The influence of biofuel energy production on the exports of the palm oil industry in Malaysia: A panel GMM and robust standard error approach

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ABSTRACT

In recent years, there has been a consistent and significant increase in the consumption of biofuels by countries across the globe. Numerous governments have implemented distinct quotas and objectives aimed at promoting and governing the augmented utilization of biofuels. The demand for biofuel is growing in European countries, which increases the export of biofuel energy in parent countries such as Malaysia. The Malaysian government has suggested receiving different sustainability certifications that are relevant to the biofuel industry. The Malaysian government has made it compulsory to attain environmental sustainability for oil-producing certification. The purpose of this article is to examine the role of biofuel energy production on the exports of the palm oil industry in Malaysia. This study uses the annual data of Malaysian palm oil exporters from 2009 to 2018 and employs the generalized method of moments (GMM) and the robust standard error methodologies. The findings showed that the production of palm oil plays a positive role in the exports of Malaysia's palm oil industry. This study will serve as a guide for future research in this area and for the authorities when formulating policies regarding exports. It is recommended that these authorities should put extra emphasis on the productivity of the palm oil industry to further enhance Malaysia's exports of biofuel, and the government needs to implement regulations to protect the environment.

Contribution/Originality: This study contributes to existing literature by examining the role of biofuel energy production on the exports of the palm oil industry in Malaysia.

1. INTRODUCTION

In the emerging world, the majority of problems are found in the harvesting of energy, and fossil fuels that release carbon emissions are considered to be the most significant contributors to global warming. There are also other concerns that exist in the assessment of energy measurements, such as accuracy and precision of measurement instruments and methodologies, data consistency, and comparability and changes in energy policies (Von Braun & Tadesse, 2012). The significance of identifying a feasible alternative to fossil fuels cannot be overstated, especially in emerging countries where their use has reached unprecedented levels. Biofuels, derived from biomass, are gaining recognition as a potentially viable solution to a range of energy-related challenges. Fuel shortages can be attributed to two main factors: the decline in petroleum sources and the need to mitigate global warming by minimizing carbon emissions associated with the consumption of fossil fuels. In response to these challenges, mechanisms have been established to effectively overcome fuel shortages. Clapp (2009) asserted that optimizing the conversion of biomass into biofuels and enhancing agricultural technologies are crucial steps in fully realizing the potential of biofuels.

Renewable energy sources play a crucial role in the diversification of our energy portfolio and the reduction of our reliance on non-renewable fossil fuels, and liquid biofuels have emerged as viable and environmentally sustainable substitutes for petroleum-based fuels. Moreover, in the pursuit of enhanced energy efficiency and the assessment of determinants impacting energy consumption and production, several investigations have provided insights into the complex interrelationships among the variables, including carbon dioxide (CO_2) emissions and GDP, among others, as noted by Epstein et al. (2012). This has been undertaken with the aim of enhancing the knowledge and understanding regarding the various aspects that influence energy production and use. These research findings offer valuable insights that can inform the creation of policies and initiatives aimed at aligning energy production with the goals of promoting environmental sustainability and fostering economic development.

Kushairi et al. (2018) proposed that in 2017 one third of the world's palm oil production (75.17 million tons) came from Indonesia and Malaysia. One of the prime reasons behind this is the weather conditions in these regions. The weather in Malaysia is optimal for the cultivation of agricultural products, and the Malaysian government and the private sector are getting the maximum output from these natural benefits by cultivating palm oil-related products. Currently, Malaysia is the second largest palm oil exporter to the USA and the European Union (EU). In 2018, the area of palm oil cultivation land increased from 5.74 to 5.81 million hectares. The largest contributor in the cultivation of palm oil is the private sector, which stands at 66% (Board, 2018). These figures are evidence of the importance of palm oil cultivation and export in Malaysia. The growing demand for biofuel among European and other countries motivated this research. It also highlights the demand for biofuel in economic growth and captures the attention of regulators when formulating policies. In addition to the above, there are multiple other factors which need to be investigated, and researchers are encouraged to further investigate this field in the future.

