Research on World Agricultural Economy
https://journals.nasspublishing.com/index.php/rwae

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An Empirical Study on Indonesia's Participation in the Global Rubber Value Chain

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ABSTRACT

Rubber is a key plantation commodity with extensive markets in global trade and a significant contribution to Indonesia's economy. Over the last decades, the development of Indonesia's natural rubber value chain has been hampered by several national and international problems, which have affected Indonesia's position and participation in the global rubber trade. This study utilizes two datasets from the Multi-Regional Input-Output (MRIO) of the Asian Development Bank (ADB) databases to assess Indonesia's participation and position in the international rubber industry value chain between 2015 and 2022, then compares the results with 35 countries trading with Indonesia. The analysis reveals that compared to 2015, Indonesia's 2022 position in the global rubber value chain declined due to weaknesses in the upstream and downstream sectors. While it continued to contribute to the global rubber market, Indonesia was consistently outperformed by other rubber-producing countries. Indonesia can yet increase the rubber industry's added value by promoting innovation and increasing domestic production. This paper concludes with policy recommendations for Indonesia to enhance its participation in the global rubber value chain, emphasizing improvements in the downstream sector by adopting good agricultural practices and applying advanced technologies, and strengthening the upstream sector by boosting domestic consumption of rubber.

Keywords: Global Value Chain (GVC); Rubber Industry; Participation of GVC; Position of GVC

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ARTICLE INFO
Received: 10 April 2025 | Revised: 30 May 2025 | Accepted: 15 July 2025 | Published Online: 14 October 2025
DOI: https://doi.org/10.36956/rwae.v6i4.1828

CITATION
Agustina, D.S., Nurmalina, R., Fariyanti, A., et al., 2025. An Empirical Study on Indonesia's Participation in the Global Rubber Value Chain. Research on World Agricultural Economy. 6(4): 497–512. DOI: https://doi.org/10.36956/rwae.v6i4.1828

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1. Introduction

Rubber (*Hevea brasiliensis*) is a key plantation commodity with a strong presence in global trade, serving as an essential raw material for various natural rubber-based industries. Its unique elasticity and heat resistance make it indispensable [1], particularly in high-tech rubber industry products that require a substantial proportion of natural rubber [2, 3]. The global rubber industry has generated significant trade flows, contributing to employment and revenue for producing countries [4, 5]. In 2021, the supply of natural rubber reached 14.05 million tons [6] while demand grew by 3%, increasing from 7.11 million tons in 2000 to 12.69 million tons in 2022 [7]. It shows a potential for further development of the natural rubber sector. As economies in developing countries grow and crude oil prices rise—making synthetic rubber more costly—the demand for natural rubber is expected to rise [8].

Southeast Asia has emerged as the hub for global natural rubber production due to its advantageous social, economic, and environmental conditions [9]. While natural rubber is originates from the Amazon Basin, nearly 90% of the world's supply comes from Asian countries, with 70% sourced from Southeast Asia [10]. In 2021, 76% percent of natural rubber was produced by Thailand, Indonesia, Vietnam, China, and India [11], followed by Malaysia, Cambodia, the Philippines, and Sri Lanka. The Ivory Coast in Africa leveraged its production in 2019, seeking to compete with Malaysia, China, and India in 2021 [12]. In the global market, Indonesia ranks as the second-largest producer and exporter of natural rubber after Thailand. In 2023, rubber production from Thailand, Indonesia, and the Ivory Coast was 33%, 18.48%, and 11%, respectively [13]. Approximately 85% of Indonesia's natural rubber exports go to countries like the US, Japan, China, India, and South Korea, with the remaining 15% used for domestic manufacturing, particularly in the automotive sector [14]. SIR crumb rubber, the main raw material for tires, makes up 95% of Indonesia's natural rubber exports, followed by SIR 20 exports at 91% in 2022 [11].

As these countries are competing to be the top supplier of natural rubber, they face challenges from global trade regulations regarding the standard for rubber commodities in international trade. Over the past decade, rubber-producing countries have faced significant rubber price volatility, which has generally followed a declining trend. This low rubber price has led many smallholders in Indonesia, who account for over 90% of the country's rubber production, to abandon rubber farming in favor of other activities [15]. It may include converting a rubber plantation to other crops or seeking non-agricultural work. This shift has negatively impacted natural rubber production in Indonesia, resulting in a decline from 2015 to 2022, which has affected export volumes and Indonesia's role in the global rubber market. The key question this study aims to answer is "What is Indonesia's current participation and position in the global natural rubber value chain, and how has this changed between 2015 and 2022?".

According to the study of Alfaridzi [16] in 2015, Indonesia's rubber industry was primarily in the upstream sector, with a tendency to move backward (import goods) instead of forward (export goods) in the Global Value Chain (GVC), largely due to the rubber and plastic sector's limited contribution to the GVC. In line with this result, the study of Kemala [17] showed that in 2022, the rubber and plastic sector is more capable of stimulating production growth in upstream production than in downstream activities. While some previous studies have sought to clarify Indonesia's involvement in the GVC for rubber, they have primarily relied on data from ICIO and MRIO databases. This study tries to provide a more detailed analysis compared to the previous study by calculating the inverse matrix table rather than just calculating only the available data in MRIO. Addressing this research gap, this paper adopts a theoretical framework of Koopman [18] to assess the current standing and participation of Indonesian's natural rubber industry in the GVC, comparing its forward and backward linkages with 35 other countries.

In an increasingly interconnected world, understanding the interactions between economies and their environmental consequences is crucial [19]. Global trade and the integration of global supply chains have created complex economic ties that extend beyond national and regional borders [20]. By examining Indonesia's position and participation in the global rubber market, we can

identify opportunities and challenges for the industry and enhance its competitiveness by optimizing its role. The findings are intended to inform policy recommendations for stakeholders invested in the rubber industry's development.

The paper is structured into four sections. Following the introduction, a literature review examines the GVC and Indonesia's participation. The third section outlines the methodology and data used in the study, while the result section discusses Indonesia's role in the global natural rubber value chain, and proposes ways to enhance its involvement and position.

