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Economic Linkage Between Rubber Plantation and Other Sectors In Indonesia

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Abstract

Rubber plantation as a part of the agricultural sector is one of the important sectors contributing to national GDP. This study aims to observe the economic linkage between rubber plantation and other sector in Indonesia by using input-output analysis approach. The result shows that the value of the backward and forward linkage coefficient of variation of the rubber plantation is respectively 0,80 and 1,54. The number of backward linkage coefficient of variation which is less than one indicates that backward linkage is low, while the number of forward linkage coefficient of variation which is more than one shows forward linkage of rubber plantation in the national economy is high. This condition describes the rubber plantation including as the forward orientation sector in the economy of Indonesia.

Keywords: backward linkage, forward linkage, rubber plantation

1. Introduction

In the structure of the national economy, there are some sectors that contribute significantly to Gross Domestic Product (GDP). Among them is the agricultural sector which is included in the third largest sector contributor to GDP after the manufacturing and trade, hotels and restaurants [1]. The agricultural sector is considered a crucial factor for achieving food self-sufficiency, sustainable economic growth, social and cultural progress, environmental preservation, as well as stability and security[2]. The achievement of agricultural development is evaluated by substantial growth in the sector and positive changes that lead to enhancements. This aims to resolve various agricultural-related problems [3].The magnitude role of agriculture in the Indonesia economy cannot be separated from some sub-sectors' support, one of them is the plantation sub-sector.

According Suwarto & Octavianty, plantation sub-sector is an important sector to boost the national economy and to solve various problems of national development, such as the problems of employment, poverty alleviation, provision of food and energy, equitable development, and environmental preservation [4]. One of the commodities to be considered in the plantation sector is rubber. Rubber is the main raw material for several important industries, including the tire industry, rubber shoes, medical equipment supplies, vehicles equipment, and other goods made of rubber. In Indonesia, the rubber plantations mostly run by smallholders (Smallholder Plantation). In addition, there are also large rubbers plantations managed by the government (Big State Plantation) and managed by private companies (Big Private Plantation). Indonesia is the third largest producer of natural rubber in the world after Thailand and Malaysia. Indonesia's rubber production in 2023 is estimated to reach 3.19 million tons, an increase from the previous year's production of 3.14 million tons. South Sumatra, North Sumatra, and Riau provinces are the three provinces with the largest rubber production nationally in 2023[5].

This is an attractive problem to be studied because of the magnitude production of Indonesia rubber should be used to develop downstream products of Indonesia rubber industry [6]. While in the reality, the absorption of downstream rubber industry in Indonesia is still below 20 percent of the total national rubber production. Therefore, it is necessary to study more about the economic linkages of rubber plantation between the upstream and downstream industries.

Spillane said that rubber business field services are also invited in the areas of shelter yield, transportation and services for the provision of various production facilities required by the rubber-producing regions. In addition, there are foodstuffs and other essentials for the well-being of millions of farmers and their families in the rubber-producing regions [7]. It shows the interconnectedness of the rubber plantation with other sectors in economy.

Therefore, the authors are interested to study how the economic linkages between the rubber with its upstream and downstream sectors in the structure of Indonesian economy. Thus, it can be mapped where the position of the rubber plantation in the national economy, is included as key sector, backward orientation, or forward orientation sector in Indonesia economy. The research from some literatures and journals on rubber plantations is limited in the economic feasibility's test (8,9). In order to research the economic linkage among sectors, input-output analysis is deemed as an appropriate tool to research it deeper than other analytical tools. From some research that has been done, the input-output analysis can be used to elaborate the interaction between sectors in the economy [9,10,19,11–18]. Understanding the interconnections between sectors in the economy is crucial because developing sectors with strong linkages to others indicates that these sectors can drive the growth of other sectors (10,11,13,17).

