's national economic growth by utilizing information obtained from Table I-O Indonesia 2016 on Railways and their Repair Services since the high-speed rail construction is still in progress. The present study aims to calculation and analyze the respective contributions of the train manufacturing and maintenance sector to national economic growth. This research has a high urgency, considering that the high speed train project has started running in Indonesia. Measuring the impact of the high-speed rail industry on the growth of the national economy through the multiplier effect can provide an overview to the government and the Indonesian people that the improvement of the HST industry will boost the national economy through higher output, income, and employment.

2. Method

The multiplier effect is divided into multiplier output, labor, and income. Input-Output Analysis Method is a method for calculating the multiplier effect[25].The amount of contribution is measured as a multiplier of output, labor, and income. The data used in the calculation were obtained from the Total Transaction Table based on Basic Price in Indonesia Input-Output Table 2016. The study methodology is shown in Figure 1.

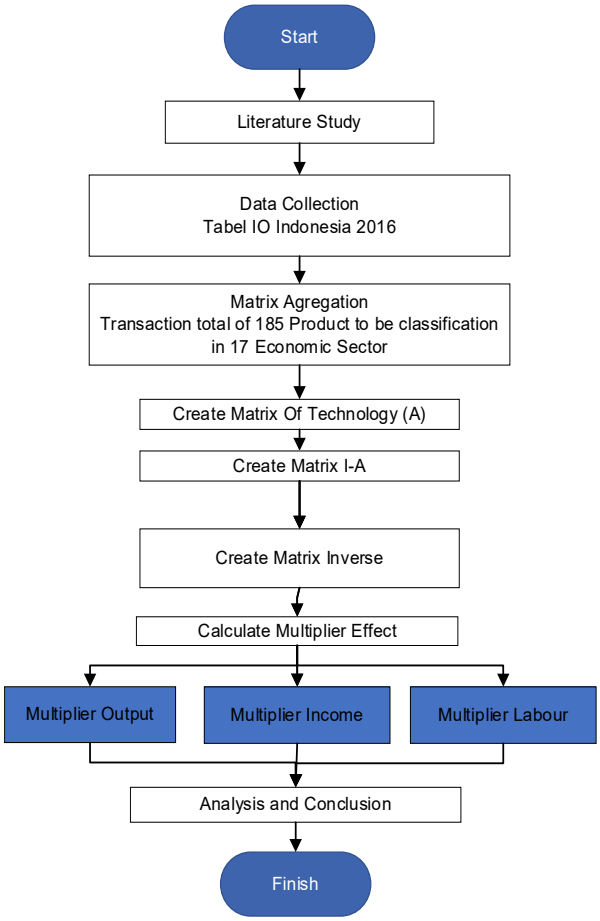

Fig. 1: Research Flow Diagram

2.1 Data Collection and Matrix Aggregation

This study uses data from the Indonesian Input-Output Table which consists of 185 x 185 products and aggregated into a matrix of 17 x 17 sectors. The format of the Input-Output Table illustrates in Table 1[26]. The symbol explanations for the equations used can be seen in the Nomenclature section.

Table 1. Structure of I-O Table

Input Source	Output Alocation				Total Supply	
	Intermediate Demand			Final Demand	Import	Sum Total Output
a. Middle Input	Production Segment			Quadrant II		
	Quadrant I					
Division 1	X11	X1j	X1m	F1	M1	X1
Division i	Xi1	Xij	Xim	Fi	Mi	Xi
Division n	Xn1	Xnj	Xnm	Fn	Mn	Xn
	Quadrant III			Quadrant IV		
b. Input Primer	V1	Vj	Vm			
Total Input	X1	Xj	Xm			

2.2 Create Matrix of Technology (A)

The technology coefficient matrix was calculated after the Indonesian Input Output Table 2016 was aggregated into a matrix of 17 x 17 sectors according to the classification of 17 economic sectors in Indonesia. The equation for technology coefficient matrix calculation is as follows. The symbol explanations for the equations used can be seen in the Nomenclature section.

$$a_{ij} = \frac{x_{ij}}{X_j} \quad (1)$$

2.3 Create Matrix I-A

The next step is to calculate the I-A matrix, by subtracting Identity Matrix (I) from the Input Coefficient Matrix (A).