2. Literature Review

2.1. Concept of Global Value Chain (GVC)

The value chain is a sequence of processes or activities that transform goods or services from their initial conception through various production stages, assembly, processing, and delivery to the end consumer, ultimately leading to disposal or recycling[21, 22]. This process involves a network of interconnected actors—primary producers, processors, traders, and service providers. The concept of value chain, popularized by Porter[23], illustrate a company's competitiveness by examining its production process, which includes product design, input provision, logistics (both inbound and outbound), marketing operations, after-sales service, and supporting activities like company infrastructure, human resources management, technology development, and procurement. When these activities take place within a complex, global context across multiple countries, the concept of GVC emerges.

GVC refers to the extensive network of operations and transactions within and between firms that convert raw materials into intermediate products and final goods[24]. Introduced by Gereffi et al. (2001), the GVC framework analyzes the global expansion and geographic fragmentation of modern supply chains, emphasizing the relationships among multinational companies, lead firms, and other business actors in an international context. GVC has been adopted by prominent researchers in different fields. Unlike traditional production methods, participation in GVCs involves firms specializing in specific activities, with multiple firms across different countries collaborating to produce the final products. For example, Japan supplies the technology for automotive vehicles, Vietnam assembles the components, and Indonesia produces and markets the cars within the country.

The GVC was first explored in a study using the global commodity chain (GCC) framework[25]. Gereffi's 1994 study using this framework highlighted not only the geographic spread of transnational production arrangements but also the organizational aspects, such as the relationships among economic agents, including the raw material suppliers, manufacturers, traders, and retailers. It is to understand the sources of stability and change. The GCC framework consists of three main dimension: 1) input-output structure, which connects a series of products and services through a set of value-adding economic activities; 2) territoriality, referring to the spatial distribution or concentration of production and distribution networks consisting of companies of various sizes and types; and 3) governance structure, which defines the authority and power relationships that determine how financial, material, and human resources are allocated and flow within a chain. In the early 2000s, GCC researches began to shift focus from commodities such as garments, shoes, and cars to the examination of value chains that link manufacturing activities across various regions.

The GVC framework has been applied across various fields of study. Economic sociology examines the social impacts of economic trade, mapping governance structures, and defining GVC typologies and their implications for regional improvement[26–28]. The literature on GVC in international economics emphasizes the efficiency of contractual organization and economic exchange, as well as the mapping of international trade flows and value creation[29–33]. In international business studies, the GVC framework primarily explores how firms establish cross-border business relationships through the activities of multinational corporations, enhance their firm-specific advantages, and derive value from these endeavours[34–37]. Thus, the study of GVCs can be integrated with several academic disciplines. Understanding GVCs not only clarifies global production

structures and the interconnections among industries and actors involved but also helps grasp the dynamics and socio-economic impacts occurring within a value chain. The integration of GVC studies with various fields can aid in understanding how GVCs influence different aspects to develop more effective and sustainable policies.

Several researchers in Indonesia and Nigeria have employed the GVC framework to study rubber commodities. For instance, analysis using the GVC framework revealed that Indonesia primarily participates as a supplier of raw materials, with much of its industry still relying on low technology [16, 38]. These studies showed that Indonesia's rubber industry is closer to upstream activities, showing a higher backward GVC value (importing goods) compared to a forward GVC value (exporting goods). Accordingly, the study suggests fostering public-private cooperation and implementing reforms that create a stable investment climate to enhance Indonesia's GVC participation within the Regional Comprehensive Economic Partnership (RCEP) and boost trade.

Another study examined four dimensions of the GVC—input-output structure, geographic scope, governance, and institutional context—to investigate the decline of Indonesia's rubber exports to the US in 2013 [39]. In this study, factors contributing to the reduction of export value, including high demand for rubber from consumer countries like China, the United States, and European regions, are developing the automotive industry. This study recommends that rubber companies in Indonesia leverage advanced technology to increase production capacity and enhance their competitiveness in the global market. Additionally, the GVC framework has been used to link green productivity and sustainability assessment in the rubber downstream sector, specifically in motorcycle tyre production [40]. To improve productivity in Indonesia's rubber value chain through environmentally-friendly strategies, it is suggested to integrate aspects of natural rubber cultivation, enhance latex production, and minimize waste. In Nigeria, the natural rubber value chain has been mapped to identify the roles of various actors, existing marketing channels, marketing margins for each value-adding activity, and constraints faced at different stages of the value chain [41, 42].

In recent decades, there has been an increase in international trade, primarily propelled by global value chains. These chains facilitate the trade of finished products, semi-finished goods, and services [30] through a series of stages involving multiple countries engaged in the GVC. The structure of global value chains has changed substantially in recent years, shaped by trade liberalization, deregulation, and technology advancement. These shifts have altered the way multinational corporations operate and compete in the global marketplace [43], creating a more fragmented process with different production stages frequently taking place in various countries. In a world where globalization has made everything more interconnected, it is crucial to understand the interactions between economies and their environmental impacts [19]. Global trade and the integration of global supply chains have established intricate economic connections that extend beyond national and regional borders [44].

2.2. Participation in Global Value Chain (GVC)

The participation of a country, industry, or firm in the GVC is indicated by its involvement in vertically fragmented production. This type of production involves multiple companies, situated in different countries and geographic regions, in the production process of a good or service, with each company specializing in a particular area and working interdependently to produce the final product. A country's GVC involvement reflects its participation level: low participation means basic processing with little added value, while high participation indicates the opposite. Regardless of the participation level, involvement in GVC is essential to bring growth opportunities to a country's economic development [45]. For example, the participating countries can gain global market access, economic integration without building the entire export industries, and focus on specific industrial value tasks, which ultimately leads to job creation, GDP boost, more productive capacity through technology transfer and skill development, industrial advancement [46], and sustainable development [47]. For developing countries, participation in GVC leverages their standing to increase productivity, income, and diversification of export commodities [48–50]. These nations can inte-

grate themselves into a global production network even without having all the relevant knowledge, technology, and resources for the production process [51]. Ultimately, developing countries that were previously engaged in menial tasks can now enter a more modern manufacturing sector which requires more advanced resources and technology [52–54].