2. Material and Methods

The data used in this study is the Indonesia's Input-Output Table in 2016 obtained from the Badan Pusat Statistik (BPS) Indonesia, released in 2021 [18]. Input-Output table contains transaction's data among interrelated economic sectors. The output of a sector will be used as input to the production process by other sectors (downstream) and the sector itself. While to produce output, a certain sectors will require input from the upstream sectors. Table 1 below illustrates the relationship among interrelated sectors in an economy.

Table 1. Illustration of Input-Output Table Transaction with 3 Sectors

Output Allocation / Input Structure			Intermediate Demand: Production Sector (*j*) 1	2	3	Final Demand (*F*)	Summary Output (X_i)
Intermediate Input	**Production Sector (*i*)**	**1**	x_{11}	x_{12}	x_{13}	F_1	X_1
		2	x_{21}	x_{22}	x_{23}	F_2	X_2
		3	x_{31}	x_{32}	x_{33}	F_3	X_3
Primary Input (*Vj*)			V_1	V_2	V_3		
Summary Input (X_j)			X_1	X_2	X_3		

Source: BPS, 2021.

Where x_{ij} is the value of the demand's transaction between sector *j* to sector *i*, F_i is the final demand of the sector *i*, V_j is the primary input of sectors *j*, X_i is the total input, and X_j is the total output. On Input-Output, total input should be equal to total output (X_i=X_j).

The data is analyzed by using *input-output analysis.* The input-output theory provides a comprehensive framework for understanding the complexity of economic interactions and assists in making informed decisions for sustainable economic development [19] . Basic matter needed in

input-output analysis is the determination of input coefficients (a_{ij}). Input coefficient value is obtained by dividing demand side among each sector (x_{ij}) with a total input or total output (Xi). In summary, it can be written in the following formula.

$$a_{ij} = \frac{x_{ij}}{X_i} \tag{1}$$

The coefficient equation of input a_{ij} also can be written in input coefficient's matrix or matrix [A] like below.

$$\mathrm{A} = \begin{bmatrix} \mathrm{a}_{11} & \mathrm{a}_{12} & \dots & \mathrm{a}_{1\mathrm{n}} \\ \mathrm{a}_{21} & \mathrm{a}_{22} & \dots & \mathrm{a}_{2\mathrm{n}} \\ \vdots & \vdots & \vdots & \vdots \\ \mathrm{a}_{\mathrm{n}1} & \mathrm{a}_{\mathrm{n}2} & \dots & \mathrm{a}_{\mathrm{nn}} \end{bmatrix} \tag{2}$$

Input coefficient matrix describes the composition of intermediate input used by each sector in production. Then, for next input-output analysis matter, it needs matrix [I-A] or subtract summary between identity matrixes [I] and input coefficient matrixes [A].

$$[\mathrm{I} - \mathrm{A}] = \begin{bmatrix} (1 - a_{11}) & (0 - a_{12}) & \dots & (0 - a_{n1}) \\ (0 - a_{12}) & (0 - a_{22}) & \dots & (0 - a_{n2}) \\ (0 - a_{31}) & (1 - a_{21}) & \dots & (0 - a_{n3}) \\ \vdots & \vdots & \ddots & \vdots \\ (0 - a_{n1}) & (0 - a_{n2}) & \dots & (1 - a_{nn}) \end{bmatrix} \tag{3}$$

The result of matrix [I-A] in equation (3) is called by Leontief matrix. Furthermore, the Leontief matrix needs to be inversed to get Leontief inverse matrix (b_{ij}) as follows.