2.4 Create Matrix Inverse

By performing the inverse operation on Matrix I-A, we get a Multiplier or Leontief Inverse Matrix. The Multiplier Matrix calculates the total sector change based on related sector production changes. Here is the equation. The symbol explanations for the equations used can be seen in the Nomenclature section.

$$B = (I - A)^{-1} \quad (2)$$

Technology coefficient matrix and multiplier matrix can be calculated in two kinds of analysis models: open and closed analysis. Open Model does not include labor fees or household income components in the coefficient matrix. The closed model includes labor fee and household income components in its coefficient matrix. This study used closed model analysis in the calculation.

2.5 Calculate Multiplier Effect

By performing the inverse operation on Matrix I-A, we get a Multiplier or Leontief Inverse Matrix. Factors that determine the amount of change in all sectors as an effect of a change in the total production of a related sector is represented in the Multiplier Matrix. The equation for multiplier matrix calculation is as follows. The next step is to calculate the effect multiplier based on the technology coefficient matrix and the multiplier matrix calculation results[27]. Multiplier analysis can be calculated for the output, income, and labor points of view with the calculation formula shown in Table 2[28]. The symbol explanations for the equations used can be seen in the Nomenclature section.

Table 2. Multiplier Calculation Equation

Mark	Multiplier		
	Output	Income	Labor
Initial Effect	1	h_i	e_i
First Effect	$\Sigma_i a_{ij}$	$\Sigma_i a_{ij} h_i$	$\Sigma_i a_{ij} e_i$
Total Effect	$\Sigma_i \alpha^*_{ij}$	$\Sigma_i \alpha^*_{ij} h_i$	$\Sigma_i \alpha^*_{ij} e_i$

3. Result and Discussion

3.1 Result

According to the Total Transaction Table based on Basic Price from Indonesia Input-Output Table 2016, there are a total of 185 products from the economic sectors in Indonesia. Transaction data of the 185 products is classified into 17 economic sectors. The industry of train and its maintenance is classified in the manufacture industry sector (code 3). The manufacture industry sector encompasses the processing of food products (livestock, fisheries, agriculture, and plantations), textile products, furniture products (wood), paper products, metal products, chemical programs (fertilizers, paints, cosmetics, and other chemical goods), pharmaceutical products, electronic products, motor vehicle products, shipbuilding and repair services, railway products/train and repair/maintenance services, aircraft products and repair services, and other manufactured products. Trains and maintenances are one of the products of the manufacturing industry. Trains and maintenances are indicated by code 133 in Input-Output Table. Data related to train products and repair/maintenance services (code 133) are separated from the broader manufacture industry sector (code 3) for conducted the multiplier effect analysis. In this analysis,

trains and maintenances are designated with code 3b, as shown in Table 3.

Table 3. Classification of the 17 Sectors

Code 17	Description	Code 185
1	Agricultural, Farm, Forestry, and Fishing	**1-36**
2	Mining and Quarrying	**37-52**
3	Manufacture industry 3 b. Train and Maintenance	**53-144**
4	Electricity and Gas Provision	**145-146**
5	Clean Water Provision, Waste Management, Waste and Recycling	**147-148**
6	Construction	**149-153**
7	Wholesale and Retail Trading; Car and Motorcycle Repairment Service	**154-156**
8	Transportation and Warehouse	**157-163**
9	Accommodation, Food and Beverages	**164-165**
10	Information and Communication	**166-169**
11	Financial and Insurance	**170-173**
12	Real Estate	**174**
13	Company Services	**175-176**
14	Government Administration, National Defense, and Essential Social Security	**177**
15	Education	**178,181**
16	Health and Social Welfare	**179,182**
17	Other Services	**180, 183-185**

Technology matrix (A) calculation is done based on the 17 sectors classification. The technology coefficient of each sector is calculated by dividing the number of transactions of each sector by the total input of all sectors in each column. Then, the I-A matrix is calculated by subtraction operation between Identity Matrix (I) and Technology Matrix (A). The I-A matrix is used to calculate the multiplier matrix. Leontief Inverse Matrix or Multiplier is obtained from the inverse operation of the I-A matrix.