Hummels et al. [55] first introduced GVC participation at the country/industry level, suggesting vertical specialization of the production process via imported inputs for export production or exported intermediate goods. However, their assumption of consistent imported inputs use and entirely foreign-sourced inputs limited their approach's relevance, especially given outsourcing in developing countries and value-added in developed nations' imports. Koopman [18] addressed these limitations by dividing exports into five components: domestic value-added in final goods and services, domestic value-added in the export of intermediate goods for domestic use, indirect value-added exports, domestic value-added re-exported to the source country, and foreign value-added. Furthermore, Koopman [18] defined GVC participation at the country/industry level based on the origin of value added in the total exports: via backward linkages (imports for exports) and forward linkages (exported intermediate goods). The backward and forward linkage approach has been applied as a powerful instrument for tracking changes in global production trends, understanding the connections between scattered activities and industrial organizations, and identifying their roles in various countries within the current global industrial landscape [44, 56, 57]. Economic research has consistently focused on exploring these connections, with the input-output (IO) model as the vital tool, and other studies use indicators based on backward linkages and forward linkages [16, 38, 58, 59].

A country or sector's participation in GVC is measured with several tools. These include the World Input-Output Database (WIOD) [58], the Trade Value Added (TiVA) database from the Organization for Economic Cooperation and Development (OECD) [60], the Multi-Region Input-Output (MRIO) database developed by the United Nations Conference on Trade and Development (UNCTAD) [44, 57], and the MRIO database from the Asian Development Bank (ADB) [17, 56]. The ADB's MRIO is one of the most current GVC trade datasets, updated as of 2022, including statistics on 35 industries and services, such as the rubber and plastic industry, across 62 countries, including Indonesia. GVC analysis is performed at the business, national, and sectoral levels [61] to understand a country/industry's standing in the GVC of international production networks [62, 63]. Accordingly, ADB's MRIO is a relevant and up-to-date resource for understanding Indonesia's participation, along with that of other countries, in the global natural rubber value chain. It can help offer policy recommendations that promote sustainable production practices within GVC, effective urban planning, strong governance, and investment in environmentally friendly infrastructure.

3. Methodology

3.1. Data Source

This research utilized the Multi-Regional Input-Output (MRIO) dataset from the Asian Development Bank (ADB), particularly comparing data between 2015 and 2022, where Indonesia experienced a decline in rubber prices in both years while seeking a recovery opportunity in the years to come. While this study primarily examined Indonesia's role in the rubber GVC, it compared and contrasted Indonesia's participation with 35 other countries engaged in trade: Thailand, Vietnam, India, China, Malaysia, Philippines, Cambodia, Japan, United States, Korea, Turkey, Canada, Brazil, Mexico, Belgium, Germany, Italy, Poland, Taiwan, Australia, United Kingdom, France, Netherlands, Singapore, Czechia, Spain, Russia, Sweden, Finland, Austria, Switzerland, Hungary, Norway, and RoW (rest of the world).

3.2. Indicators of GVC Participation

As mentioned in the literature review, the indicators of GVC participation focus on backward and forward linkages. In the backward linkage (the user's perspective), a country's participation is evaluated from the volume of intermediate goods it imports for domestic production. The forward linkage (the provider's perspectives) assesses a country's role in supplying intermedi-

ate inputs to other nations for further production.

We applied the decomposition framework detailed in Wang et al.[59] to create indices for forward and backward GVC participation by dissecting value-added and final goods within an inter-country input–output (IO) model. Our approach was grounded in the traditional world multi-regional IO accounting framework as outlined in Miller and Blair[64] and **Table 1**, encompassing n countries and m sectors (or industries) per country. The output of each sector is determined using domestic production factors and intermediate inputs, which may be sourced domestically or internationally. At the same time, this output is the intermediate input for production or final demand in the domestic and international markets. In market equilibrium, the value of a product produced in a specific sector of a country must be equal to the value of that product used both domestically and internationally.

Table 1. The general table of multi regional input-output.

	Intermediate Demand/Input								**Final Demand**								**Outputs**
	Country 1	Country 2	... ...	Country r	...	Country s	... ...	ROW R	Country 1 F_1	Country 2 F_2	... ...	Country r F_r	...	Country s F_s	... ...	ROW R F_R	X
Country 1	X_{11}	X_{12}	...	X_{1r}	...	X_{1s}	...	X_{1R}	Y_{11}	Y_{12}	...	Y_{1r}	...	Y_{1s}	...	Y_{1R}	X_1
Country 2	X_{21}	X_{22}	...	X_{2r}	...	X_{2S}	...	X_{2R}	Y_{21}	Y_{22}	...	Y_{2r}	...	Y_{2s}	...	Y_{2R}	X_2
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Country r	X_{r1}	X_{r2}	...	X_{rr}	...	X_{rs}	...	X_{rR}	Y_{r1}	Y_{r2}	...	Y_{rr}	...	Y_{rs}	...	Y_{rR}	X_r
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Country s	X_{s1}	X_{s2}	...	X_{sr}	...	X_{ss}	...	X_{sR}	Y_{s1}	Y_{s2}	...	Y_{sr}	...	Y_{ss}	...	Y_{sR}	X_s
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
ROW R	X_{R1}	X_{R2}	...	X_{Rr}	...	X_{Rs}	...	X_{RR}	Y_{R1}	Y_{R2}	...	Y_{Rr}	...	Y_{Rs}	...	Y_{RR}	X_R
Value-added	V_1	V_2	...	V_r	...	V_s	...	V_R									
Total inputs	X_1	X_2	...	X_r	...	X_s	...	X_R									

In the form of an equation, the input output table is presented as follows:

$$\begin{aligned} x11 + x12 + ... + x1n + F1 &= X1 \\ x21 + x22 + ... + x2n + F2 &= X2 \\ xn1 + xn2 + ... + xnn + Fn &= Xn \end{aligned}$$

In general, the Equation (1) is reformulated as:

$$\sum_{l=1}^{k} (xkl + Fk = Xk; k = 1, 2, 3, \ldots n) \qquad (1)$$

Where:

Xkl : The quantity of output from country k utilized as input by country l

Fk : Final demand for country k

Xk : Total output from country k

n : Number of countries

If the technical coefficient matrix is known to have the following Equation (2):

$$\text{akl} = \frac{xkl}{xl} \ldots\ldots \qquad (2)$$

Then substituting Equation (2) into Equation (1) will produce the following equations:

$$\begin{aligned} a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n + F_1 &= X_1 \\ a_{21}X_1 + a_{22}X_2 + ... + a_{2n}X_n + F_2 &= X_2 \\ .. \\ .. \\ a_{n1}X_1 + a_{n2}X_2 + ... + a_{nn}X_n + F_n &= X_n \end{aligned}$$

The simplified Equation (3) is:

$$\text{AX} + \text{F} = \text{X or } (\text{I} - \text{A})\text{X} = \text{F or X} = (\text{I} - \text{A})^{-1}\text{F} \qquad (3)$$

Where:

I : Identity matrix

F : Final demand

X : Quantity of Output

(I-A) : Open Leontief matrix

(I-A)-1 : Inverse of Leontief matrix

On this analysis, a country's position is illustrated by the predominance of forward and backward linkages in the GVC trade. Additionally, the contribution of each nation throughout an industry's production process highlights that country's level of participation.

This study utilized the method suggested by Linh and Huong[44] to assess Indonesia's involvement in the GVC of rubber using four indicators: (i) Index of backward linkage; (ii) Index of forward linkage; (iii) Position index; and (iv) Participation index. The formula is as followed:

$$\text{Index of backward linkage} = \frac{\text{FVA}}{\text{GE}}$$

$$\text{Index of forward linkage} = \frac{\text{DVX}}{\text{GE}}$$

$$\text{Position in GVC} = \log\left(1 + \text{DVX/GE}\right) - \log\left(1 + \text{FVA/GE}\right)$$

$$\text{Participation in GVC} = (\text{DVX/GE}) + (\text{FVA/GE})$$

Where:

FVA = foreign value-added earned from abroad transaction and shown in total exports

DVX = domestic value-added present in the export of intermediate goods which the importer uses directly to manufacture products and then exports to other countries

GE = stands for the total exports of the country in question

Position in GVC = the Position index in the GVC

Participation in GVC = the Participation index in the GVC

The index of backward linkage is indicated by the imports of foreign inputs or intermediate goods used in the production of exported products. Conversely, the index of forward linkage is represented by the exports of intermediate goods that importers further utilize to produce goods for export to another country.

4. Results and Discussion

4.1. Indonesia's Natural Rubber Industry Participation in the Global Value Chain (GVC)

The result of the study showed that in 2015, Indonesia's backward participation outweighed its forward participation in the GVC of the natural rubber industry. Indonesia's ranking in the backward and forward participation index was 34th and 27th out of 35 countries, scoring 0.57 and 0.31, respectively. Based on the combined forward and backward indices (0.88), Indonesia's overall involvement in GVC was ranked 32nd (**Figure 1**). Three other major producers of natural rubber—Thailand, Vietnam, and Malaysia—exhibited higher participation indices in backward and forward categories, in which Thailand leads in the forward participation index, while Malaysia and Vietnam had a more prominent backward participation. It is important to note that this study excluded the calculation of margin of error, standard deviation, and confidence level.

The 2022 analysis revealed that Indonesia was ranked 26th and 21st in the GVC forward and backward participation index, scoring 0.27 and 0.65, respectively (**Figure 2**). The combined forward and backward participation indices (total index of 0.92) placed Indonesia 28th in GVC. Similar to the 2015 results, Indonesia's backward participation in 2022 still outweighed the forward participation. While 2022's scoring marked a relatively significant increase compared to that of 2015, Indonesia's backward participations remained lagging behind Thailand, Vietnam, and Malaysia.

Upon closer investigation, we identified several factors contributing to Indonesia's more prominent backwardness in the GVC for natural rubber compared to its forward participation. First, the natural rubber industry in Indonesia faces numerous challenges. Production is declining due to the outbreak of Pestalotiopsis diseases in nearly all natural rubber-producing provinces. This has led to a substantial drop in production, prompting many farmers to convert their rubber plantations to other crops (mainly palm oil) or leave their rubber trees untapped or unattended as the rising costs of fertilizers and pesticides exceed their income. Many farmers are shifting their professions to support their livelihoods, as many rubber trees have reached their prime, no longer able to meet market demand.

Additionally, Indonesia remains highly reliant on imported raw materials, components, and services to manufacture processed natural rubber products for export. Imports like scrap, cup lump, or slab are necessary to fill shortages, while international commodities such as fertilizers, medicines, and machinery are crucial for boosting profits within the value chain. As a result, Indonesia's domestic rubber industry is more susceptible to fluctuating rubber prices and shifts in the global market. Furthermore, Indonesia's domestic production

only enhances a little added value, because a significant proportion is supplied by other countries or industries providing raw materials or production components. Further analysis identified which nations consume Indonesia's rubber products (forward participation value) and which countries Indonesia mostly relies on for inputs in the rubber industry (backward participation value). The findings indicate that Indonesia primarily sources inputs from China, Japan, Singapore, Korea, Thailand, India, and Malaysia (**Figure 3**), while the main consumers of Indonesia's natural rubber products are America, Japan, Korea, China, Germany, and India (**Figure 4**).