$$[\mathrm{I} - \mathrm{A}]^{-1} = \begin{bmatrix} (1 - \mathrm{a}_{11}) & (0 - \mathrm{a}_{12}) & \dots & (0 - \mathrm{a}_{1\mathrm{n}}) \\ (0 - \mathrm{a}_{21}) & (0 - \mathrm{a}_{22}) & \dots & (0 - \mathrm{a}_{2\mathrm{n}}) \\ (0 - \mathrm{a}_{31}) & (1 - \mathrm{a}_{32}) & \dots & (0 - \mathrm{a}_{3\mathrm{n}}) \\ \vdots & \vdots & \ddots & \vdots \\ (0 - \mathrm{a}_{\mathrm{n}1}) & (0 - \mathrm{a}_{\mathrm{n}2}) & \dots & (1 - \mathrm{a}_{\mathrm{nn}}) \end{bmatrix}^{-1}$$
$$= \begin{bmatrix} (b_{11}) & (b_{12}) & \dots & (b_{1n}) \\ (b_{21}) & (b_{22}) & \dots & (b_{2n}) \\ (b_{31}) & (b_{32}) & \dots & (b_{3n}) \\ \vdots & \vdots & \vdots & \vdots \\ (b_{n1}) & (b_{n2}) & \dots & (b_{nn}) \end{bmatrix}^{-1} \tag{4}$$

b_{ij} element is the basis for the calculation of subsequent analyzes in input-output analysis, such as linkage analysis and analysis of the impact of specific sectors in the economy. Within input-output framework, there are two kinds of economic linkages between sectors [20]. Both types of linkage analysis tools are backward linkage and forward linkage.

Backward linkage is an analytical tool to observe the relationship of the economic sector with other previous sectors as an input provider in their production. In other words, this analysis is used to determine the relationship between a sector and upstream sector in the economy. The amount of backward linkage can be seen from the backward linkage coefficient of variation (α_j). If the value of α_j is more than one, then the sector has a high backward linkage with the overall economy. The backward linkage coefficient of variation value can be determined by the following formula.

$$\alpha_j = \frac{(1/n)\sum_i \mathrm{b_{ij}}}{(1/n^2)\sum i \sum_{\mathrm{j}} \mathrm{b_{ij}}} = \frac{\sum_i \mathrm{b_{ij}}}{(\frac{1}{n})\sum i \sum_{\mathrm{j}} \mathrm{b_{ij}}} \tag{5}$$

Where α_j is the backward linkage coefficient of variation, b_{ij} is element of invers Leontief matrix, and n is amount of sector in economy.

Forward linkage is an analytical tool to observe forward relationship of an economic sector with other sectors. Forward linkage is used to determine an economic linkage a certain sector with other sectors which is an user of output sector in the economy (downstream sector). The amount of forward linkage can be viewed from the forward linkage coefficient of variation (β). If value of β an economic sector is more than one, then the sector has a high forward linkage with other sectors in the economy. The forward linkage coefficient of variation is calculated by the following formula.

$$\beta_i = \frac{(\frac{1}{n}) \sum_j b_{ij}}{(1/n^2) \sum i \sum_i b_{ij}} = \frac{\sum_j b_{ij}}{(1/n) \sum i \sum_i b_{ij}} \quad (6)$$

Where β_i is the forward linkage coefficient of variation, b_{ij} is element of invers Leontief matrix, and n is amount of sector in economy.

The function of economic linkage (backward linkage and forward linkage) is to determine the relationship between a certain sector and other sectors in the economy. If an economic sector is found out to have a high exposure, either it has linkages to the rear or to the front, it means that sector is a key sector to improve the regional economy. Nailufar explains that the key sector is the main sector that has most effectively acts as an engine of development in order to maintain sustainable development goals [21]. Key sector refers to the ability to drive and sustain growth and development throughout the economy. According to Reis & Rua, a sector is classified as a key sector if $\alpha_j > 1$ and $\beta_i > 1$. If a sector has $\alpha_j > 1$ and $\beta_i < 1$, it is classified by backward linkage orientation. In the other hand, a certain sector can be classified as forward linkage orientation if $\alpha_j < 1$ and $\beta_i > 1$ [22].