Several studies have utilized different datasets to conduct comprehensive examinations of the factors that impact the efficacy of biofuel production. Cummins and Macintyre (2002) argued that the comprehensive evaluation of biofuels is often hindered by the complex interplay between their impact on agriculture and many socioeconomic factors, such as employment and productivity. The potential of biofuels is often obscured by the intricate network of energy distribution cycles across the different economic sectors. According to Ravallion (1990), the agricultural sector plays a pivotal role, while the service industry and manufacturing sector also heavily depend on energy consumption to address the challenges they encounter. The incorporation of biofuel energy is evident across all examined sectors, and this study aims to elucidate the strategic procedures involved in sourcing raw materials, executing industrial processes, and facilitating the transportation and distribution of the end products. The selection of energy sources, including coal, gases, petroleum, hydropower, electricity, and many types of renewable energy, is a pivotal aspect in the research undertaken on this subject matter. Ciaian (2011) argued that doing an impact evaluation on the utilization of pesticides and chemical fertilizers holds great significance and contributes significantly to a comprehensive analysis of the energy emission framework. These studies offer valuable insights into the intricate dynamics of biofuel production and its impact on various sectors. This will aid the development of energy policies that focus on driving sustainability and efficiency.

The increase in the price of crude oil has not only impacted the economies of many countries, the consumption of biofuel has also increased where the production of such energy has doubled in the emerging world (Byerlee, Jayne, & Myers, 2006). This price increase has not only affected small and developing countries, it has also affected countries such as Spain, China, Brazil, the United Kingdom, the United States, Italy, and many others (Timmer, 2000). It impacts different aspects of different countries, but it is also considered an important factor that specifies the change in price and the production of biofuel, which results in dramatic changes in the prices of crops. Energy is a requirement for the growth of any sector because of its use in all areas of technology and consumer usage (Chung & Myers Jr, 1999). According to some researchers, this energy consumption leads to the production of CO_2 emissions and GDP growth; therefore, the objective of this study is not only to specify the areas that are the main victims of energy

consumption but also to specify the major areas with the best means and the best knowledge that have a positive influence on other economic sectors (Fafchamps, 1992).

Contemporary research not only incorporates the analysis of carbon dioxide emissions, but also identifies potential strategies that take into account various other emissions. This phenomenon can be attributed to the fact that CO_2 is a greenhouse gas. The initial notions surrounding energy consumption are comprehensible and plausible, and emerging markets and the exploitation of energy resources have expanded the geographical scope of industries. However, the predominant aspect that receives significant attention across industries is energy, owing to its pervasive utilization (Dietz & Rosa, 1997). The fluctuating prices of fuel have not only influenced the costs of other consumer items, but they have also resulted in an escalation of pricing for higher-end products. The agricultural sectors are categorized based on certain quantitative factors that have had various impacts. In contrast, the prices of crops have experienced enhancements alongside various other consumer goods that play a significant role in supporting the agricultural sector (Ang, 2007). Nevertheless, it is widely acknowledged that fluctuations in energy prices are inevitable. This implies that there are various measures that can be used to safeguard energy resources. The aforementioned actions encompass not just CO_2 emissions, GDP, agricultural productivity, and crop prices, but also include many additional elements that can influence the production of biofuels (Friedl & Getzner, 2003). In recent years, there has been a consistent and significant increase in the consumption of biofuels by individuals. Numerous governments have implemented distinct quotas and objectives aimed at promoting and governing the increased use of biofuels. The European Commission has assumed a substantial role in the formulation of consumer regulations that incorporate the principle of sustainability (Boden, Marland, & Andres, 2009). The category of biodiesel holds significant importance within the realm of biofuels. Renewable diesel, in its various forms, has played a crucial role in shaping fuel consumption trends. According to the research conducted by Msangi, Ewing, and Rosegrant (2010), the rise in consumption is being facilitated by a range of advancements and innovations in the technological aspects of biofuel production. Paustian, Six, Elliott, and Hunt (2000) argued that the promotion of biofuel consumption aligns closely with the quota systems and policy choices implemented by numerous governments in their pursuit of environmental and energy objectives. There has been a simultaneous increase in production as a result of the increase in demand. According to the findings of Raupach et al. (2007), the expansion of the biofuel industry has had a significant role in the fluctuations in price levels within this sector. Prominent countries, such as France, Germany, and the United Kingdom, have emerged as leading consumers and producers of biofuels. The objective of this study is to enhance our understanding of the dynamics within the constantly evolving biofuel industry investigation and to further explore the factors that impact the export business of Malaysian palm oil cultivation, building on the recommendations put forth by Kushairi et al. (2018).