One can obtain the output multiplier value based on the multiplier matix calculation. The output multiplier is calculated as the initial effect of each change unit, which is the increase or decrease of output in one monetary unit. Each element in the inverse matrix shows the total input, both direct and indirect, from a sector to the final demand. Output multiplier calculation using closed model analysis based on transaction data of 17 classified sectors in I-O Table 2016 is shown in Table 4.

Table 4. Output Multiplier (Closed Analysis)

Code	Sector	Multiplier Output
1	Agricultural, Farm, Forestry, and Fishing	2,37
2	Mining and Quarrying	2,26
3	Manufacture industry	2,97
3b	3 b. Train and Maintenance	2,91
4	Electricity and Gas Provision	3,48
5	Clean Water Provision, Waste Management, Waste and Recycling	2,10
6	Construction	3,10
7	Wholesale and Retail Trading; Car and Motorcycle Repairment Service	2,52
8	Transportation and Warehouse	2,87
9	Accommodation, Food and Beverages	2,97
10	Information and Communication	2,44
11	Financial and Insurance	2,50
12	Real Estate	1,80
13	Company Services	2,79
14	Government Administration, National Defense, and Essential Social Security	3,15
15	Education	3,06
16	Health and Social Welfare	3,03
17	Other Services	3,03

In the table it is stated that the output multiplier of the railway industry and maintenance is 2.91. This shows that if the ultimate request for trains increments by Rp. 1, then the output of the economy will increase by Rp. 2.91.

Income multiplier calculation is done by multiplying the inverse matrix and matrix from the division of labor compensation with the total input of each sector. The calculation of the income multiplier is shown in Table 5.

Table 5. Income Multiplier (Closed Analysis)

Code	Sector	Multiplier Income
1	Agricultural, Farm, Forestry, and Fishing	0,51
2	Mining and Quarrying	0,35
3	Manufacture industry	0,45
3b	3 b. Train and Maintenance	0,45
4	Electricity and Gas Provision	0,35
5	Clean Water Provision, Waste	0,27

Code	Sector	Multiplier Income
	Management, Waste and Recycling	
6	Construction	0,50
7	Wholesale and Retail Trading; Car and Motorcycle Repairment Service	0,51
8	Transportation and Warehouse	0,43
9	Accommodation, Food and Beverages	0,52
10	Information and Communication	0,39
11	Financial and Insurance	0,54
12	Real Estate	0,19
13	Company Services	0,53
14	Government Administration, National Defense, and Essential Social Security	0,67
15	Education	0,76
16	Health and Social Welfare	0,56
17	Other Services	0,66

Based on the calculation of the Income Multiplier shown in Table 5, it is found that every 1 unit of money from the final demand in the Railway sector's output will increase household income by 0.45 times.

Labor multiplier calculation is done by multiplying the inverse matrix and matrix by dividing the number of laborers with the total input of each sector[29]. The calculation of the labor multiplier is shown in Table 6.

Table 6. Labour Multiplier (Closed Analysis)

Code	Sector	Multiplier Labour
1	Agricultural, Farm, Forestry, and Fishing	0,026
2	Mining and Quarrying	0,006
3	Manufacture industry	0,013
3b	3 b. Train and Maintenance	0,007
4	Electricity and Gas Provision	0,006
5	Clean Water Provision, Waste Management, Waste and Recycling	0,013
6	Construction	0,012
7	Wholesale and Retail Trading; Car and Motorcycle Repairment Service	0,016
8	Transportation and Warehouse	0,012
9	Accommodation, Food and Beverages	0,020
10	Information and Communication	0,019
11	Financial and Insurance	0,008
12	Real Estate	0,004
13	Company Services	0,011
14	Government Administration, National Defense, and Essential Social Security	0,015
15	Education	0,018
16	Health and Social Welfare	0,015
17	Other Services	0,024

The labor multiplier shows the change in labor caused by the initial change in the output side. Every increase in one unit of labor in the basic sector will cahnge the total employment field of 0.007 times.

