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RESEARCH ARTICLE

Competitiveness of Thailand Cassava Export: An Empirical Analysis of ASEAN Markets

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ABSTRACT

Cassava is a one of important economic crop in Thailand, as it providing substantial cash, employment, renewable energy, and significantly contributing to agricultural exports. Within the ASEAN region, where Thailand is the largest exporter of cassava products, the competitive environment has intensified due to regional economic integration. This paper examines the competitiveness of Thailand's cassava exports within ASEAN markets and identifies key factors influencing trade performance. Using secondary time-series data from 1997 to 2024, this study calculates the Revealed Comparative Advantage (RCA) index and applies econometric models to explore the impact of macroeconomic and market-specific variables. The findings reveal that Thailand's cassava export competitiveness has improved significantly since 2010, supported by positive contributions from ASEAN's GDP growth and Vietnam's cassava price index. Conversely, the Thai cassava price index and exchange rate fluctuations negatively affect competitiveness. These insights provide a foundation for designing strategies and policies to enhance Thailand's cassava export performance, ensuring long-term sustainability and competitiveness in regional and global markets.

Keywords: Export Competitiveness; Revealed Comparative Advantage (RCA); ASEAN Trade Dynamics

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1. Introduction

Cassava is a significant commercial crop in developing countries, particularly in Thailand, where it covers the third largest cultivated area, following rice and maize. Cassava is regarded as a staple food in both industrialized and developing nations, serving as a fundamental component of the global diet. In ASEAN, cassava is not utilized for direct human consumption; it is mostly employed in food processing, such as for chips and pellets. Cassava serves as a significant resource in various contemporary sectors, including animal feed, alcohol production, bioethanol, culinary sweeteners, and monosodium glutamate (MSG). Thailand is recognized as the world's largest cassava exporter, accounting for 79.56% of the global cassava trade, with an approximately 68% of its production destined for export markets. This dominance highlights its significance in Thailand's agricultural and commercial sectors.

In Thailand, cassava industry provides huge benefit in economic system since it is a source of income and employment. It is also used as a renewable energy such as ethanol. Cassava production in Thailand has expanded continuously over the past two decades, with yielding approximately 31 million tons per year. Recently, ASEAN member countries became major world cassava suppliers, especially Thailand, Vietnam, and Indonesia. Thailand exports approximately 68% of its cassava products, ranking as the world's largest exporter of cassava chips and pellets. In addition, the collaboration within ASEAN provides opportunities for Thailand's cassava export. However, the ASEAN also creates a higher competitive environment in the cassava market. Thailand needs to develop a strategy and policy to enhance the competitiveness of its cassava market. Therefore, this paper aims to examine the competitiveness of cassava exports and analyze the factors affecting Thailand's cassava exports in the ASEAN region.

Numerous previous researches focused on the importance of Thailand's cassava industry within a global market. For example, Napasintuwong et al.[1] claimed that there was demand-supply gap in Thailand's cassava sector, which is influenced by the increasing in imports of cassava roots and chips from other countries such as Cambodia and Laos. These imports emphasize that is the necessity for sustainable practices and new solutions to enhance Thailand's cassava supply chain. In addition, Yue[2] and Ferto and Hubbard[3] highlight the comparative advantage analysis by using the RCA framework, while Krugman and Obstfeld[4] emphasize the role of effective trade policies in enhancing cassava export competitiveness. Recently, the study by Statista[5] illustrates Thailand's dominant position in the global cassava trade, despite market volatility and environmental challenges.

Moreover, a study on Thai cassava exports to China by Sukpanich and Wang[6] indicated that Thailand maintained the highest market share and competitiveness from 2010 to 2020. These findings align with broader trends observed in ASEAN markets, where Thailand's cassava products remain in high demand. Thailand's cassava industry has demonstrated resilience by adjusting to shifting market environmental conditions and dynamics, even in the face of variations in export performance.

This paper tries to examine the competitiveness of cassava export and analyses the factor affecting Thailand cassava competitiveness in the ASEAN. In addition, this paper employs the RCA technique to identify the economic factors that affect trade competitiveness. The results of this study provide policymakers and stakeholder practical advice on how to make Thailand more competitiveness in the global cassava market.

2. Literature Review

2.1. Theoretical Framework

This study is based on a multi-layered theoretical framework which incorporates the Comparative Advantage Theory and Heckscher-Ohlin Trade Models. The framework links macroeconomic dynamics, regional integration, and production efficiency to analyze Thailand's competitiveness in cassava exports.

2.1.1. Comparative Advantage Theory

The theory of comparative advantage, as formalized by Balassa[7], he describes how countries can take advantage from international trade by specializing in the production and exporting products that they have a lower opportunity cost compared to other countries. This framework is essential for understanding global

trade dynamics, as it emphasizes the efficiency achievable when countries focus on industries where they are most competitive. He developed the concept of Revealed Comparative Advantage (RCA), which offer an empirical method to evaluate a country's comparative advantage in particular products or industries. Unlike the traditional theories that depend on assumptions regarding to resource endowments and production costs and, the RCA employs actual trade data to discovers specialization patterns. The RCA index is estimated by comparing the proportion of a specific product in a country's total exports to the share of the same product in global exports. The RCA value greater than 1 can be said that the country has a comparative advantage in that product, since it exports value a disproportionately high share relative to global trade. The used of the Revealed Comparative Advantage (RCA) index in this study transcends simple identification of competitiveness. The RCA is utilized to clarify changes in Thailand's export dynamics from 1997 to 2024.

