Interdisciplinary Research Review
Volume 19, Number 1, Pages 44 – 59

Modeling Thai Concentrated Latex Sector

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Abstract

This study aims to identify the factors that influence the dynamics of key variables, particularly output, price, and employment in the concentrated latex sector. To this end, a Dynamic Stochastic General Equilibrium (DSGE) approach is utilized and a Bayesian estimation method is employed using monthly data from the Office of Industrial Economics database, Thailand, for domestic price, demand, and export of concentrated latex from January 2016 to January 2022, with a total of 61 observations. The results suggest that a technological shock increases output and employment while reducing output price. The cost-related shocks, on the other hand, decrease output and employment while increasing output price. Furthermore, external shocks cause a shift in imports and exports and domestic final prices of concentrated latex. Therefore, it is strongly recommended to enhance technology, labor skills, and the domestic concentrated latex industry's capacity.

Keywords: Concentrated Latex, Technology shock, DSGE, Bayesian estimation, Thailand

Article history: Received 20 March 2023, Revised 25 July 2023, Accepted 02 January 2024

1. Introduction

Since 2003, Thailand has been the world's leading producer of natural rubber (NR). Production peaked at 3.4 million tons of fresh latex in 2011, with an average yield of 1.6 tons per hectare. This output is predominantly exported to European countries, China, India, and Malaysia [1]. In comparison to Malaysia, the traditional leader in NR production in the 1980s, Thailand's success in this regard can be attributed to a number of factors, such as decreasing yields in Malaysia due to a decrease in land dedicated to rubber cultivation and an aging population of rubber farmers [2]. It is thus evident that Thailand has been able to effectively capitalize on the opportunities presented by these factors in order to emerge as the world's leading NR producer.

Rubber provides a positive contribution to Thai economy because it generates foreign exchange for the country. Moreover, the rubber industry links other sectors together through a backward linkage and forward linkage. The groups of backward linkage include, e.g., raw materials, machinery and equipment, business supporters, and infrastructure. In the same way, the groups of forward linkage include, e.g., automotive, housewares, services, transport, and others. Therefore, the rubber industry has a crucial role to play in promoting domestic industry development [3].

Thai rubber production chain has three main components: 1) upstream industries involving the growing and harvesting of rubber on plantations by growers and tappers; 2) intermediate or midstream rubber industries, or rubber processors, taking rubber produced on plantations and convert it into semi-finished products; and 3) downstream producers including manufacturers of automobile tires, latex gloves, condoms, elastics, and so on. Most of Thailand's intermediate rubber goods are sold on overseas markets for processing into downstream products. The most important end-

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use is for the production of tires (60.9 percent of all domestic demand for intermediate rubber products), followed by elastics (16.2 percent) and then other products such as hosing and condoms.

The outlook of Thailand's rubber industry is expected to remain positive throughout 2022, with output levels predicted to rise due to an expansion in the area under cultivation and more favorable climatic conditions. It is projected that the industry will enjoy an average annual growth rate of 4.5-5.5 percent over the next five years [4].

In the empirical study, it was discovered that several key factors drive the growth and development of the Thai rubber industry. These factors, which have been extensively researched, include: 1) Comparative advantage: Thailand possesses a natural comparative advantage in the production of high-quality rubber products for export. This advantage has prompted recommendations to expand the rubber industry into downstream sectors, capitalizing on lucrative export opportunities [6]. 2) Demand from downstream sector: The tire industry, in particular, serves as a major source of demand for Thai rubber. A significant portion of domestically produced Thai rubber is consumed by the tire sector [7]. 3) Foreign investment: Foreign firms play a substantial role in the Thai rubber industry, contributing a significant portion of the industry's income [7]. 4) Upstream strength: The upstream segment of the rubber value chain in Thailand is well-developed and successful. Thailand boasts a significant rubber plantation area and is one of the leading natural rubber producers and exporters globally [8]. 5) Resource endowments: Thailand possesses untapped opportunities for the development of higher value-added activities within the rubber industry, leveraging its existing resource endowments [7]. 6) Government support: Historically, the Thai government has intervened in the rubber industry to support struggling farmers and artificially stabilize rubber prices. As rubber is considered a politically significant crop, the government aims to ensure a stable supply and provide support to smallholders, who hold considerable political influence [7]. 7) Global demand: Forecasts of increasing global demand for rubber underscore the importance of expanding production in Thailand [7]. These factors collectively contribute to the growth, competitiveness, and sustainability of the Thai rubber industry in the global market.

Concentrated latex is an essential intermediate product in the rubber industry, produced from field latex using high-speed centrifuges. This process separates out water and other impurities, resulting in a concentrated latex that is at least 60 percent rubber and is ready for further processing. In 2021, the total value of concentrated latex distributed by Thai players to the market was estimated at THB 68 billion. Of this, 72.6 percent was exported, with the remaining 27.4 percent consumed domestically. In 2021, concentrated latex exports from Thailand edged up 3.4 percent to 1.19 million tonnes, with revenues from these sales increasing 22.6 percent to USD 1.56 billion. While sales to the primary market of Malaysia declined -0.8 percent to 0.57 million tonnes due to a lockdown imposed in the country, this was offset by increased sales in smaller markets such as Brazil and China [4]. Nonetheless, this concentrated latex industry is anticipated to expand and play a potential role in boosting national income [5].

Motivated by the economic significance of the concentrated latex industry, this study utilizes a Dynamic Stochastic General Equilibrium (DSGE) approach to comprehensively assess the dynamics of this sector and identify potential strategies for enhancing its performance. This work contributes to the existing literature by proposing a novel model for analysis. The subsequent sections are structured as follows: Section 2 presents the variables expected to affect the dynamics of the model formulated in this work. Section 3 outlines the construction of

the models, while Section 4 presents the results, with a brief discussion.

2. Literature Review

This section provides the most pertinent research findings that revealed the factors anticipated to influence the dynamics of the model to be developed in this study.

The influence of government policies on agriculture has been found to significantly impact rubber production, as indicated by previous scholarly studies [9]. One of the most impactful ways in which government policies shape rubber production is through subsidies provided to rubber growers. These subsidies aim to support and incentivize domestic rubber production, enabling growers to expand their plantations and increase output. Government subsidies can take many forms, such as financial assistance, tax incentives, or access to affordable credit. By reducing production costs and increasing profitability, these subsidies play a crucial role in encouraging both small-scale and large-scale rubber farming. For instance, subsidies can help cover the cost of acquiring high-quality rubber seeds, fertilizers, and machinery. This allows farmers to improve efficiency, enhance yield, and compete more effectively in the global rubber market.