2. LITERATURE REVIEW

The production of biofuel has gained significant attention and recognition in numerous countries as a vital aspect of technological transformation. It has become an integral part of discussions focused on reviewing production methods and the utilization of biofuel as a sustainable energy source. Many studies have concentrated on assessing the efficiency of biofuel energy production, with a particular emphasis on technological improvement and the final stages of refining. However, in contrast to the enthusiasm surrounding biofuel production, it is imperative to acknowledge that certain critical elements required to meet sustainability criteria may be lacking for achieving desirable energy yields (Davis & Caldeira, 2010). The production process demands a thorough review to ensure optimal efficiency in the energy consumption and production phases. Notably, Zhou and Thomson (2009) conducted an analysis that identified Asia as the world's largest biofuel producer. Various sectors within the industry have a fundamental concern with energy consumption, often intertwined with agricultural and industrial operations, which are strongly associated with biofuels. Biofuels not only produce certain gases but also give rise to various other environmental and economic considerations (Holtz-Eakin & Selden, 1995). The energy derived from the biofuel

production process plays a pivotal role in contributing to overall energy sustainability. As the world continues to grapple with energy challenges, biofuels represent a promising avenue for addressing energy needs while minimizing the environmental impact.

2.1. Biofuel Production

The influence of energy on agricultural production is widely recognized. The use of oil accounts for approximately 90% of the global energy production dedicated to commercial activities. The link between biofuel production and agriculture is an undeniable aspect that cannot be disregarded. For further details, refer to Jekanowski, Williams, and Schiek (2000), Jekanowski et al. (2000), and Paustian et al. (2000). Numerous studies have been conducted to elucidate the correlation between biofuel production and agricultural productivity (e.g., Jekanowski et al. (2000)). The existing literature suggests that there is a positive correlation between the rising demand for biofuel and its impact on agricultural productivity. There is a hypothesis suggesting that the growing demand for biofuel may have an impact on agricultural productivity. In recent decades, a noticeable increase has been observed in the share of energy obtained from biofuels. The findings of the study conducted by Paustian et al. (2000) indicate that there is a positive correlation between rising commodity prices and the subsequent increase in the costs of agricultural products. The mitigation of agricultural production cost increases can be achieved through a reduction in biofuel consumption. However, it is important to note that this statement alone oversimplifies the issue. The increasing need for biofuel is not limited to the US and the EU but extends to many regions across the globe. The association between the utilization of biofuel energy and the escalation of agricultural product prices has been established in a study by Fafchamps (1992). Furthermore, the analysis conducted by Scott, Van Walbeek, Kennedy, and Anyeti (1972) yielded comparable findings, providing additional support for these conclusions. There are several other factors associated with biofuel that indirectly influence the cost of agricultural commodities. An illustration of this phenomenon can be observed in the implementation of policies, such as the adoption of environmentally sustainable practices. If the Malaysian government were to implement strict measures regarding environmental sustainability, such as the certification and rigorous regulation of land used for biofuel production, it could potentially lead to fluctuations in agricultural prices (Chen & Sun, 1991).

Biofuel importers have strict environmental sustainability requirements, which increases biofuel prices. This increasing trend will further impose a greater burden on agriculture prices in Malaysia. This biofuel and agriculture equation varies from nation to nation. Dietz and Rosa (1997) proposed that in the USA, the supply and demand for food articles affect the entire market for biofuel. The raw materials for the production of biofuel are agricultural crops. Hence, there is a linkage between agricultural crops and biofuel (Pons Jr et al., 1966). One of the reasons behind the increasing price of agriculture is the rising demand for agricultural crops for biofuel. In another investigation by Raupach et al. (2007), it was proposed that three major factors stand behind the increasing food prices: 1) biofuel production, 2) petrol prices, and 3) the weak position of the US dollar. These results are supported by Paustian et al. (2000). In the past decade, the Malaysian government has made special efforts to enhance biofuel energy as a result of variations in fuel prices. Another study, by Ciaian (2011), proposed that the increase in agriculture prices was not due to the high usage of biofuel consumption but was instead because of the artificial variation in petroleum prices, weak dollar health, and low commodity fund investment (Hill, 2009). Clapp (2009) proposed that increasing trends in oil prices will result in a decrease in the supply of food and will have a negative effect on the extension of biofuel around the globe.