3. Results and Discussion

Based on Domestic Transactions Table of Basic Price in 2016, it is known that rubber plantation has interconnection to the upstream and downstream industries. Upstream industrial rubber is input supply industries for rubber plantation. From the analysis result of Indonesia's Input-Output Table in 2016, it is known that the upstream and downstream industries related to rubber plantation respectively is equal to 67 and 30 of the whole sectors in the Indonesian economy (185 sectors).

Sub sectors of fertilizer, services agriculture, fisheries and forestry, trade other than automobiles and motorcycles, financial services and banking, and rubber industries are the five upstream rubber industries with a big transaction value (Table 2). This indicates that the rubber plantation requires many inputs from those five upstream industries. Rubber plantations require the output of the upstream sectors to support the production process. To support the funding and capital, rubber plantations requires input in the form of funds from financial services sector and banking. For example, to expand the land, rubber plantation industry will need large financial support, so that the role of financial services and banking will be very important. The transaction value between fertilizer industry and rubber plantation sector is quite large and its position at first among upstream rubber industries (Table 2). It because fertilization is one of the most important activities in order to support the successfulness of rubber cultivation business. When plant phase has not produced latex yet, it should be fertilized well in order to speed up its growth, stem's diameter, bark thickness and plant height. Thus, the immature phase of rubber plant will run shorter so it can be tapped more quickly.

Table 2. Five Upstream Rubber Based On Largest Domestic Transaction Value Based On Basic Price

No.	IO code	Information	Transaction Value (Billion Rupiah)
1.	097	Fertilizer	2.574.427
2.	030	Services agriculture, fisheries and forestry	1.723.262
3.	156	Trade other than Automobiles and Motorcycles	1.221.981
4.	170	Financial services and banking	1.088.939
5.	018	Rubber	893.812

Source: Indonesia's Input-Output Table in 2016, processed.

Meanwhile, there are 5 of 30 downstream rubber industries that are related directly to the rubber plantation sub-sector with a big transaction value. Those five industries include crumb rubber and fume rubber, Initial driving machine, rubber, synthetic resins, plastic materials, and synthetic fibers, and maintenance and repair services for manufactured metal products, machinery, and equipment. From Table 3, it is known that the output of the rubber plantations is used by those five industries to be processed into further various products. The output produced from rubber plantations is the sap of rubber (latex) that obtained by tapping rubber trees (start from 5 years old). Latex is useful for paint and a variety of medical equipment and supplies in hospitals, such as pipettes, tubing stethoscope, gloves, and condoms [7].

From the overall downstream industries related to rubber plantation, crumb rubber and fume industry is an industry with the largest transaction value of the output of natural rubber (Table 3). This is because crumb rubber industry needs latex as an input for production process. Crumb rubber is a semi-finished material that will be processed into other goods. Some industries which need crumb rubber in the production process are tire industry, equipment industry, and household equipment. In addition, sports clothing industry also requires crumb rubber in order to make shoes, sandals, balls (volley ball, basketball, soccer ball), as well as wetsuits.

Crumb rubber and fume rubber play an important role in the overall rubber economy, helping to create added value from waste, enhancing sustainability, and providing broad economic benefits. Crumb rubber is rubber that has been recycled from used tires and other rubber products, then processed into small particles. Crumb rubber adds economic value by recycling rubber products that are no longer in use, reducing waste, and providing inexpensive raw materials for other industries. Crumb rubber is used in the production of rubberized asphalt, which improves the durability and quality of roads. Additionally, it is used in products such as sports flooring, mats, and other construction products.

Fume rubber is obtained through the pyrolysis process, where rubber waste is heated without oxygen to produce pyrolysis oil, gas, and carbon black residue. Fume rubber helps reduce the amount of rubber waste in landfills while also producing useful products such as pyrolysis oil, which can be used as an alternative fuel, and carbon black, which can be used in various industrial applications. The pyrolysis process provides an efficient and sustainable waste management solution, reducing dependence on fossil raw materials and creating added value from waste products. This also encourages innovation in the waste processing and rubber manufacturing industries.