For the domestic price of natural rubber, it is affected by the exchange rate, the volume of production, exports [7, 8], input costs, fertilizer subsidies, domestic consumption, the foreign price of natural rubber [9, 10], total domestic natural rubber supply, the total stock of natural rubber in the world, and natural rubber demand [14]. *Exchange rates* play a crucial role in determining the import and export dynamics of a country. For natural rubber-producing nations, this is especially true. When the domestic currency weakens against other currencies, the cost of importing natural rubber increases. This prompts the domestic price of natural rubber to rise, as producers pass on the additional costs to consumers. Conversely, when the domestic currency strengthens, the cost of imports decreases, resulting in a potential decrease in the domestic price of natural rubber. The relationship between *domestic production* volume and natural rubber prices is rooted in the basic principles of supply and demand. When the volume of domestic production increases, it leads to a surge in supply in the market. This excess supply can exert downward pressure on prices. As the domestic supply increases, it also enhances the competitiveness of domestic producers in the international market. With a larger output, domestic players can leverage economies of scale, potentially enabling them to offer lower prices to capture market share globally. The fluctuations in *export volumes*, therefore, directly impact domestic prices in several ways. Increased exports, reduced domestic supply: As countries export more natural rubber, the domestic supply within their borders decreases. This reduction in supply creates a scarcity effect, driving domestic prices upward. Reduced exports, increased domestic supply: Conversely, when countries restrict their exports, domestic supplies increase, leading to a surplus effect and a subsequent decline in domestic prices. These direct correlations between export volumes and domestic prices form the foundation of the interplay within the rubber market. *Production costs* of natural rubber are subject to various factors, such as labor, energy, and land. Labor plays a crucial role in rubber tapping, latex processing, and overall production. Similarly, energy costs, including electricity and fuel expenses, impact the extraction and processing stages of natural rubber. Additionally, access to suitable land for cultivation and other raw materials further contributes to the overall cost of production. *Fertilizer subsidies* have a profound impact on both production and pricing. Farmers who benefit from these subsidies experience enhanced nutrient availability for their rubber trees, resulting in increased yield per hectare. Moreover, the usage of fertilizers leads to improved quality rubber, contributing to its overall market value. From a supply and demand perspective, fertilizer subsidies lead to an increase in the overall volume of natural

rubber available. With lower production costs due to the reduced expense of fertilizers, farmers are incentivized to cultivate more rubber. Consequently, this increased supply often leads to market saturation and price volatility. Supply-demand imbalances in the rubber market can have significant ramifications on natural rubber prices. When *the domestic demand* for rubber surpasses the available supply, shortages occur, leading to an increase in prices. This shortage can have severe implications for downstream industries that rely on rubber-based products, affecting their production costs and profitability. On the other hand, oversupply, resulting from a decline in domestic demand or an increase in rubber production, can drive prices down. This oversupply is often a consequence of various factors, such as economic slowdowns or unforeseen market disruptions. The correlation between domestic and *foreign natural rubber prices* stems from several factors that intertwine the two markets. Firstly, imports and exports significantly influence domestic rubber markets. Since most countries cannot produce enough natural rubber to meet their demand, they rely on imports to bridge the gap. Consequently, changes in the international price of natural rubber directly affect the cost and availability of imported rubber, thereby impacting domestic pricing levels. In addition to imports, international price benchmarks play a crucial role in determining domestic rubber prices. As a result, fluctuations in foreign rubber prices invariably influence the pricing decisions made within domestic markets. The fluctuations in total domestic supply also play a pivotal role in shaping the dynamics of supply and demand in the natural rubber market. When the supply exceeds demand, a surplus is created, leading to a decrease in the price of natural rubber.

Regarding productivity and efficiency of rubber production, it was found to be influenced by the number of households, years of experience of the farmer, and frequency of the extension agent's visit [15], capital-labor ratios, wage rates, and firm size [16] and that investing in technology and research is necessary to improve productivity and efficiencies [17]. One of the determining factors in rubber production is the number of households involved in cultivation. Rubber trees require careful nurturing and maintenance, and an increased number of households enables more labor resources for these activities. Additionally, it allows for a more distributed workload, reducing the risk of excessive workloads and potential inefficiencies caused by overburdened farmers. The level of experience farmers possess significantly impacts their knowledge and expertise in rubber cultivation and maintenance. Experienced farmers are more likely to understand the intricacies of rubber tree care, including critical aspects such as tapping for latex extraction, disease prevention, and pest control. Their accumulated knowledge enables them to make informed decisions, leading to increased productivity and efficiency in rubber production. The presence and regular visits from extension agents are critical in ensuring the success of rubber production. These trained professionals provide guidance, support, and expertise to farmers, enabling them to adopt best practices, modern techniques, and remain updated on the latest advancements in the industry. Frequent visits allow for timely interventions, addressing issues such as disease outbreaks or identifying potential challenges before they escalate - contributing to enhanced productivity and improved quality of rubber produced. Achieving the right balance between capital and labor resources is essential for optimizing productivity in rubber production. Adequate investment in machinery, equipment, and infrastructure helps streamline operations, minimize errors, and reduce time-consuming manual tasks. Introducing automated processes and mechanization can significantly minimize labor requirements, allowing workers to focus on more specialized tasks, thus maximizing overall efficiency and output. Setting fair and competitive wage rates is crucial for ensuring a

motivated workforce and high-quality rubber production. When workers are fairly compensated, they are more dedicated, committed, and driven to excel in their tasks. Additionally, fair wages attract skilled workers, contributing to optimal performance, improved yield, and enhanced overall productivity in the rubber industry. The size of the rubber production firm also plays a significant role in determining productivity levels. Larger firms often have access to extensive resources, including finance, technology, and expertise. They can invest in better infrastructure, research, and development initiatives, and adopt advanced technologies. These advantages, combined with economies of scale, contribute to enhanced efficiency, increased output, and improved overall productivity. Investing in technology and innovation is crucial for meeting the growing demands and overcoming challenges. Modern technologies offer improved efficiencies in various aspects of rubber production, including precision tapping, predictive pest and disease management, GPS-assisted mapping for optimal plantation layouts, and real-time crop monitoring systems. By incorporating innovative technologies, rubber farmers can streamline their operations, reduce waste, enhance precision, and maximize productivity. Research and development (R&D) efforts in the rubber industry are vital for continuously improving productivity and developing new techniques and strategies. R&D initiatives help identify and address industry challenges, explore alternative cultivation methods, and develop disease-resistant rubber tree varieties. To create a sustainable and resilient rubber industry, substantial investments in R&D are necessary to advance the understanding of best practices, refine existing techniques, and discover new approaches to rubber production.