The policies designed for the cultivation of agricultural crops also affect the prices of agricultural end products for biofuel. There are multiple artificial methods of agricultural cultivation that also affect the price of end products. In Malaysia, the cultivation of palm oil affects environmental sustainability, so the government has designed some regulations to protect the environment (Lehtomäki, Viinikainen, & Rintala, 2008). The Malaysian government has suggested different sustainability certifications to deal with the biofuel industry. The government has made it

compulsory to attain environmental sustainability certification for oil production and is being strict regarding compliance with the rulings. The producers operate in accordance with the government guidelines that increase biofuel prices (Purwanto et al., 2019), whereas other organizations that do not have sustainability certification enjoy the high biofuel price by having lower operational costs. The environmental sustainability factor also affects agricultural product prices. The USA and the EU, two of the major importers of biofuel, require all of their vendors to strictly follow the regulations imposed by the relevant authorities for the cultivation of raw materials for biofuel (Subhadra, 2010).

2.2. Biofuel Energy Production and Exports

In 2017, the palm oil export business made a contribution of 3.8% to the Malaysian economy's GDP, amounting to a total of 44.8 billion Malaysian Ringgit (Board, 2018). The key markets for Malaysian palm oil exports and imports include India, China, and Pakistan. There is a positive association between a nation's GDP and its exports. Based on the research findings, a notable association has been observed between the exportation of palm oil and the pricing dynamics of agricultural commodities; the prices within the agriculture sector are significantly impacted by the production levels of palm oil as well as its importation.

The production of palm oil utilizes agricultural leftovers as a primary input. Nevertheless, the cultivation of these crops exerts a significant influence on the long-term sustainability of the environment. The government devised a range of initiatives to maintain a balance between oil exports and environmental sustainability. The implementation of additional restrictions has led to an increase in the costs associated with agricultural output, and as a result of this advancement, there has been a positive trend observed in the prices of agricultural commodities.

Numerous nations rely on their GDP as a foundation for their economic development, and Brazil is among these nations. Boden et al. (2009) claimed that there are several interdependent factors that have significant implications for economies. GDP exhibits a positive correlation with these components, and the utilization of energy can significantly enhance overall development and growth. The increase in energy consumption in Brazil during recent decades is widely attributed to the country's growing standard of living. When a dominant component contributes significantly to the rise in energy consumption, it may also have implications for other aspects of the economy. In this particular instance, the enumerations assert certain assumptions on the increase in energy consumption in Brazil, which is mostly attributed to the reliance on imported fossil fuels. This reliance on imported fossil fuels poses significant challenges to Brazil's energy sector (Marland, Andres, & Boden, 1994). Hence, the Brazilian government implemented proactive measures aimed at bolstering security protocols pertaining to energy consumption and production. The aforementioned preventive measures represent the policies and programmes implemented to decrease reliance on fossil fuels through the development of renewable energy sources. The study also examines the escalating consumption of energy, with a specific focus on the utilization of biofuel (Olivier, Peters, & Janssens-Maenhout, 2012). When examining the Brazilian economy in its entirety, encompassing the impacts on energy consumption and production, it becomes evident that a thorough investigation into the influence of biofuel energy on Brazil's GDP is important.

According to Morgans et al. (2018), in the course of examining the interrelationships among these factors, a comprehensive review of relevant scholarly works has been conducted to ascertain a significant link between exports and biofuel energy generation. The purpose of this action was to establish a connection between the two entities. The assessment and examination of prior publications have involved a critical evaluation of two main aspects: the significance of the research in relation to biofuel energy and exports, and the focus of the models used in these studies (Morrow & Mohsenin, 1966). Krokida, Karathanos, and Maroulis (1998) observed that many authors have undertaken the task of quantifying the breakdown of energy consumption into multiple components that originate from fossil fuel sources. Numerous studies have shown various long-term associations between exports and biofuel energy production. However, certain researchers have also highlighted the presence of bidirectional causation among the