2.1.2. Heckscher-Ohlin Model and Factor Endowments

The Heckscher-Ohlin (H-O) framework, which developed by Eli Heckscher and Bertil Ohlin, provides a theoretical basis for understanding how nations' factor endowments and shape their trading patterns. The model states that countries would export products that rely on their abundant production factors and import products that necessitate factors in which they are comparably scarce [8]. This model is particularly relevant to Thailand's cassava industry, which benefits from abundant agricultural resources, including vast arable land, a favourable tropical climate, and a relatively low-cost labour force, enabling cost-effective cassava production. This paper supports the H-O model by presenting that these plentiful factor endowments are the main source of Thailand's competitive advantage in cassava production. Since cassava is a land-intensive crop, Thailand's vast agricultural acreage offers a competitive advantage over nations with restricted farming areas. Moreover, the accessibility of inexpensive labour has allowed Thailand to sustain production efficiency, hence keeping costs lower than those of competitors such as Vietnam and Indonesia. These factor endowments enable Thailand to excel in the manufacture of cassava-derived products, such as bioethanol, animal feed, and processed starch, establishing it as the foremost exporter in the ASEAN area.

However, Thailand's cassava industry might not completely benefit from the H-O framework's assumptions of perfect factor mobility and substitutability across industries. Economical resource allocation is hampered by structural inefficiencies, such as antiquated farming methods, poor transportation systems, and a lack of mechanization. Furthermore, climate variability is a considerable problem, as cassava production is acutely vulnerable to fluctuating weather patterns, pests, and soil degradation [9]. These characteristics indicate that Thailand's comparative advantage is not wholly assured and relies on overcoming these structural problems.

Empirical evidence suggests that Thailand must enhance its factor productivity through investments in infrastructure, technological innovation, and sustainable agricultural practices to maintain its competitive edge. Pongsiri and Kanjanapas [10] highlight the potential of precision agriculture technologies—such as GPS-equipped machinery and real-time monitoring systems—to optimize resource use and mitigate environmental risks. Moreover, policies promoting crop diversification and value-added cassava products, such as biodegradable plastics and functional food ingredients, could help Thailand sustain its competitive advantage beyond low-cost production.

Despite Thailand's dominance in cassava exports, competition from neighbouring countries such as Vietnam and Cambodia, which are also endowed with similar factor resources, continues to pose challenges. Vietnam, for example, has been investing heavily in improving its cassava supply chain and developing cost-efficient processing technologies to capture a larger market share [11]. This underscores the need for Thailand to enhance its production capabilities and develop resilience strategies to maintain its leadership position.

In conclusion, while Thailand's comparative advantage in cassava production is well-explained by the Heckscher-Ohlin model, the country's reliance on traditional factor endowments makes it vulnerable to both

domestic and external challenges. Addressing inefficiencies in production infrastructure, adapting to climate change, and embracing technological advancements are critical for sustaining long-term competitiveness in the global cassava market.

2.2. Empirical Review

Cassava is considered as a significant agricultural commodity in Thailand as its diverse economic contributions. In addition, cassava serves as a major source of income and employment and is integral to various industries, including animal feed, bioethanol, and sweeteners for food processing. Numerous literatures related to the issue of cassava especially examined the factors influencing cassava's competitiveness and export performance, particularly in ASEAN markets.

The empirical literature in this section offers valuable insights into the principal factors influencing its performance within ASEAN and global markets by critically examining previous studies focusing on three main aspects, Thailand's competitive position in the global cassava market, the key determinants influencing cassava export performance, and the future opportunities.

2.2.1. Thailand's Competitive Position in the Global Cassava Market

A key component of Thailand's agricultural economy, the cassava industry plays a crucial role in the nation's economic development, job creation, and rural livelihoods. Thailand, as the foremost supplier of cassava products, significantly contributes to worldwide markets by supplying cassava chips, pellets, starch, and bioethanol, so creating considerable export profits and improving the nation's trade balance. The industry supports millions of farmers, particularly in rural areas, providing them with a stable source of income and fostering socio-economic development. Cassava also contributes to Thailand's renewable energy initiatives, as it serves as a key raw material for bioethanol production, aligning with national energy policies and sustainability goals. Moreover, the industry's integration with regional and international markets through trade agreements, such as the ASEAN Free Trade Area (AFTA), has further strengthened Thailand's competitive advantage, enabling the country to capitalize on growing global demand for cassava-based products.

Several empirical studies highlight Thailand's dominance in the global cassava trade, with the country accounting for approximately 79.56% of the world's cassava exports[5] Sukpanich and Wang[6] found that Thailand maintained the highest market share in cassava exports to China, its largest trading partner, from 2010 to 2020. This competitive edge has been attributed to Thailand's efficient production systems, government policy support, and strong supply chain networks. Similarly, Yue[2] and Ferto and Hubbard[3] employed the Revealed Comparative Advantage (RCA) index to examine Thailand's comparative advantage in the global cassava market, concluding that the country has consistently demonstrated strong export competitiveness relative to regional competitors such as Vietnam and Indonesia.

However, emerging competitors are progressively diminishing Thailand's market share. Zhou and Liu[11] states that Vietnam's expansion in cassava exports, supported by targeted government policies and improved production techniques, poses a significant challenge to Thailand's traditional dominance. This finding indicates that while Thailand retains a competitive advantage, strategic interventions are necessary to sustain its leading position in the face of intensifying competition.