In the case of rubber export, it is influenced by financial credit [18], price of domestic natural rubber, volume of domestic rubber production [19], exchange rate, interest rate, and real GDP of the destination country [20]. Financial credit plays a pivotal role in facilitating the growth of rubber export. It serves as a catalyst, allowing rubber exporters to access the capital necessary to expand their operations and explore new markets. Through affordable loans and credit facilities, manufacturers are incentivized to ramp up their production of rubber for international trade. Inadequate availability of financial credit or prohibitively high interest rates, on the other hand, can severely hinder the growth potential of rubber exports. Restrictive financial conditions can limit the ability of exporters to invest in infrastructure, research and development, and other crucial aspects necessary for expanding their market presence. The price of domestic natural rubber is a key determinant of the success and profitability of rubber exports. A competitive and stable price stimulates rubber exporters to increase their production and explore international trade opportunities. When domestic natural rubber prices are favorable, businesses are encouraged to invest in expanding their production capabilities and to satisfy the growing global demand for rubber. However, fluctuations in the price of domestic natural rubber can have a substantial impact on the profitability of exporting businesses and ultimately influence export volumes. The volume of domestic rubber production undoubtedly plays a central role in determining the availability of rubber for export. An increase in domestic production can open up significant opportunities for rubber exporters, as it enhances the supply of rubber for international trade.

The above knowledge provides a comprehensive understanding of the key processes and variables involved in concentrated latex manufacturing. Through this analysis, it is possible to gain insight into the interdependent relationships between variables, forming the basis for the formulation of a model in the subsequent section.

3. Model Formulation

This work applies the Dynamic Stochastic General Equilibrium (DSGE) approach, a widely-used framework in economic modeling, to analyze the dynamics of the concentrated latex industry. By utilizing a set of equations and mathematical relationships, the DSGE approach captures the macroeconomic dynamics, incorporating the element of time and uncertainty. This makes it a valuable tool for policy analysis and forecasting. A distinguishing feature of the DSGE approach is its focus on general equilibrium. It considers all markets in the economy simultaneously, taking into account the interactions between different sectors and agents. This comprehensive approach provides a more realistic understanding of the economic system. In addition, Bayesian estimation is employed in this research. Bayesian estimation is a statistical technique that allows economists to estimate the parameters of a model using Bayesian inference principles. Unlike traditional maximum likelihood estimation, which relies on a single point estimate, Bayesian estimation assigns probabilities to different parameter values. This approach is particularly useful when dealing with complex models that have multiple parameters and limited data.

The formulated model presented herein is based on the works of Mesike et al. (2008), Oktora & Firdani (2019), and Mulyani et al. (2021) [18- 20]. It involves three principles agents in the production of concentrated latex: a competitive final concentrated latex producer, a farmer, and a domestic concentrated latex manufacturer. The respective production specifications for each of them are as follows:

The competitive final concentrated latex producer combines domestic and foreign intermediate concentrated latex using the following CES technology:

$$X_{H,t} = \left(\varpi_{HD}^{\frac{1}{\eta_H}} X_{D,t}^{\frac{\eta_H - 1}{\eta_H}} + \left(1 - \varpi_{HD}\right)^{\frac{1}{\eta_H}} X_{M,t}^{\frac{\eta_H - 1}{\eta_H}} \right)^{\frac{\eta_H}{\eta_H - 1}}, \quad (1)$$

where ϖ_{HD} denotes the proportion of the domestically manufactured concentrated latex in the final concentrated latex product. η_H is the elasticity of substitution between the domestically manufactured concentrated latex and the imported concentrated latex in the final concentrated latex product.

The farmer produces the latex, $X_{A,t}$, by using the Cobb-Douglas production technology written by:

$$X_{A,t} = A_{A,t} \left(F_{A,t}\right)^{\alpha_1} \left(N_{A,t}\right)^{1-\alpha_1}, \quad (2)$$

where $A_{A,t}$ is a labor productivity specific to the agricultural sector. $F_{A,t}$ and $N_{A,t}$ denote the quantity of fertilizer and the number of workers, respectively. α_1 express the proportion of fertilizer used in the production of latex.

The domestic concentrated latex manufacturer produces its product, $X_{B,t}$, by using the Cobb-Douglas production technology written by:

$$X_{B,t} = A_{B,t} \left(K_{B,t}\right)^{\alpha_2} \left(N_{B,t}\right)^{\alpha_3} \left(X_{A,t}\right)^{1-\alpha_2-\alpha_3}, \quad (3)$$

where $A_{B,t}$ is a technology unique to the concentrated latex manufacturing industry. $K_{B,t}$ and $N_{B,t}$ denote the quantity of capital and labor, respectively. α_2 and α_3 express the proportions of capital and labor used in the production of concentrated latex, respectively.

The export is written by:

$$X_{E,t} = X_{f,t}\varpi_{HD}\frac{eP_{f,t}^{\eta_H}}{P_{D,t}^{\eta_H}}. \quad (4)$$

Assuming that $A_{B,t}$, $W_{B,t}$, $R_{KB,t}$, $W_{A,t}$, $R_{KA,t}$, $P_{F,t}$, $P_{f,t}$, e_t, and $X_{f,t}$ evolve according to AR (1) process. Finally, market clearing condition is specified by $X_{B,t} = X_{D,t} + X_{E,t}$.

The log-linear forms of the solutions from the above equations are as follows:

$$\tilde{X}_{D,t} = \eta_H\left(\tilde{P}_{H,t} - \tilde{P}_{D,t}\right) + \tilde{X}_{H,t}, \quad (5)$$

$$\tilde{X}_{M,t} = \eta_H\left(\tilde{P}_{H,t} - \tilde{P}_{f,t} - \tilde{e}_t\right) + \tilde{X}_{H,t}, \quad (6)$$

$$\tilde{P}_{H,t} = \frac{(\varpi_{HD}-1)\left(\tilde{e}_t + \tilde{P}_{f,t}\right)P_{fss}^{1-\eta_H}e_{ss}^{1-\eta_H} - \varpi_{HD}\tilde{P}_{D,t}P_{Dss}^{1-\eta_H}}{(\varpi_{HD}-1)P_{fss}^{1-\eta_H}e_{ss}^{1-\eta_H} - \varpi_{HD}P_{Dss}^{1-\eta_H}}, \quad (7)$$

$$\tilde{N}_{A,t} = \tilde{P}_{A,t} + \tilde{X}_{A,t} - \tilde{W}_{A,t}, \quad (8)$$

$$\tilde{F}_{A,t} = \tilde{X}_{A,t} - \tilde{P}_{F,t} + \tilde{P}_{A,t}, \quad (9)$$