selected components, which serves as the most suitable framework for understanding the study (Yang & Ying, 2011). Numerous scholars have discussed the interconnections from diverse viewpoints, while the convergence of multiple nations has been employed to list the outcomes and establish the conclusive findings. In the literature review, certain authors have expanded their analyses beyond the examination of the relationship between biofuel production and export growth in specific countries. They have conducted comprehensive investigations into this relationship within the United States of America, emerging nations, a selection of 10 developing countries, as well as specific OECD countries. This includes African nations and major consumers of biofuels (Costa et al., 2011). The present study examines the consumption patterns and quantities of biofuel energy in the selected nations, while also investigating the relationship between the consumption of biofuel energy and the GDP growth of these countries. When examining perspectives on consumption, it is also important to consider the influence of production factors. The production characteristics discussed by Meier et al. (2015) provide evidence of positive outcomes for both the individual countries and the overall output within the economic context of biofuel. Current scholarly investigations have placed significant emphasis on the intricate relationship between the utilization and generation of biofuels. This research has yielded noteworthy advancements in economic and environmental domains, highlighting the need for sustainable alternatives within the biofuel business. The existing literature has extensively explored a broad range of topics. These investigations have not only focused on the relationships between various variables and the limitations of the methodologies employed, but have also yielded noteworthy findings that support optimistic expectations in this field (Bredahl, Meyers, & Collins, 1979). This phenomenon can be attributed to the constraints imposed on both the variables and the approaches used. Numerous scholarly investigations have consistently demonstrated that energy consumption plays a crucial role in overall economic development and growth. This holds true regardless of whether the energy originates from non-renewable or renewable sources (Babcock & Clemens, 2004). Furthermore, these circumstances have positive implications for policy implementation.

The increasing exportation of palm oil is a source of revenue generation for the economically disadvantaged segments of the nation's populace. There is a positive correlation between the quantity of exports and the desire for agriculture expansion, resulting in growth in agricultural revenue. Farmers are the primary contributors of labor in the agricultural production process, exerting significant effort while receiving comparatively minimal compensation. A positive association has been shown between the export of palm oil and the potential decrease or eradication of poverty in Malaysia. The leading exporters of palm oil from Malaysia are expressing growing apprehension regarding the implementation of environmental certificates, as it results in an escalation of production costs and a decrease in profit margins. Conversely, enterprises that choose not to pursue certification often see greater financial gains due to their ability to provide export pricing that are on par with their competitors, despite the fact that the manufacturing costs for the latter are considerably higher.

2.3. Biofuel Energy Production and CO₂ Emissions

The mitigation of global warming can only be achieved through the protection of the environment, ensuring its sustainability for the benefit of future generations. The requirement imposed by the Malaysian government for enterprises to acquire social sustainability certification is a commendable measure aimed at reducing carbon dioxide emissions. The US and the EU, as the primary importers of petroleum, are exerting pressure on exporting nations to ensure compliance with the established criteria. There is a negative correlation between global warming and the environmental sustainability of the earth. The factors contributing to global warming have emerged as a key subject in recent times. David and Ragauskas (2010) asserted that the impacts of global warming are becoming more evident. The escalation of global warming can be ascribed to various contributing factors. The depletion of the ozone layer, which encircles the Earth, has occurred due to global warming. This stratum serves as the primary safeguard for the planet in terms of shielding against the Sun's UV radiation. The rapid progression of climate change serves as a major catalyst for the emission of carbon dioxide (CO_2). One potential strategy for mitigating global warming involves the

implementation of measures aimed at decreasing the emission of carbon dioxide into the Earth's atmosphere. Ongoing research is being conducted to explore strategies aimed at reducing CO_2 emissions (Zhu & Zhuang, 2012). The existing body of research has indicated a correlation between the utilization of biofuel-derived energy and the emission of carbon dioxide. Zhao, Shen, Ge, and Yoshikawa (2014) proposed a hypothesis suggesting the existence of a bidirectional relationship between the utilization of biofuel energy and the production of carbon dioxide in Greece. The authors asserted that this correlation exhibits bidirectional causality. Conversely, the aforementioned link was examined in two distinct nations, wherein it was contended that while the findings garnered support when applied within the Chinese context, they yielded entirely different outcomes when applied within the Indian environment. As stated by Cramb and Ferraro (2012), these data suggest that the outcomes are influenced by geographical boundaries. In contrast, Ou, Zhang, Chang, and Guo (2009) conducted a study in Malaysia which posited that the relationship between the utilization of biofuel energy and CO_2 emissions is unidirectional, specifically with regard to the country's economic growth. Mukherjee and Sovacool (2014) asserted that the findings indicate variations in results across different nations. According to Ravallion (1990), in the United States, the relationship between CO_2 emissions and two significant factors, namely economic growth and energy consumption intensity, was identified as having a considerable impact. Timmer (2000) investigated the correlation between development variables and CO_2 emissions, positing that the latter is influenced by the former. Furthermore, it has been suggested that the technological advancements in the agricultural sector are an additional factor contributing to the escalation of carbon emissions in Pakistan. Based on research, the utilization of renewable fuel within the transportation sector, which exhibits a strong correlation with carbon dioxide (CO_2) production, leads to a reduction in the emission levels of carbon dioxide. Governments worldwide are presently engaged in the development of legislation and policies aimed at promoting the adoption of renewable fuel to mitigate CO_2 emissions. Biodiesel is an additional variant of biofuel, and Subhadra and Edwards (2010) asserted that the use of CO_2 emission-reduced biodiesel constitutes 7% of Europe's overall fuel usage.