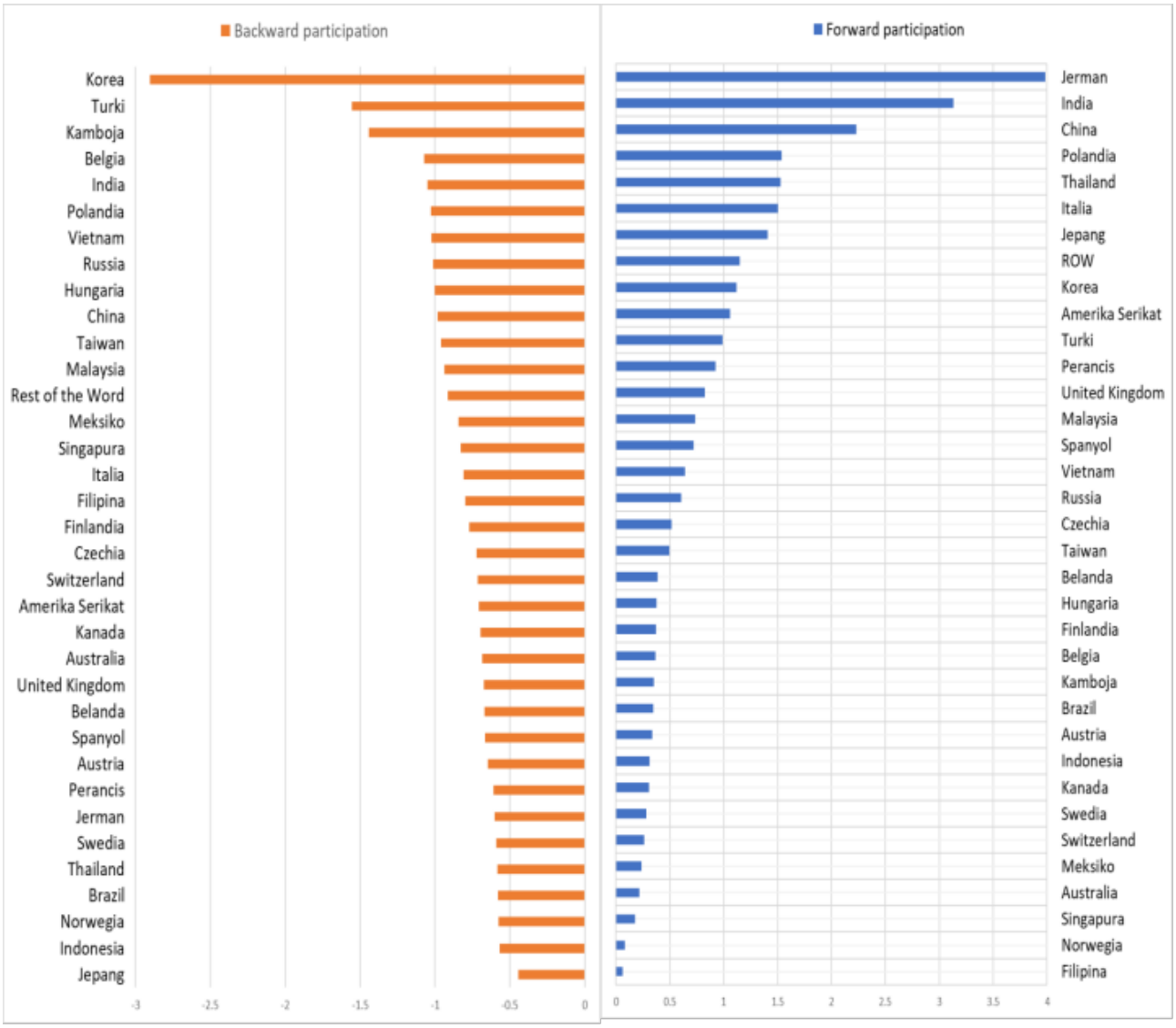

Figure 1. Indonesia's GVC participation in the global natural rubber value chain in 2015.

Accordingly, Indonesia must increase the added value of its natural rubber by advancing domestic production and fostering innovation. Previous studies have suggested various ways to enhance Indonesia's role in the GVC and trade [38, 65], such as improving the quality of primary commodities, expanding domestic financing, broadening capital sources, and reforming the investment climate. It is important to understand that efforts to boost productivity should not overlook the challenges farmers face in replanting their rubber plantations to achieve higher productivity. Indonesia can learn from the successes of leading natural rubber producers, like Thailand, Malaysia, and China. These countries have managed to enhance their natural rubber pro-

duction while focusing on developing their downstream sectors, allowing them to maintain a high-level engagement in the industry compared to other natural rubber-producing countries like Cambodia and India.

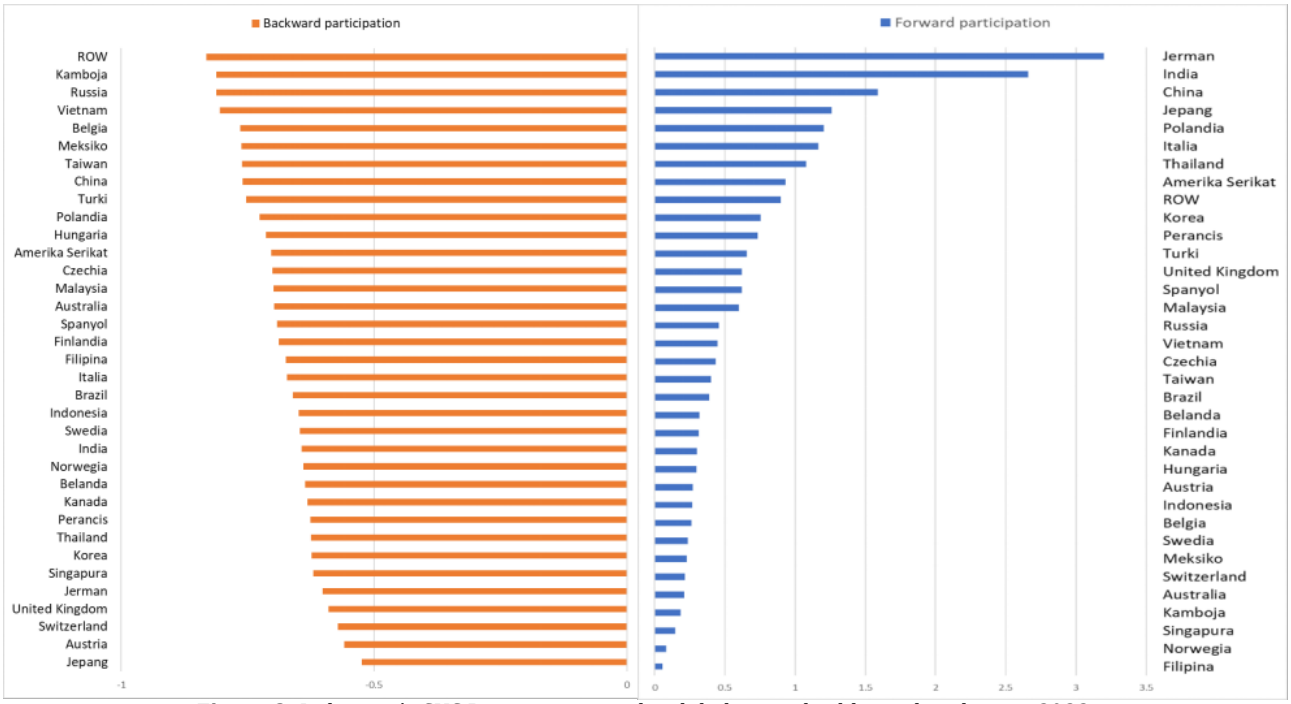

Figure 2. Indonesia's GVC Participation in the global natural rubber value chain in 2022.