2.2.2. Key Determinants Influencing Thailand's Cassava Export Performance

Thailand's competitiveness in exporting cassava has been found to be significantly influenced by a number of macroeconomic and market-specific factors. The study by Napasintuwong et al.[12] indicated that GDP growth in ASEAN countries as a major factor driving demand for Thai cassava exports. Greater regional income levels influencing the use of cassava in industrial processes such as the manufacturing of bioethanol production. The impact of regional economic growth is further supported by regression analyses conducted by Sukpanich and Wang[6], which revealed a positive relationship between ASEAN GDP and Thailand's RCA index.

Price competitiveness is another significant factor affecting ccassava export performance. As the research by Poramacom et al.[13] claimed that fluctuations in the Thai cassava price index have a direct impact on export

volumes, higher domestic prices lead to reducing competitiveness in international markets. The research indicated that wholesale and FOB prices significantly influence Thailand's capacity to maintain its export volumes, emphasizing the need for price stabilization measures. Similarly, exchange rate volatility has been identified as a key risk factor of export competitiveness. Choi and Choi [14] demonstrated that currency fluctuations, particularly the appreciation of the Thai Baht against the US Dollar, led to higher export prices, undermining competitiveness.

Technological advancements also play an important role in enhancing productivity and reducing costs. Pongsiri and Kanjanapas [10] highlighted the increasing adoption of precision agriculture technologies, such as GPS-enabled machinery and automated processing systems, which have improved production efficiency and quality. These innovations have the potential to sustain Thailand's competitiveness by reducing production costs and improving product consistency to meet international standards.

2.2.3. Challenges and Future Opportunities

Although Thailand's export performance is robust, the cassava industry is confronted with numerous critical obstacles that could impede its long-term sustainability. Climate variability and environmental factors present substantial threats to cassava output and quality. Khamporn and Lertpatarakomol [9] demonstrated that unpredictable weather patterns, soil degradation, and pest infestations have adversely affected production levels, necessitating the adoption of climate-resilient agricultural practices. The study recommended investment in irrigation infrastructure and crop diversification to mitigate these risks.

Market diversification is another key challenge for Thailand's export performance. According to Wongrat and Thammavong [15], Thailand's heavy reliance on China and ASEAN markets makes it vulnerable to economic downturns and trade policy changes. Their study suggested that developing new markets in regions such as Europe and North America, where demand for cassava-based bio-products is increasing, could provide Thailand with greater stability and growth opportunities.

Furthermore, Thailand's limited focus on value-added cassava products has been identifiedas a weakness in maintaining long-term competitiveness. The research by Truong and Khuong [16] pointed out that cassava-derived products, such as bioplastics and dietary fibers, offer significant potential for market expansion and higher profit margins. However, Thailand's cassava industry remains predominantly focused on low-value exports such as chips and pellets. Encouraging innovation and investment in high-value products could diversify Thailand's cassava export portfolio and reduce dependency on traditional markets.

Overall, the existing empirical literature provides a comprehensive understanding of Thailand's cassava export competitiveness, emphasizing the country's strong market position, the key factors driving export performance, and the challenges that need to be addressed. Thailand's leading position in the global cassava trade is primarily attributed to its cost-effective production systems and regional economic integration, which have facilitated market access and sustained export growth. Key determinants of competitiveness include regional GDP growth, which drives demand for cassava products, price competitiveness that influences Thailand's ability to maintain market share against emerging competitors, and technological advancements that enhance production efficiency and product quality. However, several challenges threaten the long-term sustainability of Thailand's cassava exports, including climate risks that impact yield and quality, exchange rate fluctuations that affect export pricing and profitability, and limited market diversification, which increases the industry's vulnerability to economic and policy changes in key importing countries. Addressing these challenges through strategic investments in climate-resilient agriculture, stable pricing mechanisms, and expansion into new markets will be crucial for maintaining Thailand's global competitiveness in the cassava sector.

3. Materials and Methods

This paper investigates the competitiveness of Thai cassava exports within the ASEAN countries, utilizing secondary a spanning from 1997 to 2024. By analysing

trends and relationships over this extended period, the study aims to provide updated insights into the factors influencing the Related Competitive Advantage (RCA) of Thai cassava. The methodology includes several key steps: data collection, pre-processing (including stationarity testing), calculation of the RCA index, regression analysis, and testing for cointegration among the key variables. The sections below detail these steps.

3.1. Testing for Stationery and Unit Root Test

Since the research conducted by using secondary data, it is essential to identify non-stationary within the time series data. A standard method for detecting unit roots was developed by Dickey and Fuller[17]. However, the original Dickey-Fuller test (DF test) is only valid if the error term is shown to be white noise. The DF test presupposes that the error term is uncorrelated. The error term will demonstrate autocorrelation if the dependent variable in the regression model exhibits autocorrelations. Consequently, they suggested an alternate technique to identify a unit root when the error term is unlikely to exhibit white noise features. This framework is often acknowledged as the Augmented Dickey-Fuller test (ADF test).