The transport industry in Thailand is accountable for the highest energy consumption levels on a consistent basis. The dependence on imported oil is attributed to its significant utilization within the energy supply chain. The Thai government has developed a series of rigorous rules along the whole biofuel production and supply chain that are designed to ensure environmental sustainability and minimize carbon dioxide emissions. Importers are required to adhere to these regulations in order to maintain compliance. The US and the EU have reached an agreement on the implementation of a zero-tolerance policy for importers of crude oil as a means to protect the environment. Road transport in Europe constitutes the second most significant contributor to greenhouse gas emissions on the continent, surpassed solely by electricity generation.

The vehicle transport sector within the EU's economy has been identified as the sixth most significant source of CO_2 emissions. The EU has outlined its agenda up to 2050, which includes a proposed reduction of up to 70% in the emission of various gases. Based on the results of several studies, it has been determined that the CO_2 emission threshold can be achieved in the next ten to fifteen years. The EU is making substantial efforts to enact laws that will compel all participants in the gasoline business to adhere to the newly established criteria.

Cherubini et al. (2009) conducted specific investigations on the reduction of CO_2 emissions from passenger vehicles. When evaluating the impact of biofuel on CO_2 emissions, various methodologies are employed, with each technique being dependent on the specific geographical limits under consideration. The collection of biomasses for energy generation has both positive and negative implications for global warming, which is recognized as being one of the most urgent global challenges.

The utilization of biofuel has a minimal influence on the adjacent ecosystem. It is highly recommended that the newly established policies pertaining to these issues, which have been formulated by the EU, be diligently implemented.

2.4. Biofuel Energy Production and Agriculture Production

The favorable climatic conditions in Malaysia are widely recognized for their suitability in cultivating agricultural crops that can be utilized for the production of biofuel. Malaysia's endeavors in the biofuel sector have witnessed a notable surge in investment, particularly in the production of biofuel intended for exportation. The Malaysian government has implemented regulations that impose specific obligations on oil exporting firms in terms of the cultivation and shipment of their product. Based on data provided by the Malaysian Palm Oil Board (MPOB), the volume of oil shipped in 2020 was projected to amount to around 1.40 million tons.

The discourse surrounding the topics of fuel and food is currently garnering a growing level of interest. Biofuel production involves the utilization of unprocessed agricultural products, and the utilization of biofuel has been found to have adverse effects on the long-term sustainability of the environment. Hidayat, Glasbergen, and Offermans (2015) asserted that the maintenance of a clean environment is crucial for ensuring good health, despite the undeniable need for food to sustain life. Achieving a harmonious equilibrium between food production and environmental conservation is crucial. Zhu, Pan, and Zalesny (2010) asserted that there is significant concern throughout the international community over this matter. To ensure the preservation of environmental sustainability, the US and the EU have mandated that the importation of biofuel must be accompanied by a certification verifying its adherence to environmental sustainability standards. The implementation of environmental certification will lead to an increase in the production costs associated with biofuel, thereby impacting the pricing of food commodities. The escalation in cost has a detrimental impact on the raw materials utilized in the production process, resulting in a decrease in the production capacity of food goods. De Gorter, Drabik, and Just (2013) suggested that the escalation in biofuel prices leads to a reduction in agricultural output, hence exerting a detrimental impact on the agricultural commodities market. Since 2006, there has been a discernible upward trajectory in the cost of agricultural commodities, concomitant with a corresponding increase in the demand for biofuels in food production. The rise in the production and utilization of biofuel has resulted in negative consequences for economies that are in the early stages of growth (Hill, 2009).