Rubber is a highly important and versatile material, impacting various industries beyond the automotive sector. This makes rubber a strategic commodity in global trade. Rubber has significant connections with several other trade industries, such as the construction industry, household appliances industry, and medical and healthcare industry. In the construction industry, rubber is used in various products such as adhesives, sealants, waterproof coatings, and insulation materials. These products are essential for maintaining the integrity of buildings and infrastructure. In the household appliances industry, rubber serves as a raw material for various household products such as water

hoses, rubber mats, sandals, and gloves. These products are part of global trade due to consumer demand worldwide. Meanwhile, in the medical and healthcare industry, rubber is used as a raw material for medical products such as latex. Latex is used in the manufacture of surgical gloves, catheters, tourniquets, and various other medical devices. Overall, rubber plays a crucial role in various industries, making it a vital commodity in global trade.

Table 3. Five Downstream Rubber Industries Based On Largest Domestic Transaction Value Based On Basic Price

No.	IO code	Information	Transaction Value (Billion Rupiah)
1.	108	Crumb rubber and fume rubber	38.563.816
2.	128	Initial driving machine	2.346.136
3.	018	Rubber	893812
4.	098	Synthetic Resins, Plastic Materials, and Synthetic Fibers	690.092
5.	144	Maintenance and repair services for manufactured metal products, machinery, and equipment	635.674

Source: Indonesia's Input-Output Table in 2016, processed.

3.1 Backward Linkage

Bulmer & Thomas said that the aim of backward linkage is to measure the potential stimulus to other activities from investment in any sector *j* [23]. Backward linkage shows if the increasing of 1 unit of final demand from certain sector will increase the amount of domestic output produced by all sectors of economy. It means that the increasing of backward linkage from a sector will enlarge the output growth in all sector economy if there is an increasing in the final demand of that sector. Backward linkage from rubber plantation is the linkage of rubber plantation with its upstream industry which supplies input for rubber plantation sub sector. Based on analysis result, backward linkage of rubber plantation is 0,80 (Table 4). The value of rubber backward linkage describes that if there is an increasing of 1 unit in rubber's final demand, it will increase input demands equal to 0,80 unit from others sectors, including rubber plantation sub sector itself. Based on backward linkages analysis, rubber plantation has low linkage with input suppliers of its industry (upstream industry). It can be seen from the value of the backward linkage coefficient of variation which is still below one. It means that the backward linkage of rubber plantation is under average of overall economy.

Table 4. Backward Linkage Index Values

IO Code	Description	Backward Linkage Index
012	Sugarcane	0.82
013	Tobacco	0.87
014	Fiber crops	0.72
015	Other plantation products	0.73
016	Fruits	0.75
017	Medicinal plants	0.77
018	**Rubber**	**0.80**
019	Coconut	0.73
020	Palm oil	0.83
021	Coffe	0.75
022	Tea	0.81
023	Cocoa	0.75
024	Clove	0.77
025	Cashew	0.72

Source: Indonesia's Input-Output Table in 2016, processed.

Nonetheless, rubber plantation includes as a very important sector in the agricultural sector. It can be seen from the backward linkage coefficient of variation of rubber plantation which is above average in overall agricultural sector. Similarly, in the sub-sector of plantation, rubber plantation includes as a superior commodity among other commodities. Rubber plantation also has a value of backward linkage coefficient of variation which is more than the average of plantation sub-sector in Indonesia. Figure 1 below illustrates the comparative value of the backward linkage coefficient of variation of rubber plantation with the average of plantation sub-sector, the average of agricultural sector, and the average of overall economy sectors in Indonesia.