$$\tilde{P}_{A,t} = (1-\alpha_1)\tilde{W}_{A,t} + \alpha_1\tilde{P}_{F,t} - \tilde{A}_{A,t}. \quad (10)$$

$$\tilde{N}_{B,t} = \tilde{P}_{D,t} + \tilde{X}_{B,t} - \tilde{W}_{B,t}, \quad (11)$$

$$\tilde{K}_{B,t} = \tilde{P}_{D,t} + \tilde{X}_{B,t} - \tilde{R}_{KB,t}, \quad (12)$$

$$\tilde{X}_{A,t} = \tilde{X}_{B,t} + \tilde{P}_{D,t} - \tilde{P}_{A,t}, \quad (13)$$

$$\tilde{P}_{D,t} = (1-\alpha_2-\alpha_3)\tilde{P}_{A,t} + R_{KB,t}\alpha_2 + \tilde{W}_{B,t}\alpha_3 - \tilde{A}_{B,t}, \quad (14)$$

$$\tilde{X}_{E,t} = \tilde{X}_{f,t} + \eta_H\left(\tilde{P}_{f,t} + \tilde{e}_t - \tilde{P}_{D,t}\right), \quad (15)$$

This model will be estimated using a Bayesian estimation method with monthly data from the Office of Industrial Economics database for domestic price, demand, and export of concentrated latex from January 2016 to January 2022, including 61 observations. These data are directly relevant to the variables presented in the formulated model.

4. Result and Discussion

The model is estimated using the initial values of the following parameters: η_H=5.4, ϖ_{HD}=0.7, α_1=0.6, α_2=0.3, and α_3=0.3. The estimation results are as follows:

Table 1. Estimated parameters

Par.	Prior		Posterior		
	Distr.	Mean	Mean	HPD inf	HPD sup
ρ_{AB}	beta	0.5	0.4372	0.1726	0.6758
ρ_{WB}	beta	0.5	0.6377	0.5574	0.7214
ρ_{RKB}	beta	0.5	0.4941	0.1731	0.7505
ρ_e	beta	0.5	0.5345	0.1513	0.9384
ρ_{Pf}	beta	0.5	0.3439	0.2398	0.4534
ρ_{Xf}	beta	0.5	0.3391	0.1143	0.5358
ρ_{XH}	beta	0.5	0.2912	0.1733	0.393
ρ_{AA}	beta	0.5	0.3876	0.0877	0.6603
ρ_{PF}	beta	0.5	0.4235	0.086	0.8007
ρ_{WA}	beta	0.5	0.5486	0.2959	0.8758

In the following, the effects of shocks will be discussed.

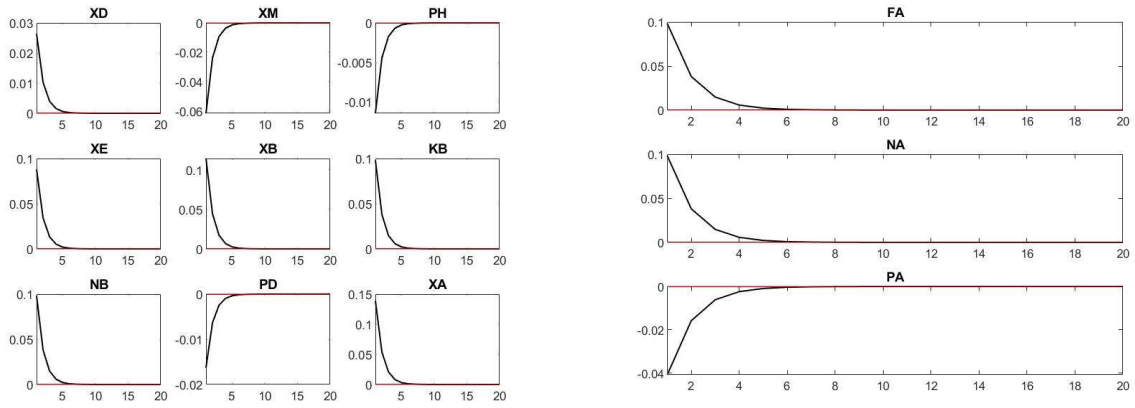

Figure 1. Effect of labour productivity shock in agricultural sector

Figure 1 demonstrates that labor productivity shock in the agriculture sector leads to an increase in agricultural outputs (XA), agricultural employment (NA), fertilizer usage (FA), and manufacturing outputs (XB). However, it decreases the output price (PA) of agriculture and the output price of manufacturing (PD). The explanations are that with the improvement in labor productivity, farmers are able to produce more output with less input. This increased output allows farmers to generate higher profits and create additional employment opportunities (NA). As a result, the agricultural sector has seen an increased demand for labor. The increased fertilizer usage (FA) is a result of the increased output of agricultural products. Fertilizer is essential for ensuring optimal crop yields, and with the increased output, farmers need to use larger amounts of fertilizer than before. For the increased manufacturing output (XB), it is a result of increased agricultural output. By producing more agricultural products, farmers are able to supply manufacturers with more raw materials. The decreased agriculture output prices (PA) and decreased manufacturing output prices (PD) are a result of increased productivity in the agricultural sector. As farmers are able to produce more output with less input, the prices of agriculture and manufactured goods have decreased.