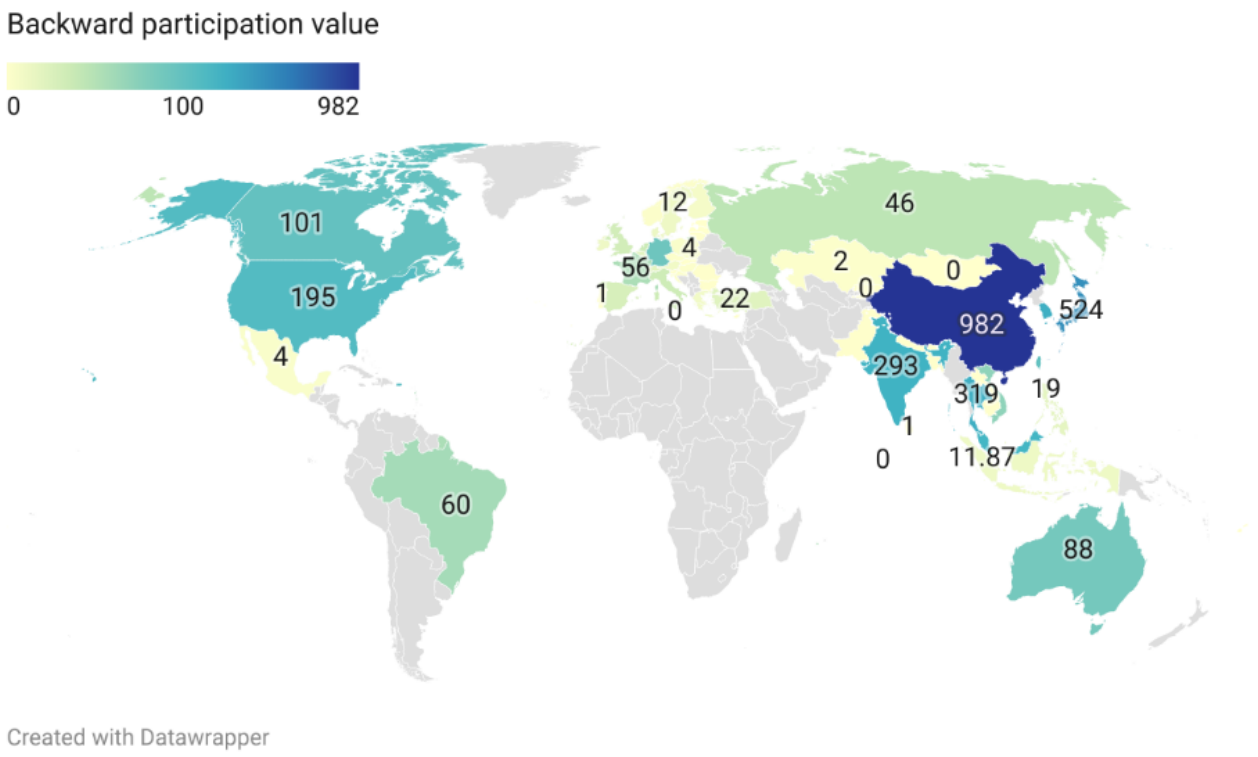

Figure 3. Indonesia's natural rubber value chain participation in trading partner countries based on backward participation in 2022.

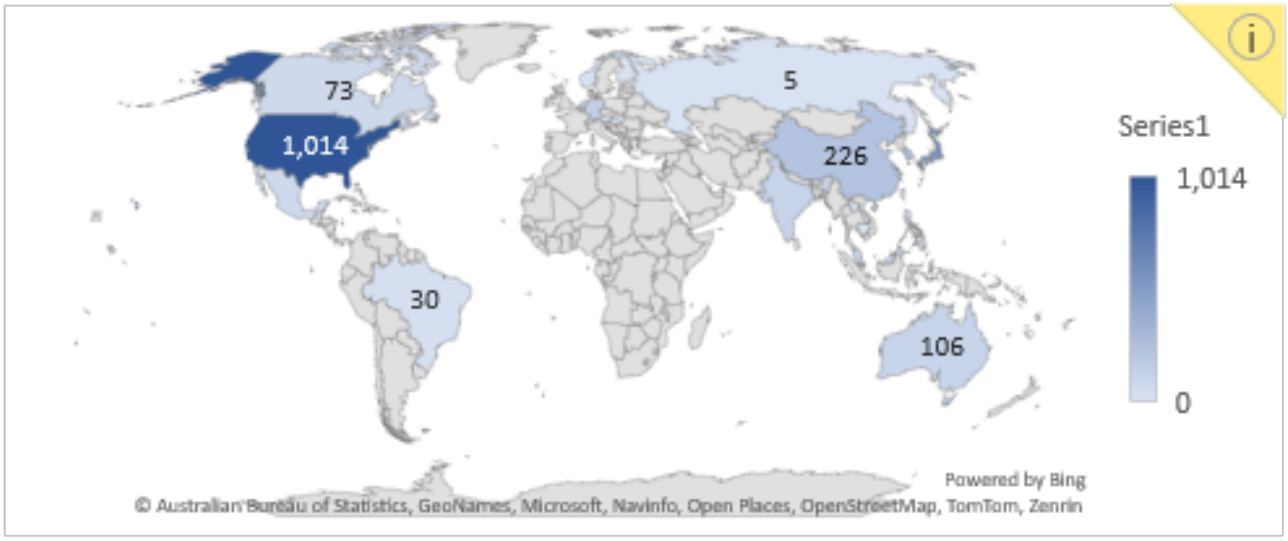

Figure 4. Indonesia's natural rubber value chain participation in trading partner countries based on forward participation in 2022

4.2. The Position of Indonesia's Natural Rubber Industry in the Global Value Chain (GVC)

The analysis of Indonesia's natural rubber industry's position within the GVC is illustrated in scatter plots showing both forward and backward linkages for 2015 and 2022 (**Figures 5** and **6**). The plots are segmented into four quadrants based on the average values of the backward linkage index on the X-axis and the forward linkage index on the Y-axis. Quadrant I represent countries with both backward and forward linkages above the global average. In Quadrant II, countries have backward linkages below the global average but forward linkages above it. Quadrant III includes countries with backward linkages above the global average and forward linkages below. Finally, Quadrant IV displays countries with both forward and backward linkages below the global average.