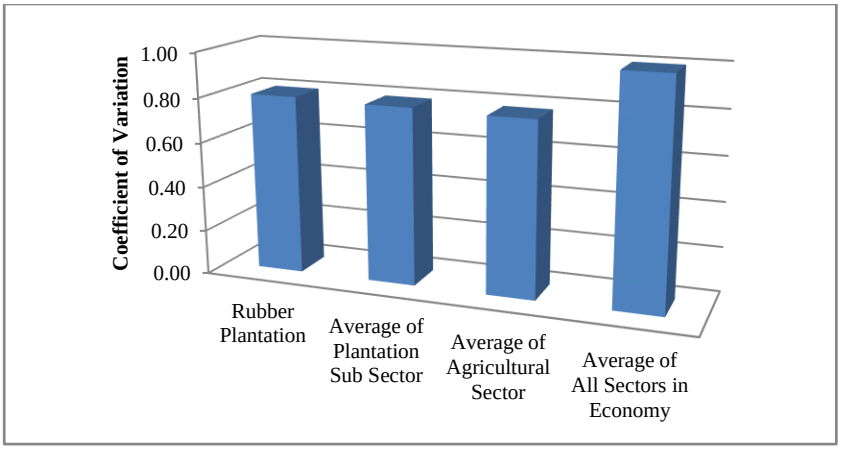

Figure 1. The Backward Linkage Coefficient of Variation

From the graph, it can be seen respectively that the backward linkage coefficient of variation of rubber plantation is above the average of plantation commodities and the average of the agricultural sector. But it is below value of the backward linkage coefficient of variation in overall economic sector. This illustrates that in general, the agricultural sector including plantation sub-sector and in particular the rubber commodity has a relatively low linkages with upstream industry in Indonesia. In other words, if there is a change of final demand in the rubber plantations sub-sector, the effect on the rubber upstream industry is still low. This condition also shows that the ability of the rubber plantation to pull previous input providers industries (upstream industries) is low.

3.2. Forward Linkage

Forward linkage describes a linkage of a certain sector with downstream sectors. The basic idea of forward linkage is to trace the output increases which occur or might occur in using industries when there is a change in the sector supplying inputs [23]. Forward linkage can be seen from the value of forward linkage coefficient of variation, where this value can be used to estimate the impact of economic growth on a certain sector. Forward linkage indicates if there is an increasing in final demand in all sector, the production of a certain sector will respond it by increasing output of the sector with multiple of linkage coefficient.

Based on the analysis, forward linkage of rubber plantation is relatively high because the value of forward linkage coefficient of variation is more than 1, namely 1,54 (Table 5). It means that each increase of one unit in the rubber plantation output, then the additional output will be distributed as an input to other sectors and rubber plantation itself so that it will raise the output of these sectors amounted to 1,29. This condition shows the rubber plantation has the ability to push the downstream industries to develop when there is an increase in the rubber plantation.

Table 5. Forward Linkage Index Values

IO Code	Description	Forward Linkage Index
012	Sugarcane	0.82
013	Tobacco	0.88
014	Fiber crops	0.62
015	Other plantation products	0.72
016	Fruits	0.99
017	Medicinal plants	0.69
018	**Rubber**	**1.54**
019	Coconut	0.92
020	Palm oil	1.45
021	Coffe	1.00
022	Tea	0.70
023	Cocoa	0.94
024	Clove	0.73
025	Cashew	0.63

Source: Indonesia's Input-Output Table in 2016, processed.