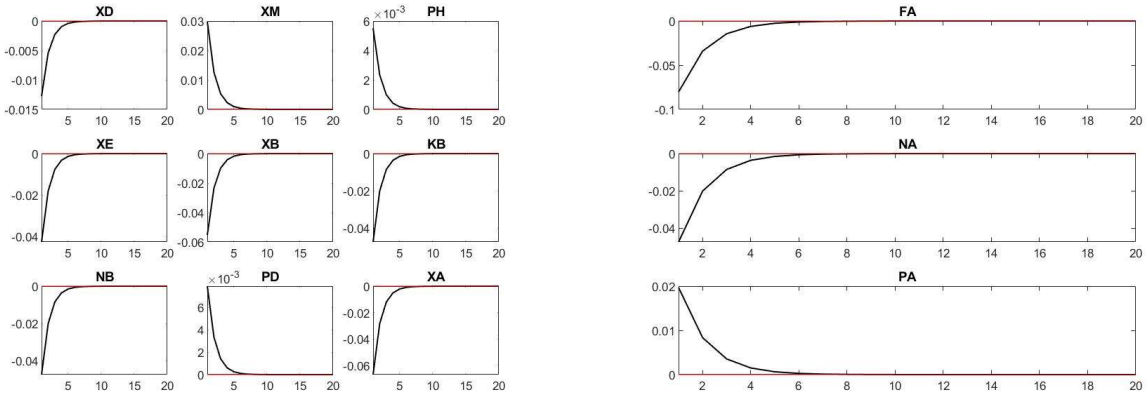

Figure 2. Effect of fertilizer price shock

In Figure 2, it shows that fertilizer price shocks in the agriculture sector lead to a decrease in agricultural outputs (XA), agricultural employment (NA), fertilizer usage (FA), and manufacturing outputs (XB). However, it raises the prices of agricultural (PA) and industrial output (PD). This is due to the fact that a rise in fertilizer prices can cause an increase in production costs, resulting in a decline in agricultural output. In addition, high fertilizer prices can lead to a reduction in the amount of fertilizer used (FA), thereby reducing agricultural output. Increasing fertilizer costs may also have an effect on manufacturing outputs (XB). Since agricultural production is a significant source of raw materials for manufacturing, a rise in fertilizer prices can reduce the output of manufactured goods. In addition, the rising cost of fertilizer can have a positive effect on the cost and, consequently, the price of agricultural output (PA) and manufacturing output (PD).

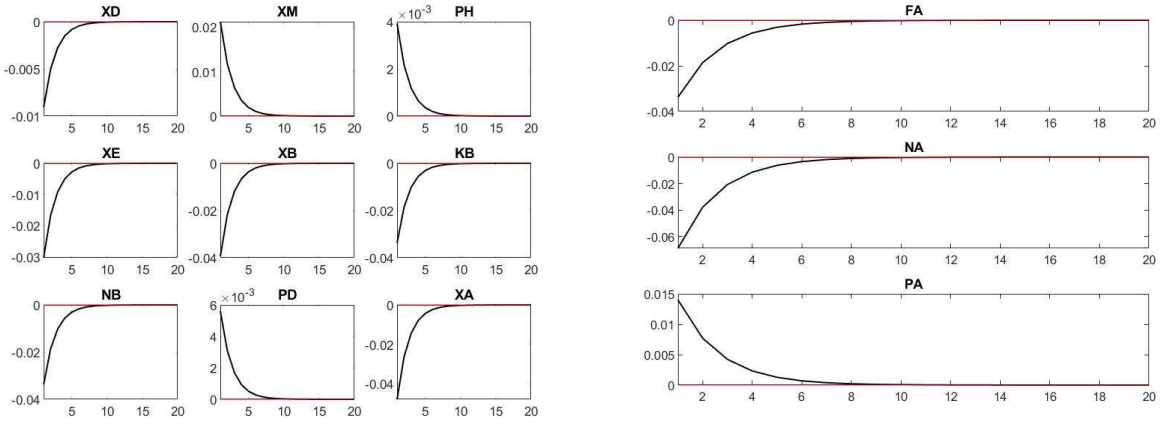

Figure 3. Effect of wage shock in agricultural sector

Figure 3 illustrates that wage shock in the agriculture sector leads to a decline in agriculture outputs (XA), agriculture employment (NA), fertilizer usage (FA), and manufacturing outputs (XB). However, it raises both the agriculture output price (PA) and the manufacturing output price (PD). This is because when wage increases in the agricultural sector, the cost of production rises, making it more expensive to produce agricultural goods. This increased cost of production leads to a decrease in agricultural output (XA), as producers are unable to produce as much as they would have prior to the wage increase. As a result, there is a decrease in agricultural employment (NA) and fertilizer usage (FA). Moreover, the increased cost of production can leads to an increase in agricultural output prices (PA) and an increase in manufacturing output prices (PB). This is due to a basic economic principle known as the law of supply and demand. As the cost of production of agricultural goods increases, the supply of agricultural goods decreases, driving up the price of agricultural goods. Similarly, as the cost of production of the manufacturing goods increases, the supply of the manufacturing goods decreases (XB) which driving up the price of the manufacturing goods.

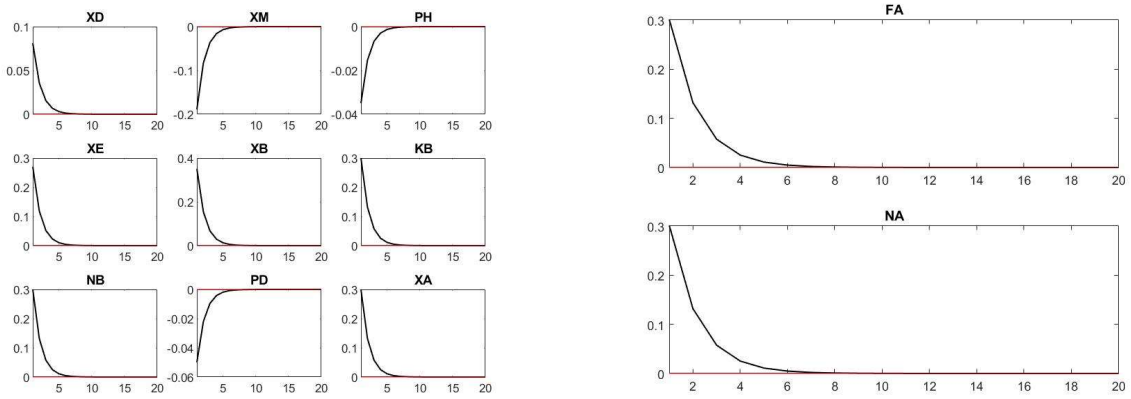

Figure 4. Effect of tech shock in latex manufacturing sector

Figure 4 demonstrates that a manufacturing technology shock increases manufacturing outputs (XB), manufacturing employment (NB), and demand for agricultural outputs (XA) while decreasing manufacturing prices (PD) and the domestic final concentrated latex price (PH). Due to the introduction of efficient methods and machines, technological advancement in the manufacturing sector has resulted in higher outputs (XB). In a short period of time, highly efficient and automated machines can produce vast quantities of goods. This, in turn, leads to greater productivity and output, which can reduce manufacturing prices (PD). In addition, technological advancements have resulted in an increase in manufacturing sector employment (NB) due to the expansion of manufacturing businesses. Increased technological advancement in the manufacturing sector has also led to an increase in demand for agricultural products (XA), as automated machines enable the production of more manufactured goods, which necessitate an increase in agricultural product consumption. Because there are more manufactured goods on the market, domestic final concentrated latex prices (PH) may decline.