The Augmented Dickey-Fuller (ADF) test is an extension of the Dickey-Fuller (DF) test, which includes an additional ρ lag value on the dependent variable to reduce autocorrelation. This study employed the ADF method to examine the unit root of each variable included in the model. The equation employed for the examination is as follows:

$$\Delta y_t = \delta Y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \epsilon_t \quad (1)$$

$$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \epsilon_t \quad (2)$$

Where y_t is the time series variable at time t, y_{t-1} is the lag of the time series variable, p is the coefficient of lag of the time series, t is time, t = 1, 2..., and ϵ is the disturbance term which is independent and identically distributed (iid) with zero mean and variance.

The hypothesis of ADF testing is the same as the original DF test. Therefore, the null hypothesis of the unit root test is that H0: δ = 0 and the alternative hypothesis is H1: δ < 0

The results of the ADF test will inform the differencing procedure if necessary. The ADF test will be performed on the new dataset covering the period from 1997 to 2024. The outcomes will determine whether the variables are integrated at the first difference (I(1)) or require further processing. The ADF process will be tested by comparing the absolute value of the ADF statistic (t-statistic of δ) against the MacKinnon critical value. If the absolute value of the ADF statistic exceeds the absolute value of the critical value, the null hypothesis of a unit root is rejected, indicating that the series is stationary. If the ADF test statistic is lower than the critical value, the series is nonstationary. If the time series shows nonstationarity at the level, it will undergo first differencing, second differencing, and so on. The differencing method will continue until the null hypothesis is rejected.

3.2. Related Competitive Advantage (RCA)

This study utilizes the Related Competitive Advantage (RCA) index, developed by Danna-Buitra and Stellian Ilyas[18] to assess the competitiveness of Thai cassava exports. The computation spans from 1997 to 2024 to assess the export competitiveness of Thai cassava. The formula for RCA is as follows:

$$\text{RCA} = \frac{Xrt/Xrw}{Xt/Xw} \quad (3)$$

Where RCA is Related Competitive Advantage

Xrt is Value of Thai cassava exports

Xrw is Value of world cassava exports

Xt is Value of total exports of Thailand

Xw is Value of total world exports

3.3. Regression Model for Factors Affecting RCA

To assess the factors influencing Thailand's cassava export competitiveness, the study employs a multiple regression analysis model, updated for the data from 1997 to 2024. The model is specified as:

$$\text{RCA} = \alpha_0 + \alpha_1 ASGDP + \alpha_2 CAS_P + \alpha_3 LnEXC + \alpha_4 P + \alpha_5 VEIP \quad (4)$$

RCA (Related Comparative Advantage) indicates the relative competitiveness of Thailand's cassava exports in relation to other countries. An RCA exceeding

1 implies that Thailand has a comparative advantage in cassava exports, whilst an RCA below 1 denotes a comparative disadvantage. The RCA is calculated using trade data and the ratio of cassava exports to total global exports and Thailand's total exports.

ASGDP (Gross Domestic Product of ASEAN countries) This variable denotes the economic output of ASEAN countries, which influences the demand for Thai cassava. An increase in GDP among ASEAN nations has led to heightened demand for Thai cassava exports, resulting in elevated RCA values. With an increase in GDP, consumers and industries in ASEAN countries can acquire an increased amount of imports, especially agricultural products like cassava.

CAS_P (Thai Cassava Price Index) This index measures the local prices of cassava in Thailand. The price of cassava significantly impacts export competitiveness, since high prices may reduce the attractiveness of Thai cassava in the international market. A rise in the domestic price of cassava could undermine Thailand's competitive advantage, since customers from abroad could shift to lower priced substitutes. An escalation in CAS_P would generally yield an adverse impact on RCA, signifying a reduction in competitiveness.

LnEXC (Exchange rate, THB to USD) The exchange rate between the Thai Baht and the U.S. Dollar directly affects the price of Thai export products. An appreciated Baht increases the cost of Thai exports in worldwide markets, hence reducing Thailand's export competitiveness. A depreciated Baht increases the affordability of Thai goods on the global market, hence enhancing competitiveness. This variable is expected to have a negative association with RCA, suggesting that an increase in the exchange rate (a stronger Baht) will reduce the RCA of Thai cassava.

VEI_P (Vietnam cassava price index) Vietnam is a significant competitor to Thailand in the ASEAN cassava market. The price of Vietnamese cassava influences Thailand's competitiveness; if Vietnamese cassava lowers in cost, it divert purchasers from Thailand, thus decreasing Thailand's RCA. This variable indicates foreign competitive pressure from the cassava market in Vietnam. An elevation in VEI_P would typically result in an augmented RCA for Thailand, dependent on favorable market conditions in Vietnam that bolster competitiveness.

4. Results

This section delineates empirical findings from the paper, including the results of the Augmented Dickey-Fuller (ADF) unit root test for stationarity, the multiple regression analysis evaluating factors affecting Thailand's cassava export competitiveness (RCA), and a thorough interpretation of the results. Each phase is crucial for testing the econometric models and understanding the factors influencing Thailand's position in the global cassava export market.

4.1. Unit Root Test Result

This study begins by identifying stationary data for all variables in the model, as the application of stationary data is an essential requirement for time series analysis. The Augmented Dickey-Fuller (ADF) unit root test is utilized to assess the stationarity of each variable. The result of the ADF test are illustrated in **Table 1**, where the figures represent the ADF statistic and the numbers in parentheses denote the optimal lag length of the ADF statistic.