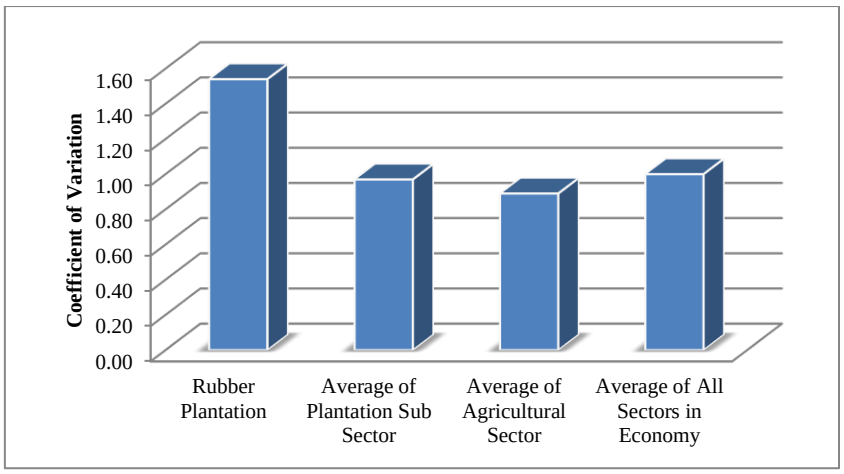

Figure 2. The Forward Linkage Coefficient of Variation

This high forward linkage coefficient of variation also shows that the rubber plantation has important role in supporting the advancement of the national economy, especially in agriculture sector. It because the forward linkage coefficient of variation of rubber plantation is above the average of plantation sub-sector, the average of agricultural sector and the average of the overall national economy in a whole. This condition also shows that the ability of the rubber plantation to push downstream industries is high.

3.3. Classification of Rubber Plantation in Indonesian Economy

As has been explained before, the rubber plantation has a low backward linkages and high forward linkages with the other sectors of the Indonesian economy. In summary, the explanation can be seen in Table 4 below.

Table 4. Classification of Rubber Plantation in Indonesian Economy

Linkages		**Forward Linkages**	
		Low(β<1)	**High**(β>1)
Backward Linkages	**High**(α>1)	-	-
	Low(α<1)	-	**Forward Orientation Sector** (α=0,80 and β=1,54)

Source: Secondary Data Analysis

Based on Table 4, it is known that rubber plantation includes in the classification of sectors that are forward orientation in the Indonesian economy. Therefore, efforts should be made to support the rubber plantation into a key sector in the economy. The high forward linkage indicates that the output of rubber plantation is widely used by other sectors directly (direct forward linkage). In addition, the high forward linkage also illustrates that the rubber plantation sub-sector role in meeting the final demand of all sectors in the economy (indirect effect). Each increase of one unit of output at a rubber plantation, then the additional output will be distributed as an input to other sectors and the rubber plantation itself so that it will raise the output of these sectors directly or indirectly. High forward linkage also shows that the rubber plantation sector is sensitive to the economy, if there is a changing in final demand in the economy as a whole in Indonesia.

Rubber in Indonesia is classified under "forward linkage orientation" due to its pivotal role as a primary raw material for diverse downstream industries that produce valuable end products. This interconnectedness generates employment opportunities, boosts export value, and enhances economic diversification, positioning rubber as a crucial commodity in Indonesia's economic landscape. Natural rubber cultivated in Indonesia undergoes processing and serves as a foundational material across various sectors, yielding a range of value-added goods that bolster different segments of the economy. Economically, the rubber sector and its downstream activities foster employment across production stages, spanning from plantations to the manufacturing of finished goods. The transformation of natural rubber into higher-value downstream products elevates national income and contributes significantly to GDP. Moreover, processed rubber products command robust demand in global markets, thereby supporting increased foreign exchange earnings through exports. By nurturing the growth of diverse downstream industries reliant on rubber, Indonesia aims to diminish its dependency on raw material exports while fortifying economic resilience.

4. Conclusion

4.1 Conclusion

From the discussion above, it can be concluded that the rubber plantation includes in the classification of a forward orientation sector in the Indonesian economy. It is because rubber plantation has a high relationship to the downstream industry, although the relationship with the upstream industry is still low. Thus, it is needed the development for domestic downstream rubber industry because it still has an inadequate number of downstream rubber industry in Indonesia. If the downstream rubber industry continues to be developed in Indonesia, it is expected to support the advancement of the economy in Indonesia.

4.2. Suggestion

Rubber plantation development needs to be improved, because it has a high relationship to downstream industry in the future. The high forward linkage coefficient of variation value indicates that the domestic market for the rubber plantation commodity actually needs to be fulfilled optimally.

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