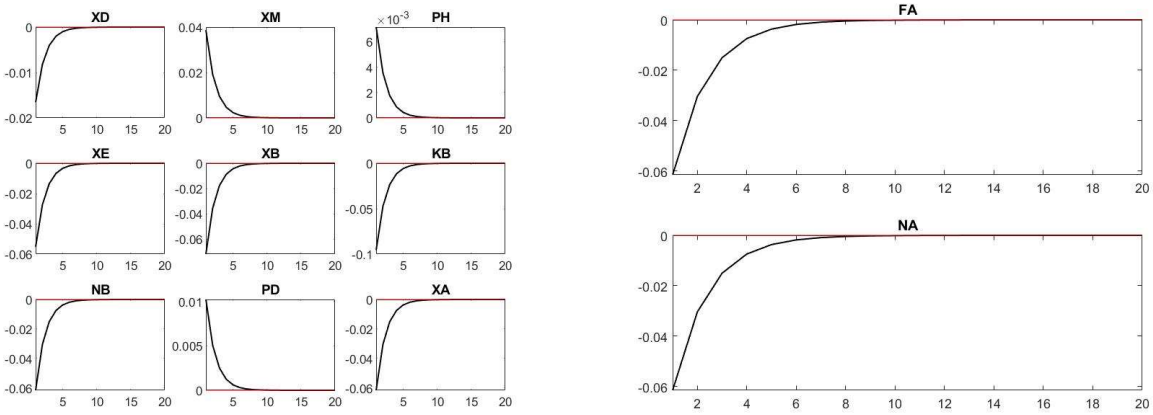

Figure 5. Effect of capital rental rate shock in latex manufacturing sector

Figure 5 depicts that a shock to the capital rental rate in the manufacturing sector reduces manufacturing outputs (XB), manufacturing employment (NB), and demand for agricultural outputs (XA) while increasing manufacturing prices (PD) and domestic final concentrated latex prices (PH). A rise in the capital rental rate can reduce manufacturing output because firms

are forced to pay more to obtain the necessary capital for production. This is due to the fact that higher capital rental rates result in higher costs that must be passed on to businesses, resulting in lower profits. Consequently, firms are less able to finance their operations, and as a result, they produce less output (XB). Additionally, a rise in the capital rental rate leads to a decline in manufacturing employment (NB), as firms become less likely to hire employees due to the increased costs of capital. Since this product's demand is derived from the manufacturing sector, agricultural outputs (XA) also experience a decline in demand. A rise in the capital rental rate results in an increase in the manufacturing price (PD), as firms are compelled to pass on the higher capital costs to consumers. This increased cost leads to higher consumer prices for the manufactured goods, resulting in a decline in demand for them as a whole. Simultaneously, the increased cost of capital can lead to an increase in the price of domestic final concentrated latex (PH), as the producer is forced to pay higher prices for manufacturing inputs.

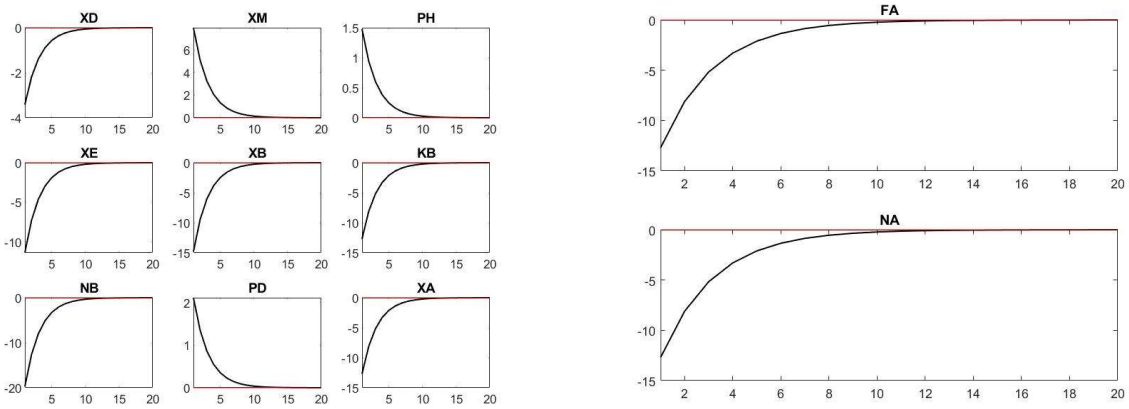

Figure 6. Effect of wage shock in latex manufacturing sector

Figure 6 reveals that a wage shock in the manufacturing sector reduces manufacturing outputs (XB), manufacturing employment (NB), and demand for agricultural outputs (XA) while increasing manufacturing prices (PD) and the domestic final concentrated latex price (PH). This is primarily due to the substitution effect. In order to reduce labour costs, firms in the manufacturing sector are likely to substitute labour (NB) with capital when wages increase. This increase in the cost of labour results in an increase in the price of manufactured goods (PD), as firms are now able to pass along the cost of capital equipment to consumers. Additionally, the increase in the price of manufactured goods reduces the demand for agricultural outputs (XA). This is because, as the price of manufactured goods rises, consumers are less likely to buy them (XB) because they can no longer afford them. This decrease in manufacturing output demand results in a decline in agricultural input demand (XA). Due to the fact that the price of manufactured goods has an effect on this price, the domestic final concentrated latex price increase is a result of rising wages in the manufacturing sector.

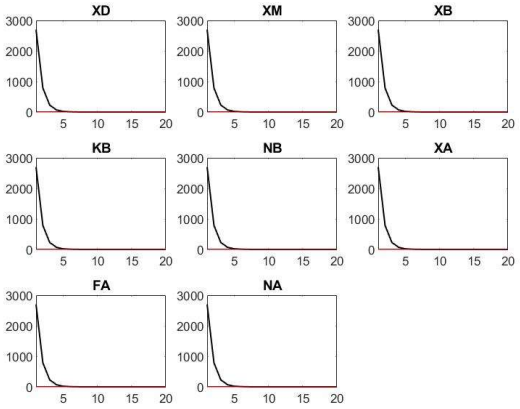

Figure 7. Effect of domestic demand shock

Figure 7 indicates that the domestic demand shock for final concentrated latex increases agricultural output, manufacturing output, and concentrated latex imports (XM). Since domestic final concentrated latex originates from the manufacturing sector and is imported, the increase in demand will lead to an increase in agricultural production, manufacturing output, and concentrated latex imports.