The results indicate that the null hypothesis of a unit root cannot be rejected for the majority of variables included in the model, with the exception of ASGDP. It can be stated that the majority of variables are non-stationary at their level. However, the ADF statistics at the first difference of the time series indicate that the null hypothesis of unit roots can be rejected at the 1% significance level for each variable. This indicates that every variable contained in the model does not possess a unit root, or is integrated of order 1 (I(1)). Consequently, it may be inferred that all variables exhibit stationarity at the initial difference and are suitable for time series analysis.

4.2. Related Competitive Advantage (RCA) of Thai Cassava Exports

The Related Competitive Advantage (RCA) index was computed annually from 1997 to 2024 to evaluate

Table 1. Summaries the Result of Unit root test.

Variable	ADF Statistic at Level	ADF Statistic at First Difference
RCA	−0.28 (0)	−5.28 (1)*
ASGDP	−3.52 (0) *	−6.19 (0)*
CAS_P	1.75 (3)	−3.67(0)*
VCAS_P	−0.53 (3)	−4.93 (0)*
LNEXC	2.27 (0)	−4.72 (0)*

Note: * indicate the significance at 0.01 level, the number in ( ) indicates the optimum lag-length of ADF.

the competitiveness of Thai cassava exports over time. When compared to other exporting countries, this score offers a clear picture of Thailand's position in the worldwide cassava market. The RCA index is an essential indicator for evaluating Thailand's cassava exports in comparison to global exports, indicating the country's competitive advantage or disadvantage in this significant agricultural sector. The competitiveness of Thai cassava exports is seen in **Figure 1**.

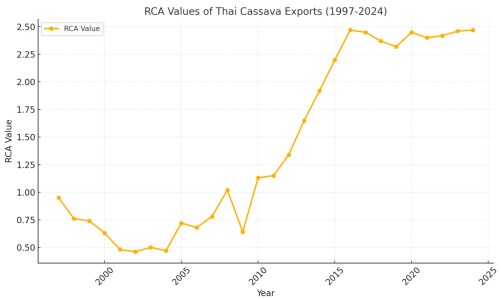

Figure 1. The Related Competitive Advantage index (RCA) of Thai Cassava Exports value.

Figure 1 illustrates that from 1997 to 2024, Thailand's RCA for cassava exports demonstrates considerable fluctuations, indicative of variations in both domestic and worldwide market conditions. The data illustrates that between 1997 and 2009, Thailand's RCA constantly remained below 1, indicating a comparative disadvantage in the globally cassava export market. The RCA score varied from 0.46 to 0.95, demonstrating Thailand's difficulties in competing with other cassava-producing countries, particularly in Africa and Southeast Asia.

During this period, Thailand faced challenges such as diminished output and export volumes, which impeded its ability to scale up the industry and improve export infrastructure. Furthermore, global competition from other countries such as Nigeria, Indonesia, and Vietnam, which also increased their cassava production, it put pressure on Thailand's export competitiveness. The unpredictability of global cassava prices further affected the cost-competitiveness of Thai cassava goods, worsening Thailand's market position.

Between 2010 and 2015, Thailand's RCA score exceeded 1, indicating a transition towards a competitive advantage in the cassava export industry. This competitiveness is controlled by several critical aspects. The enhancement of cassava growing methods, including the implementation of high-yield varieties and improved pest management, has improved Thailand's cassava production as well as effectiveness. The Thai government has implemented supportive policies, including price guarantees, subsidies for farmers, and infrastructural expenditures. This decade has witnessed a rise in global demand for cassava-derived products, including bioethanol, animal feed, and cassava starch, generating new export opportunities, particularly in China and Europe. These synergies helped Thailand to capitalize on growing global markets and improve its competitiveness.

From 2016 to 2024, the Thailand's RCA index consistently increased, culminating in a peak of 2.47 in 2024, which is the highest recorded during the study period. It is significant strengthening of Thailand's cassava export competitiveness. This rise is attributable to multiple factors, including the expansion of significant export markets, with Thailand sustaining robust export relations with China, Japan, and Europe, with an increasing emphasis on bioethanol production, which has created new export opportunities. The global movement towards renewable energy, especially for bioethanol production, has increased the demand for cassava, with Thailand, as a prominent exporter of cassava for biofuel, benefiting from this trend. Thailand's ongoing efforts to improve

production efficiency, coupled with favorable exchange rates, have increased the cost competitiveness of Thai cassava exports, as demonstrated by the RCA index consistently surpassing 2.0 from 2017 to 2024, thereby establishing Thailand's position as the leading global cassava exporter.

Overall, from a time of comparative deficit (1997–2009) to a high comparative advantage beginning in 2010 and lasting into 2024, Thailand's Revealed Comparative Advantage (RCA) in cassava exports has seen a dramatic transition. The rise in RCA is due to multiple factors, including improved production efficiency, governmental regulation, and the growing global demand for cassava-based products, particularly in bioethanol and animal feed. Thailand's strategic focus on expanding its primary export markets within ASEAN and beyond, along with its ability to enhance cost competitiveness, has solidified its position as the leading global supplier of cassava. Despite heightened competition from other ASEAN countries, such as Vietnam and Indonesia, Thailand has successfully maintained its regional dominance by capitalizing on market trends and using its strengths in biofuel production. Maintaining Thailand's leading position in the global cassava market will require continued investments in production technologies, market diversification, and trade relations.