As shown in **Figure 5**, Indonesia was in quadrant II in 2015, meaning its backward linkages were below the global average, while its forward linkages exceeded it. Despite the low input absorption, Indonesia's national rubber production in 2015 met export demands. However, **Figure 6** suggests that by 2022, the Indonesian rubber industry may shift to quadrant IV, joining countries like Laos, Sri Lanka, Denmark, and Greece. This change indicates that Indonesia's rubber industry has both forward and backward linkages that fall below the global average. The output from Indonesia's rubber industry used by other nations has remained limited, as indicated by a decline in export volume. In 2015, Indonesia produced 3,145 million tons of natural rubber, but it dropped by 13.6% in 2022. Additionally, the export volume in 2022 was 22% compared to 2015, partly due to a 3% decrease in the productivity of rubber plants. Despite possessing the largest rubber plantation area, Indonesia's productivity lags behind other leading producers. In 2022, Indonesia's rubber productivity was only 1,008 kg/ha/year, significantly lower than Vietnam's 1,840 kg/ha/year, India's 1,489 kg/ha/year, Ivory Coast's 1,690 kg/ha/year, Malaysia's 1,393 kg/ha/year, and Thailand's 1,356 kg/ha/year. Additionally, Indonesia is experiencing a decline in input utilization on the backward linkage, which adversely affects domestic natural rubber production, and consequently, export volumes.

Indonesia has the largest rubber cultivation area, but its productivity is significantly lower than that of other rubber-producing countries. The contributing factors include the fact that many farmers continue to use non-clonal rubber plants inherited from previous generations instead of adopting high-yield rubber clones. Research by Alamsyah et al.[66] reports that only about 65% of farmers in Muara Enim Regency, South Sumatra, have switched to superior rubber seedlings. In comparison, the neighboring

Banyuasin Regency has a much higher clone adoption rate of 91%[67] due to its reputation as Indonesia's largest community rubber center. Furthermore, the removal of subsidized fertilizer for rubber farmers has increased the price of fertilizer for farmers, making it unaffordable for many. Consequently, farmers are less likely to fertilize their rubber plants as the low market price of rubber is not comparable to the increased costs of fertilizer and other production inputs. A study by Bukit and Syarifa[68] in Serdang Bedagai Regency, North Sumatra, confirmed that farmers no longer fertilize their rubber crops.

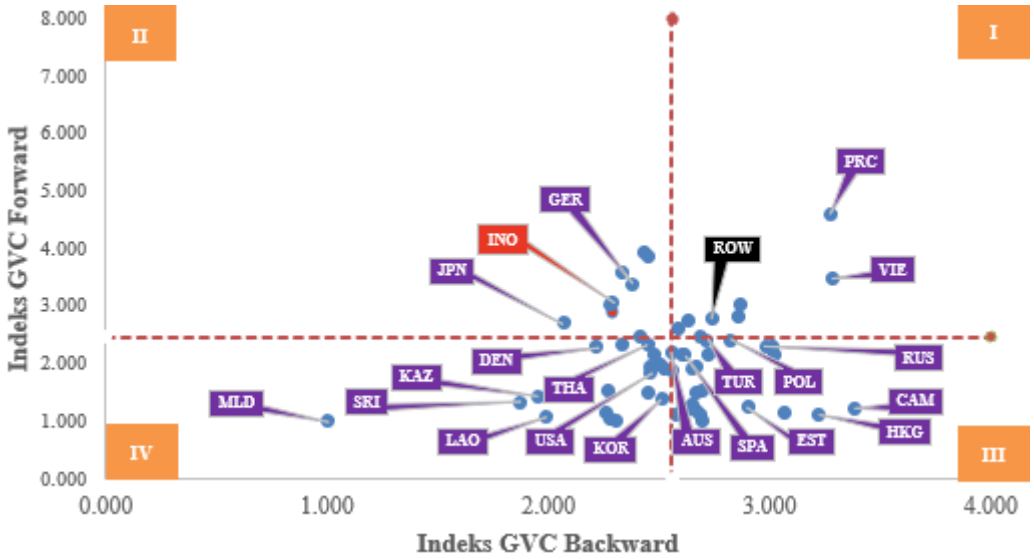

Figure 5. Position of Indonesia's natural rubber industry in the global natural rubber value chain in 2015.

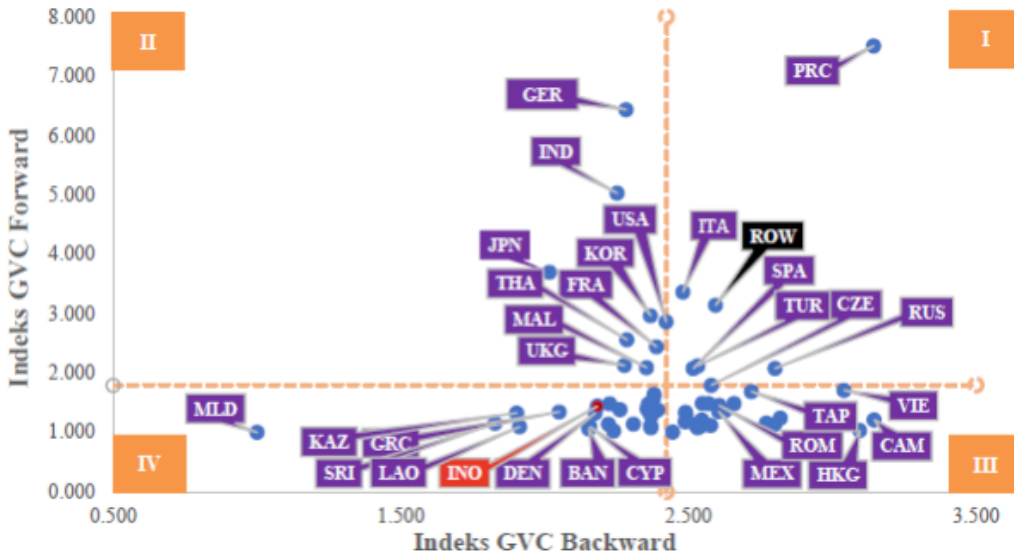

Figure 6. Position of Indonesia's natural rubber industry in the global natural rubber value chain in 2022.