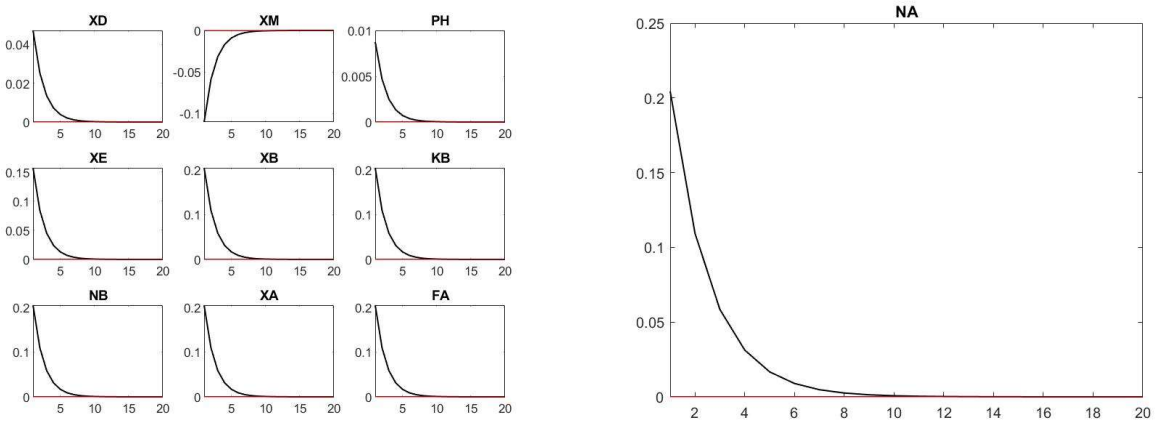

Figure 8. Effect of exchange rate shock

Figure 8 demonstrates that an exchange rate shock or baht depreciation increases concentrated latex export (XE), but decreases concentrated latex import (XM). As exchange rates change significantly, so do the relative costs of exporting and importing goods, leading to proportional changes in the volume of international trade. When the exchange rate increases or the baht depreciates, purchasing concentrated latex from abroad becomes more expensive. Consequently, the price of importing concentrated latex is now greater than it was previously. This causes a decrease in the importation of concentrated latex (XM). However, a rise in the exchange rate or depreciation of the baht results in a reduction in the price of concentrated latex for foreign buyers. Therefore, it is more likely that foreign buyers will purchase concentrated latex from Thai producers. This causes an increase in the export quantity of concentrated latex (XE).

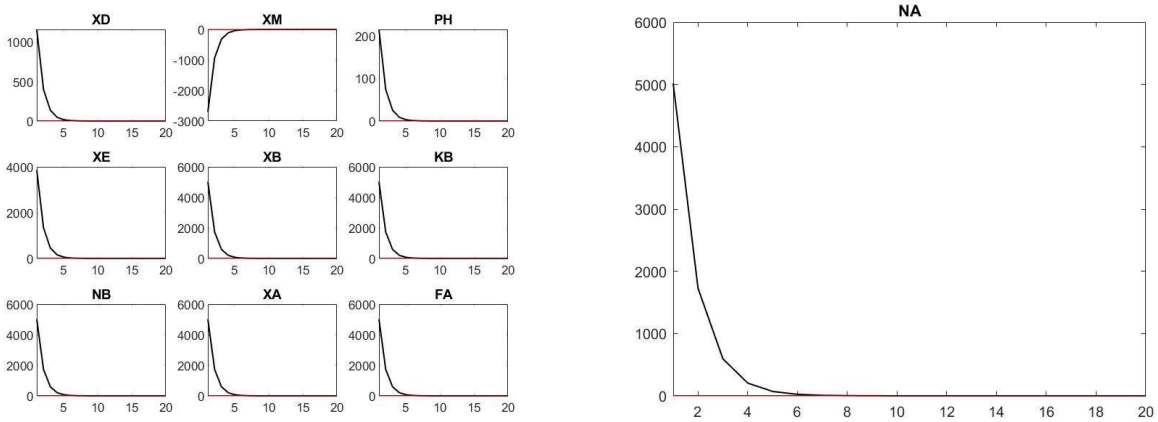

Figure 9. Effect of foreign price shock

Figure 9 shows that the foreign concentrated latex price shock causes an increase in concentrated latex exports (EX), a decrease in concentrated latex imports (XM), and an increase in the domestic price of concentrated latex (PH). A rise in foreign prices increases the relative desirability of exports of Thai concentrated latex. This is due to the fact that, as foreign prices rise, Thai concentrated latex exports (XE) become relatively less expensive for foreign buyers. Therefore, foreign buyers are more likely to purchase concentrated latex at a lower price from Thailand. However, a rise in foreign prices also reduces imports of concentrated latex (XM). This is due to the likelihood that domestic buyers will purchase concentrated latex within countries with lower prices. As the foreign price of concentrated latex is included in the domestic final price of concentrated latex (PH), when the foreign price increases, so does the domestic final price.

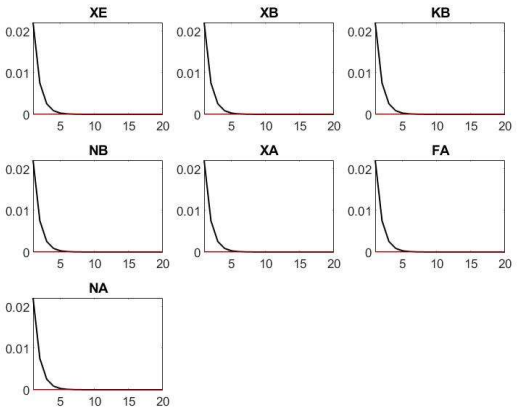

Figure 10. Effect of foreign demand shock

Figure 10 illustrates that foreign concentrated latex demand shocks lead to an increase in concentrated latex exports, which stimulate agricultural and manufacturing outputs. The shock of foreign demand induces exports that must be met by Thailand. This directly results in an increase in the demand for the manufacturing product (XB), which in turn encourages the demand for the domestic agricultural product (XA).

5. Recommendations

Based on the results of the analysis, the following recommendations are suggested: 1) investing in production technology in the manufacturing sector to improve production efficiency and productivity, e.g. integrating

smart sensors and data analytics into the production process to provide real-time insights into latex quality and production metrics; 2) implementing practices to minimize the negative effects of increasing fertilizer price, wage, and capital rental rate, such as supporting domestic fertilizer production, increasing labor productivity through equipping workers with new knowledge and skills, and utilizing as much of the capital capacity as possible; and 3) encouraging domestic concentrated latex demand by supporting the growth of downstream producers through credit support and building proper infrastructure. Furthermore, the government should leverage external shocks that are out of its control by strengthening the domestic concentrated latex industry, which is less reliant on foreign countries in the event of a concentrated latex global crisis. For a more comprehensive analysis that accurately reflects the dynamics within this industry, it may be beneficial to incorporate other types of shocks or investigate the long-term effects of the identified factors on the concentrated latex sector.