4.3. Factors Affecting Thailand's Cassava Export Competitiveness

In time-series data analysis, it is essential to test for cointegration among variables to determine whether they have a long-term equilibrium relationship. In order determine whether the variables have a long-term equilibrium relationship, it is essential to test for cointegration. Cointegration is a statistical characteristic that signifies if a collection of non-stationary time-series variables, when integrated separately, exhibit a tendency to move in unison over time, implying that their relationship is consistent in the long term. This is essential in econometric modeling, as non-stationary variables may yield false findings if cointegration is not adequately checked. If the variables are integrated, they may or may not exhibit cointegration, indicating that they could either possess a stable long-term relationship or evolve independently over time. In the context of Thailand's cassava exports, factors such as economic growth in ASEAN nations, domestic cassava prices, exchange rates, and regional competitiveness, particularly Vietnam's cassava prices, may demonstrate long-term linkages despite short-term volatility. Consequently, determining the cointegration of these parameters facilitates more precise predictions and analyses of Thailand's cassava export competitiveness. This study applied Johansen Cointegration to accurately evaluate the long-term relationship among these variables. The Johansen test is an effective method for determining the quantity of cointegrating relationships among many time-series variables. This test analyzes the cointegration of variables and estimates the number of cointegrating vectors within the system. The long-term relationships between the model's variables are indicated by each cointegrating vector, which shows that the variables move steadily and predictably over time.

The Johansen Cointegration Test enables the evaluation of whether the variables influencing Thailand's cassava export competitiveness conform to a long-term equilibrium, which is important for understanding the factors affecting export performance and developing informed economic strategies. The presence of cointegration indicates that changes in one variable, such as ASEAN's GDP or Thai cassava pricing, will likely have long-term effects on the competitiveness of Thailand's cassava exports, rather than simply causing temporary fluctuations. As a result, the test serves as an essential tool for evaluating the strong and long-lasting relationships between the study's main variables.

The Johansen Cointegration test results for the factors influencing Thai cassava exports' competitiveness are shown in **Table 2**, which specifically looks at whether the main variables in the model have a long-term relationship. The findings suggest that the examined variables encompass ASEAN GDP, Thai cassava prices, currency rates, and Vietnamese cassava prices, all of which may be interconnected throughout time in affecting Thailand's cassava export performance. The trace statistic for a maximum of 3 cointegrating vectors is 23.74, notably exceeding the 5% critical limit of 20.26. The result indicates the existence of three cointegrat-

ing vectors, signifying three long-term equilibrium relationships among the variables in the model. This indicates that the variables analyzed exhibit a consistent comovement across time, implying that their correlation is not only coincidental but reflects a significant, enduring relationship.

The existence of three cointegrating vectors is significant as it signifies that, despite short-term variations or deviations, these variables are interconnected by long-term forces that influence their movements collectively. This indicates that, in the long term, economic growth in ASEAN nations, domestic cassava prices in Thailand, currency rate fluctuations, and competitive pricing in Vietnam are interconnected. The test results highlight the necessity of evaluating these variables collectively when assessing Thailand's cassava export competitiveness, as their interrelations are both immediate and enduring, influencing Thailand's overall market standing.

The identification of cointegration among the variables enhances the validity of the regression model and its findings. The cointegration of the variables enhances the reliability of the regression analysis results by incorporating the long-term correlations among these elements.

The factors influencing the competitiveness of Thai cassava exports in this study were analyzed using normalized cointegration vectors, which represent the coefficients of the long-run relationships among the key variables. The number in parentheses of to each coefficient indicates the standard error, showing the precision of each computed coefficient. This analysis indicates the Related Competitive Advantage (RCA) index as the dependent variable, influenced by several independent variables: the Gross Domestic Product (GDP) of ASEAN countries (ASGDP), the Thai cassava price index (CAS_P), the exchange rate (LnEXC), and the Vietnam cassava price index (VEI_P).

To estimate the long-term factors that influence Thailand's cassava export competitiveness, the coefficients from the cointegration model were normalized by setting the coefficient of RCA to -1. Subsequently, each cointegrating vector was divided by the negative value of the appropriate coefficient. This methodology allows the vectors to represent the function of RCA and calculate the long-term elasticity of the RCA index, in accordance with the procedure established by Chowdhury (1997). The elasticity indicates the percentage change in the RCA due to a one-percent change in the relevant variable, providing critical insight into the long-term sensitivity of Thailand's cassava export competitiveness to fluctuations in essential economic and market factors.

The result or the long-term determinants influencing Thailand's cassava export competitiveness are displayed in **Table 3**, which includes the normalized cointegrating vectors and their corresponding coefficients. These results demonstrate the extent and direction of the correlations between RCA and the independent variables over the long term, explaining the impact of numerous economic conditions on Thailand's competitive position in the global cassava market. By comprehending these long-term relationships, policymakers and stakeholders can make well-informed decisions regarding strategies to improve Thailand's cassava export performance, including altering prices, managing exchange rate fluctuations, or fortifying regional economic connections within ASEAN.

The regression analysis results offer significant insights into the determinants affecting Thailand's cassava export competitiveness. The intercept of 0.743 indicates that Thailand's cassava export competitiveness (RCA) would be at 0.743 when all independent variables are set to zero, suggesting a modest comparative disadvantage in cassava exports compared to other producers worldwide. However, there are a number of important elements that affect genuine competitiveness. The economic growth in ASEAN countries (ASGDP) exhibits a positive correlation with RCA, indicated by a coefficient of 0.155, which is statistically significant at the 1% level (p-value = 0.000). This demonstrates the strong correlation between regional economic expansion and the demand for Thai cassava products, as the Revealed Comparative Advantage (RCA) of Thai cassava exports increases by 0.155% for each 1% rise in the GDP of the ASEAN countries.