Junaidi[69] also noted that low productivity, particularly on smallholder plantations, can be attributed to the prevalence of aging rubber trees that require rejuvenation through improved cultivation practices. This inadequate use of inputs hampers Indonesia's export potential, as evidenced by the challenges in the backward linkages. Meanwhile, neighboring countries have much higher adoption rates for clonal seedlings, with Malaysia at 90%, Thailand at 95%, India at 99%, and Vietnam at 100%[66].

A comparison between the backward and forward GVC indices reveals that Indonesia's backward GVC index is higher than its forward GVC index. This indicates that the domestic content in the Indonesian rubber industry exceeds its foreign content in global trade. This aligns with Alfaridzi's (2020) analysis, which found that the domestic content of the Indonesian rubber industry is greater than its foreign content in international trade. The industry tends to be more focused on the upstream sector, as indicated by a higher backward GVC value compared to the forward GVC. As a result, the Indonesian rubber industry remains heavily reliant on inputs from other sectors and countries, including fertilizers, machinery, pesticides, raw rubber materials, chemicals, and other support items. Indonesia primarily acts as a supplier of raw materials without engaging in significant processing or transformation. This situation benefits other countries, which can process the raw materials exported from Indonesia into finished rubber products that offer much higher added value.

Among the 35 nations studied, Cambodia, China, and Vietnam showed the highest scores in the backward GVC index, while China, Germany, and India led in the forward GVC index. Notably, China is the only country excelling in both backward and forward GVC, highlighting its dominance in both upstream and downstream sectors. In 2015, Thailand, recognized as the leading global producer of natural rubber, was positioned in quadrant IV, but by 2022, it moved up to quadrant II. This shift signifies Thailand's progress not only in upstream production but also in strengthening its downstream industry, as it transitions from merely exporting raw materials to also exporting finished rubber products. Thailand's rubber finished goods industry flourishes, supported by well-organized government regulations. The Rubber Authority of Thailand (RAOT) is a government agency that oversees the industry, ensuring effective governance across both upstream and downstream sectors, including rubber rejuvenation operations. Funding for these rejuvenation programs is sourced from rubber export levies (cess funds) to ensure the effective implementation of the rubber rejuvenation program. Furthermore, ongoing improvements in technology and infrastructure aim to enhance production efficiency and quality.

These findings align with research by Septiyanti and Nurmalina (2025), which highlights a decline in Indonesia's rubber industry market position from 2020 to 2022. Despite maintaining its presence in the global rubber market, Indonesia continues to face competition from other natural rubber-producing countries.

5. Conclusion and Policy Implications

Indonesia is present in the natural rubber market, but it faces challenges in competing with leading producers. An analysis from 2022 showed that among 35 countries, Indonesia ranked 26th in forward participation in the GVC, 21st in backward participation, and 28th in combined participation, with scores of 0.27, 0.65, and 0.92, respectively. It indicates that Indonesia relies on more imports than exports in the rubber industry. Given that many farmers depend on this industry for their livelihood, significant improvements are essential to enhance both the upstream and downstream sectors, ultimately aiming to reduce reliance on imported rubber components and goods. To begin, the productivity of smallholder farmers needs to be improved through government initiatives, particularly from the Ministry of Agriculture and its regional offices. These efforts should focus on accelerating the replanting program using high-yielding clones and promoting best agricultural practices. These could involve providing quality planting materials, subsidizing fertilizers for smallholder farmers, managing plant diseases, and offering other relevant support.

Additionally, Indonesia should create incentives for technology development within the research centres for the rubber industry, similar to the financial scheme like BPDPKS for rejuvenating oil palm trees in Indonesia. Technology transfer should be integrated into extension programs, making relevant and practical technology accessible to smallholder farmers and actors in the rubber industry to boost productivity. Furthermore, the government needs to develop policies that encourage the absorption of rubber in the infrastructure facilities, such as rubberised asphalt and com-

ponents for dock fender and railway bearing, at the national level. In line with this, the government should foster collaboration and partnerships among stakeholders in the value chain. Finished rubber goods, such as tires, are made of other components, so the government needs to coordinate policy support for these component industries. A lesson learned from the tire industry in Thailand is that the industry flourishes because it is integrated with the automotive industry cluster, along with other component industries, enabling dynamic growth.

Lastly, Indonesia should focus on strengthening a close linkage among key players in the domestic value chain to meet the EUDR standard of the rubber industry. These may include improving road facilities and a warehouse for collecting rubber at the farmers' group while strengthening the farmers' group to establish a direct partnership with the crumb rubber factory. Such initiatives can help address inefficiencies and high-cost logistics services, ultimately enhancing the competitiveness of Indonesia's rubber industry in GVC.

Author Contributions

Conceptualization, D.S.A., R.N., A.F., and B.; methodology and formal analysis, D.S.A., R.N., A.F., and B.; data collection, D.S.A.; writing – original draft preparation, D.S.A.; writing – review and editing, D.S.A., R.N., A.F., and B.; visualization, R.N., A.F., and B.; supervision, R.N., A.F., and B. All authors have read and approved the manuscript.

Funding

This research is funded by Indonesian Rubber Research Institute.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data in this study we got from the following source: https://www.adb.org/what-we-do/data/regional-input-output-tables

Conflicts of Interest

The authors declare no conflict of interest.

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