3.2 Discussion

Leontief Inverse Matrix contains information on the economic structure that can be analyzed by defining the relationship between sectors in the area. Based on the result of the output multiplier calculation (closed analysis) that is shown in Table 4, IDR 1 change in demand for the train manufacturing sector will affect the total economy output by IDR 2,9. If the price of a train set HST is IDR 400 billion then there is an increase in economy output by IDR 1,160 Trillion. Based on the income multiplier calculation shown in Table 5, each monetary unit from final demand in train manufacturing sector output will increase household income by 0,45 times. If the price of a train set HST is IDR 400 billion then there is an increase of income by IDR 180 Billion.The result of labor multiplier calculation using closed analysis, as shown in Table 6, found that with an increase of 1 final output from the production of a set of HST trains, it would result in an additional 0.007 times of labor. If the price of a train set HST is IDR 400 billion then there is an increase in employment of 2800 labor.

In line with Dwiatmoko's findings, the current research underscores that the railway transportation sector is not merely a stand-alone industry but rather an integral part of the larger economic framework[23]. The movement of goods, people, and resources facilitated by the railway system has far-reaching implications for tourism, manufacturing, and trade sectors. The multiplier effects generated by the railway transportation sector amplify its economic significance, as increased activity within this sector triggers positive changes throughout the economy.

By emphasizing the alignment with Dwiatmoko's study, the current research contributes to the accumulation of knowledge regarding the multifaceted impacts of sectors beyond industry on Indonesia's economic growth. This convergence of findings highlights the robustness and

consistency of these effects over time and reinforces the importance of considering holistic economic strategies that account for the interconnectedness of various sectors, including the pivotal role of railway transportation.

4. Conclusion

The contribution of train production in the Manufacturing Industry Sector can be measured by calculating the multiplier effect. The result appears that production of train as one of the the manufacturing industry's activities will impact national economic growth. Thus, it can be concluded that developments in the railway industry, such as high speed trains, will grant a multiplier impact on the national economy. The limitation of the current research is the data utilized, which is still based on railway product data from the entire manufacturing sector, rather than specific data from high-speed train products themselves. This is due to the absence of a dedicated manufacturing industry for high-speed trains in Indonesia. Additionally, the conducted multiplier effect analysis is based on effects stemming from the direct costs incurred in producing a train set unit, without accounting for other external costs.

External costs, such as those associated with environmental degradation and public health impacts, holds significant relevance within transportation systems and infrastructure. The emission of pollutants, including greenhouse gases and particulate matter, from transportation activities contributes to air pollution and climate change, resulting in a range of societal and economic consequences. By quantifying the reduction in external costs, particularly the cost savings achieved through emission reduction, future research endeavors can provide a more comprehensive assessment of the high-speed rail project's true economic and societal impact. As well as the inauguration of the Jakarta-Bandung high-speed rail approaches, a prime avenue for future research lies in conducting a comprehensive evaluation of the project's operational implementation. This study could encompass multifaceted assessments, including ridership patterns, socioeconomic effects on local communities, modal shift impacts, and the rail's contribution to sustainable urban development. The evaluation study should address the immediate impacts and offer insights into long-term sustainability.

Additionally, a careful analysis of potential challenges and operational hurdles would be crucial. It could encompass logistics management, passenger safety, ticket pricing strategies, and seamless integration with existing transportation networks. The evalution study would provide valuable insights for the continuously enhancing the high-speed rail system by identifying areas for optimization and addressing challenges proactively. This inclusive evaluation aids policymakers and stakeholders in making informed decisions that prioritize sustainable development and long-term societal well-being.

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Nomenclature

a_{ij}	Input coefficient of segment j from segment i (row i column j)
x_{ij}	Input utilization by segment j from segment i
X_j	Output of segment j
B	Multiplier Matrix
I	Identity Matrix
A	Input Coefficient Matrix
a_{ij}	Output coefficient
h_i	Household income coefficient
e_i	Labour Coefficient
α^*_{ij}	Leontif Closed Model Inverse Matrix

Subscripts

-1	Inverse Operation on Matrix

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