Koizumi (2015) examined the economic implications of biofuel production on food safety. The author posited that the long-term elasticity of the supply chain equation serves as a crucial factor in determining the pricing dynamics of agricultural products when biofuel is produced. A negative association has been shown between the production of biofuel and the safety of food. However, it is plausible that the expansion of the agricultural sector may lead to the emergence of new opportunities. The governments of the Association of Southeast Asian Nations (ASEAN) countries are promoting the adoption of biofuels as a means to save the natural environment and enhance farmers' income levels. The majority of countries in the ASEAN region are categorized as either developing or economically disadvantaged. Additionally, these countries are acknowledged for their significant role as importers of food products. Koizumi and Ohga (2007) believe that the escalation of social disorder can be attributed to price hikes resulting from intense competition within the food industry. To mitigate the repercussions of food-related issues on Asian nations, it is imperative for international stakeholders to collaborate to avoid these issues.

Msangi et al. (2010) discovered a favorable association between the increasing use of agricultural commodities for biofuel production and food consumption. This finding led them to infer that the demand for both food and fuel is closely aligned. There is an apparent association between increasing levels of household income and escalating levels of energy consumption, with transport emerging as a prominent driver of this upward trajectory. The aforementioned scenario also applies to the global population. An observable positive trajectory can also be demonstrated with regard to the quantity of energy or fuel being utilized. The increasing prevalence of this phenomenon is exerting an adverse influence on the global environment, as it contributes to the generation of supplementary resources that can be utilized for energy provision, such as biofuel or palm oil (Yoshizaki et al., 2012). Furthermore, Fuglie et al. (2011) conducted an investigation of the evolving trends of investment in research and development undertaken by both the private and public sectors with the aim of meeting the increasing demand for food. The private sector plays a crucial

role in facilitating the integration of innovation within the agricultural business to effectively address the increasing global demand for food. The escalating demand for energy, particularly biofuel, is placing further strain on the private sector to augment its financial investments in research and development in order to effectively adapt to the rapid fluctuations in demand.

3. RESEARCH METHODS

This study employs a quantitative approach to evaluate the influence of biofuel energy production on the exports of the palm oil companies in Malaysia. We use the log of total biofuel energy production and the log of biofuel exports in US dollars to represent biofuel energy production and exports, respectively. In addition, carbon emissions are measured by log of CO_2 emissions from the total energy production. Sales growth is measured by the change in the income from the previous year divided by the previous year's income. Firm size is measured by the log of total assets.

Based on the literature, this study uses the following model:

$$EX_{it} = \beta_0 + \beta_1 LBFEP_{it} + \beta_2 LCO2_{it} + \beta_3 SG_{it} + \beta_4 FS_{it} + e_{it} \qquad (1)$$

Where i = the ith firm, t = time period, EX = exports of biofuel energy, LBFEP = log of biofuel energy production, LCO2 = log of carbon emissions from total energy production, SG = sales growth, FS = firm size, LPR = log price of crude oil. Table 1 details the measurement of the variables.

Table 1. Measurement of variables.

Variable	Measurement	Source
Exports	US dollars	Shahida, Hafizuddin-Syah, and Fuad (2018)
Biofuel energy production	Log of total biofuel energy production	Gupta, Jain, and Yadav (2011)
CO_2 emissions	Log of carbon emissions from total energy production	Schneider and McCarl (2003)
Sales growth	(Revenue$_1$ - Revenue$_0$) / Revenue$_0$	Ramasamy, Ong, and Yeung (2005)
Firm size	Log of total assets	Ramasamy et al. (2005)

3.1. Data

There are currently 17 palm oil companies operating in Malaysia that have sustainability certification, but only seven companies are involved in the exporting process of biofuel energy to other countries. Since the social sustainability certification was only available in Malaysia after 2008, the data was extracted from the annual reports of the seven companies (see Table 2) that exported biofuel from 2009 to 2018.

Table 2. List of Malaysian palm oil exporters.

S. no.	Company	RSPO certification	MSPO certification
1	Felda Global Venture Bhd.	Yes	Yes
2	Sime Darby Bhd.	Yes	Yes
3	IOI Corp. Bhd.	Yes	No
4	Keck Seng (Malaysia) Bhd.	Yes	No
5	Kuala Lumpur Kepong Bhd.	Yes	No
6	Kwantas Corp. Bhd.	Yes	No
7	IJM Plantations Bhd.	Yes	Yes

Note: RSPO: Roundtable on sustainable palm oil.
MSPO: Malaysian sustainable palm oil.