6. Conclusion

Concentrated latex is an intermediate rubber product that serves a unique purpose in the rubber industry as the primary raw material for a variety of rubber manufacturing processes. This industry contributes positively to the economy by facilitating the growth of other industries and generating foreign currency. Due to the economic significance of the concentrated latex industry, this study employs the DSGE method to describe the factors that influence the dynamics of key variables, including output, price, and employment, in the upstream and midstream of the industry. The model is estimated using a Bayesian estimation method with monthly data from the Office of Industrial Economics database for domestic price, demand, and export of concentrated latex from January 2016 to January 2022. The results indicate that a technological shock increases output and employment while reducing output price. The cost related shocks decrease output and employment while increasing output price. As anticipated, external shocks cause a shift in imports and exports and domestic prices. Therefore, enhancing technology, labour skills, and the domestic concentrated latex sector is strongly recommended.

Acknowledgement

This research is supported by School of Economics, Sukhothai Thammathirat Open University, Thailand.

References

[1] W. Jawjit, P. Pavasant, and C. Kroeze, “Evaluating environmental performance of concentrated latex production in Thailand,” *Journal of Cleaner Production*, vol. 98, pp. 84–91, 2015.

[2] R. Doner and G. Abonyi, “Upgrading Thailand’s rubber industry: Opportunities and challenges,” *Thammasat Economic Journal*, vol. 31, no. 4, pp. 44–66, 2013.

[3] P. Tengsuwan, A. Kidsom, and S. Dheera-Aumpon, “Economic linkage in the Thai rubber industry and cluster identification: Input-output approach,” *Asian Administration & Management Review*, vol. 2, no. 2, pp. 147–159, 2019.

[4] C. Sowcharoensuk, “Industry outlook 2021-2023: Natural rubber processing,” Bank of Ayudhya Public Company Limited, Krungsri Research, 2021. Accessed: Feb. 21, 2023. [Online]. Available: https://www.krungsri.com/getmedia/90b33d78-8944-4d67-9d58-332d2844e8fc/IO_Rubber_210416_EN_EX.pdf.aspx

[5] S. Afreen, K. R. Haque, M. S. Islam, and M. K. Huda, “Essential Latex Processing Plant (ELPP): A pioneer approach in the production of concentrate latex from local resource to manufacture male contraceptive in Bangladesh,” *Journal of Chemical Engineering*, vol. 27, no. 2, pp. 11–14, 2012.

[6] P. Kampan, "Sustainability and competitiveness of Thailand's natural rubber industry in times of global economic flux," *Asian Social Science*, vol. 14, no. 1, p. 169, 2017.

[7] R. Doner and G. Abonyi, "Upgrading Thailand's rubber industry: Opportunities and challenges," *Thammasat Economic Journal*, vol. 31, no. 4, pp. 44–66, 2013.

[8] S. Leepromrath, J. Zhu, J. Zhou, T. Li, and D. Zhou, "Rubber crop diversity and its influential factors in Thailand," *Journal of Rubber Research*, vol. 24, no. 3, pp. 461–473, 2021.

[9] H. Umar, D. Y. Giroh, N. Agbonkpolor, and C. Mesike, "An overview of world natural rubber production and consumption: An implication for economic empowerment and poverty alleviation in Nigeria," *Journal of Human Ecology*, vol. 33, no. 1, pp. 53–59, 2011.

[10] P. Kampan, "Sustainability and competitiveness of Thailand's natural rubber industry in times of global economic flux," *ASS*, vol. 14, no. 1, pp. 169–182, Dec. 2017, doi: 10.5539/ass.v14n1p169.

[11] Y. C. Fong, A. A. Khin, and C. S. Lim, "Conceptual review and the production, consumption and price models of the natural rubber industry in selected ASEAN countries and world market," *Asian Journal of Economic Modelling*, vol. 6, no. 4, pp. 403–418, 2018.

[12] P. Daulika, K.-C. Peng, and N. Hanani, "Analysis on export competitiveness and factors affecting of natural rubber export price in Indonesia," *Agricultural Socio-Economics Journal*, vol. 20, no. 1, pp. 39–44, 2020.

[13] P. Srisuksai, "The rubber pricing model: Theory and evidence," *The Journal of Asian Finance, Economics and Business*, vol. 7, no. 11, pp. 13–22, Nov. 2020, doi: 10.13106/JAFEB.2020.VOL7.NO11.013.

[14] H. T. T. Co, T. T. M. UONG, and C. V. NGUYEN, "The Impact of capital structure on firm's profitability: A case study of the rubber industry in Vietnam," *The Journal of Asian Finance, Economics and Business*, vol. 8, no. 7, pp. 469–476, Jul. 2021, doi: 10.13106/JAFEB.2021.VOL8.NO7.0469.

[15] A. Aliyu, I. A. Latif, M. N. Shamsudin, and N. M. Nawi, "Factors affecting technical efficiency of rubber smallholders in Negeri Sembilan, Malaysia," *JAS*, vol. 9, no. 5, pp. 226–232, Apr. 2017, doi: 10.5539/jas.v9n5p226.

[16] M. F. Abdullah, L. W. Sieng, N. Sulaiman, and M. H. I. Abd Rahim, "Measuring inefficiency in the rubber manufacturing industry," *International Journal of Economics, Management and Accounting*, vol. 28, no. 1, pp. 79–96, 2020.

[17] E. Ahmed, "Factors affecting the Malaysian natural rubber production and consumption," *Academy of Strategic Management Journal*, vol. 21, pp. 1–12, Jan. 2022.

[18] C. Mesike, D. Giroh, and O. Owie, "Analyzing the effect of trade liberalization policy on Nigerian rubber industry," *Journal of Agriculture & Social Sciences*, vol. 4, no. 3, pp. 132–134, 2008.

[19] S. I. Oktora and A. M. Firdani, "Natural rubber economics between China and Southeast Asia: The impact of China's economic slowdown," *The Journal of Asian Finance, Economics and Business*, vol. 6, no. 2, pp. 55–62, May 2019, doi: 10.13106/JAFEB.2019.VOL6.NO2.55.

[20] M. Mulyani, K. Kusnandar, and E. Antriyandarti, "Analysis of Indonesian rubber export supply for 1995-2015," *The Journal of Asian Finance, Economics and Business*, vol. 8, no. 1, pp. 93–102, Jan. 2021, doi: 10.13106/JAFEB.2021.VOL8.NO1.093.

[21] S. Tanboon, "The Bank of Thailand structural model for policy analysis," Bank of Thailand, Discussion Paper DP/12/2008, 2008.

[22] L. Guerrieri, D. W. Henderson, and J. Kim, "Investment-specific and multi-factor productivity in multi-sector open economies: Data and analysis," *Seoul Journal of Economics*, vol. 30, no. 3, pp. 251–289, 2017.