The Thai cassava price index (CAS_P) shows a negative relationship to the RCA, indicated by a coefficient of -0.027 (p-value = 0.072), which is marginally signif-

Table 2. The Johansen Cointegration for factors affecting competitiveness of Thai cassava export.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.229	163.128	76.972	0.000
At most 1 *	0.898	80.237	50.079	0.000
At most 2 *	0.645	41.375	35.192	0.009
At most 3 *	0.612	23.747	20.261	0.015
At most 4	0.361	7.619	9.164	0.097

* denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) p-values.

Table 3. Regression Results for Factors Affecting the RCA.

Variable	Coefficient	Standard Error	t-Statistic	p-Value
Intercept	0.743	0.212	3.50	0.001
ASGDP	0.155	0.032	4.84	0.000
CAS_P	−0.027	0.015	−1.80	0.072
LnEXC	−0.311	0.086	−3.61	0.002
VEI_P	0.084	0.020	4.20	0.000

Adjust R-square 0.71, F-statistic 24.93 (p-value < 0.0001).

icant at the 10% level. This indicates that Thailand's export competitiveness diminishes as domestic cassava prices increase, as elevated prices dissuade foreign buyers from acquiring Thai cassava. The coefficient indicates that a one-unit increase in cassava costs leads to a 0.027 unit reduction in RCA.

The exchange rate (LnEXC) significantly affects Thailand's competitiveness, as indicated by a coefficient of -0.311 (p-value = 0.002). The negative correlation underscores the impact of currency volatility on Thailand's export sector. An appreciation of the Thai Baht elevates the currency rate, leading to increased expenses for overseas purchasers of Thai cassava and reducing the country's competitiveness. For every 1% increase in the value of the Thai Baht against the U.S. Dollar, RCA encounters a decline of 0.311%.

Finally, Vietnam's cassava price index (VEI_P) has a positive effect on RCA, with a coefficient of 0.084 (p-value = 0.000), indicating that higher cassava prices in Vietnam reduce competitive pressure on Thailand, thus benefiting its export competitiveness. A 1% increase in Vietnam's cassava prices results in a 0.084% improvement in Thailand's RCA, reflecting how competitive pricing in neighboring countries affects Thailand's ability to attract buyers.

Overall, the regression results highlight the importance of both internal factors, such as domestic prices, and external factors, such as regional economic growth and exchange rate stability, in determining Thailand's cassava export competitiveness. These findings offer important implications for policy formulation aimed at sustaining and improving Thailand's position as a leading cassava exporter.

5. Discussion

This regression analysis identifies the determinants influencing the competitiveness of Thailand's cassava exports. These findings highlight the complex connection among domestic market conditions, regional economic development, foreign competition, and fluctuations in exchange rates. The Related Competitive Advantage (RCA) of Thai cassava exports is influenced by internal factors, including domestic prices and production efficiency, as well as external factors such as ASEAN economic growth, exchange rates, and regional competition, particularly from Vietnam.

Overall, Thailand's cassava export competitiveness is influenced by a combination of economic, market, and policy-related factors that impact its ability to sustain a dominant position in the global market. Understanding these factors is crucial for developing strategic policies and interventions to ensure long-term sustainability and growth in the cassava sector.

Economic growth within the ASEAN region significantly affects Thailand's cassava export competitiveness. The increasing in GDP of ASEAN countries, particularly China and Vietnam, has led to an increased demand for cassava-based products such as starch, bioethanol, and animal feed. A strong economic performance in these markets creates opportunities for Thailand to expand its exports, while economic downturns can pose risks. Moreover, Thailand's domestic economic policies, including subsidies, price support programs, and investment in agricultural infrastructure, play a crucial role in enhancing production efficiency and maintaining competitiveness. This finding aligns with previous studies on trade and economic growth, indicating that economic development in adjacent nations frequently results in elevated trade volumes and heightened demand for agricultural exports). ASEAN integration significantly enhances regional commercial linkages, as trade liberalization strengthens economic connections and offers Thailand an expanded market for its cassava exports. The growth of ASEAN economies has led to an increased demand for cassava, utilized as mainly a food crop and for industrial purposes such as bioethanol and animal feed As a result, Thailand is positioned to benefit significantly from the current regional economic growth. Policies that bolster ASEAN economic cooperation, reduce trade barriers, and improve logistics infrastructure would strengthen Thailand's cassava export performance.

The export competitiveness of Thailand is significantly influenced by price stability, as seen by an opposite relationship between domestic cassava prices (CAS_P) and RCA. Price is a key determinant of Thailand's cassava export performance. Domestic factors such as production costs, labor availability, and input prices directly influence the price at which Thai cassava is offered in international markets. Exchange rate fluctuations, particularly the appreciation of the Thai Baht against major trading currencies such as the US Dollar, can reduce Thailand's price competitiveness by making exports more expensive. Conversely, depreciation can provide a temporary advantage. Competition from other major cassava-exporting countries, such as Vietnam and Indonesia, exerts downward pressure on prices, compelling Thailand to maintain cost-efficient production methods to sustain its market share.

This link emphasizes the importance of price stability strategies that could mitigate cassava price volatility. Improving cassava production efficiency through the adoption of improved varieties, enhanced pest management strategies, and investment in agricultural infrastructure can maintain competitive pricing while ensuring fair compensation for farmers' yields. Fuglie[19] assert that augmenting agricultural productivity in rising countries like Thailand is necessary for sustaining their competitive position in global agricultural markets.

The competitiveness of Thailand's cassava exports is greatly influenced by the exchange rate between the Thai Baht and the US dollar (LnEXC). The competitiveness of Thai cassava diminishes in global markets as a result of the rise of the Thai Baht, leading to increased costs. This finding aligns with previous studies on currency fluctuations and trade competitiveness, which have shown that a nation's export advantage can be compromised by currency appreciation, increasing the cost of its goods for foreign consumers[14]. The export sector of Thailand is very sensitive to currency swings, particularly for agricultural items like cassava, where price competitiveness is crucial. The central bank of Thailand and export stakeholders must synchronize their monetary policies to mitigate the adverse effects of currency volatility. Policy interventions, such as exchange rate stabilization programs and the promotion of currency hedging for exporters, may alleviate the risks associated with currency volatility

The regression analysis indicates a positive association between the Vietnam cassava price index (VEI_P) and Thailand's RCA. Thailand's export competitiveness seems to rise concurrently with the pricing of cassava in Vietnam. Thai cassava exports face less competitive pressure because of rising prices in Vietnam, consequently enhancing the attractiveness of Thai products for global consumers. This finding corresponds with the research by Truong and Khuong[16], which examined the competitive dynamics of the cassava market in Southeast Asia, suggesting that price increases in one country can benefit other producers by reducing regional competition. This study indicates that Thailand's cassava in-

dustry must consistently evaluate the pricing strategies of its regional competitors, particularly Vietnam, to respond to changes in market dynamics. Furthermore, it suggests that Thailand could benefit from market diversification strategies or regional price coordination mechanisms that reduce reliance on competitors' pricing practices.

6. Policy Implications for Thailand's Cassava Export Competitiveness

The conclusions of this study encompass several essential policy recommendations for preserving and improving Thailand's position as a leading cassava exporter. Regulations for price stability must be implemented to manage local price fluctuation and preserve the competitiveness of Thailand's cassava in global markets. The government ought to promote the adoption of high-yield, pest-resistant cassava varieties and support research and development (R&D) in the cassava sector to improve productivity and reduce production costs.

Thailand ought to strengthen its economic connections within ASEAN and pursue broader market access beyond the region. By diversifying its export markets, especially to regions with rising demand for bioethanol and other cassava-derived products, Thailand might reduce its susceptibility to market volatility and improve its export stability.

Furthermore, controlling currency exchange rate fluctuations is crucial for maintaining Thailand's competitive advantage. The government ought to implement monetary policies to stabilize the Baht and reduce fluctuation that negatively affect the cassava export industry. Furthermore, exporters may be motivated to utilize hedging instruments to effectively manage foreign exchange rate risks.

7. Conclusions

This study has examined the key factors influencing Thailand's cassava export competitiveness, highlighting the long-term relationships among variables such as ASEAN's GDP, domestic cassava prices, exchange rates, and Vietnam's cassava pricing. The findings indicate that both internal market conditions and external economic factors significantly influence Thailand's cassava export competitiveness, as assessed by the Related Competitive Advantage (RCA) index. The positive correlation between ASEAN's GDP growth and Thailand's Revealed Comparative Advantage (RCA) suggests that regional economic expansion enhances demand for Thai cassava, hence improving the nation's export performance. The study underscores the adverse effect of domestic cassava prices on competitiveness, emphasizing the need for price stability measures to maintain Thailand's competitive edge. The currency rates greatly affect Thailand's export competitiveness, as a higher Baht diminishes the nation's pricing competitiveness in global markets.

Competition from Vietnam, an important cassava producer in ASEAN, was recognized as a factor influencing Thailand's RCA. The expansion of cassava prices in Vietnam has a substantial impact on the competitiveness of Thailand's exports, suggesting that market behavior is significantly influenced by regional price dynamics. These findings underscore the necessity for Thailand to monitor and respond to competitive challenges from surrounding countries to preserve its position as a leading global exporter of cassava.

These discoveries have clear implications: The cassava export sector of Thailand needs emphasize price stability, regional economic integration, and currency exchange rate management to sustain its competitiveness in international markets. Policymakers should prioritize advancements in domestic production by investing in technology, research, and enhanced agricultural practices to boost output and reduce costs. Furthermore, efforts to diversify export markets and reduce dependence on a restricted number of countries may help mitigate issues associated with price fluctuation and global market instability.

In conclusion, while Thailand has markedly enhanced its cassava export competitiveness, it is imperative for the country to continually adapt its approach to the evolving global and regional economic landscape. To maintain its leadership in the global cassava export market, Thailand must solve the concerns identified in this

study, particularly by enacting governmental reforms that ensure stability in pricing, currency, and market conditions. Future research may investigate the impact of climate change on cassava production and evaluate government programs designed to enhance the cassava sector, thereby offering a more comprehensive understanding of sustaining Thailand's long-term competitive edge.

Author Contributions

Conceptualization,S.R.; methodology, S.R.; software, S.R.; validation, S.R.; formal analysis, S.R.; investigation, X.X.; resources, X.X.; data curation, S.R.; writing—original draft preparation, S.R.; writing—review and editing, K.M.; visualization, S.R.; supervision, K.M.; project administration, K.M.; funding acquisition, K.M. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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