3.2. Data Analysis

This study employs the panel data approach for data analysis. Prior to the panel data analysis, multicollinearity is checked by employing the variance inflation factor (VIF) and correlation matrix. The multicollinearity is evaluated using the following equations:

$$R^2{}_{EX} \qquad EX_{it} = \alpha_0 + \beta_1 LBFEP_{it} + \beta_2 LCO2_{it} + \beta_3 SG_{it} + \beta_4 FS_{it} + e_{it} \qquad (2)$$

R^2_{LBFEP} $LBFEP_{it} = \alpha_0 + \beta_1 EX_{it} + \beta_2 LCO2_{it} + \beta_3 SG_{it} + \beta_4 FS_{it} + e_{it}$ (3)

R^2_{LCO2} $LCO2_{it} = \alpha_0 + \beta_1 LBFEP_{it} + \beta_2 EX_{it} + \beta_3 SG_{it} + \beta_4 FS_{it} + e_{it}$ (4)

R^2_{SG} $SG_{it} = \alpha_0 + \beta_1 LBFEP_{it} + \beta_2 LCO2_{it} + \beta_3 EX_{it} + \beta_4 FS_{it} + e_{it}$ (5)

R^2_{FS} $FS_{it} = \alpha_0 + \beta_1 LBFEP_{it} + \beta_2 LCO2_{it} + \beta_3 EX_{it} + \beta_4 SG_{it} + e_{it}$ (6)

$j = R^2_{EX}, R^2_{LBFEP}, R^2_{LCO2}, R^2_{SG}, R^2_{FS},$ (7)

$VIF = \dfrac{1}{Tolerance}$

$Tolerance = 1 - R^2_j$ (8)

Following an initial analysis of the economic obstacles associated with multicollinearity, the research subsequently proceeds to investigate the effects of biofuel production. To achieve this, we employ both the generalized method of moments (GMM) and the robust standard error methodologies. The GMM methodology has the capability to address the challenges related to serial correlation, outliers, and multicollinearity commonly encountered in the examination of secondary data (Shen, Lin, Ren, & Li, 2019). Within the GMM framework, there are two distinct methodologies for addressing these difficulties. One of the suggested strategies by Arellano and Bond (1991) is the utilization of the initial differences of the variables, which eliminates the fixed effects and is commonly known as the Difference GMM. Javid and Katircioglu (2017) proposed that the initial Difference GMM model effectively removes the time-invariant fixed effects. Additionally, they argued that the delayed dependent variables serve as suitable instruments for the first differenced variable. In their study, Arellano and Bover (1995) observed that the utilization of a lagged level of regression may lead to the presence of weak instruments when examining first-differenced variables, particularly in cases when these variables exhibit serial correlation. Arellano and Bover (1995) proposed that the system GMM is an alternative model that effectively addresses the difficulties posed by the Difference GMM. Furthermore, the study conducted by Blundell and Bond (1998) provides evidence supporting the notion that system GMM outperforms the Difference GMM in terms of predictive accuracy. According to Wooldridge (2016), the advantages associated with the utilization of the system GMM include the capacity to address endogeneity, unobserved heterogeneity, measurement errors, and omitted variable bias. Consequently, the system GMM was selected in order to address the obstacles presented by autocorrelation, heteroscedasticity, and multicollinearity. The robust standard error is commonly utilized as an estimator in regression models to ensure the validity of statistical findings when the assumptions of the models are violated. The alternative covariance estimator, which is widely employed nowadays, was developed by Huber (1967). The aforementioned approach successfully and reliably estimates the standard errors, even in the face of heteroscedasticity problems within the residuals. Hence, in the presence of heteroscedasticity in the data, employing a robust standard error estimation can yield the most accurate estimation while simultaneously addressing the issue of heteroscedasticity. Furthermore, if the residuals exhibit correlation, the generalized estimator will also yield a consistent standard error. The violated assumptions were addressed by employing the robust standard error estimator, which led to the acquisition of an appropriate estimation from the model in this study, owing to the utilizations of both of these methods.

4. FINDINGS

The results obtained from the variance inflation factor (VIF) analysis show that there are no multicollinearity concerns (see Table 3). There is a low level of correlation between the data and the constructs, as evidenced by all values being below 5.

The results obtained from the correlation matrix indicate the absence of multicollinearity among the constructs. Additionally, the values below 0.90 for all variables suggest a weak association between them. The findings of this study also indicate the presence of multicollinearity. Table 4 presents a summary of the correlation matrix.

Table 3. Variance inflation factor results.

Variable	VIF	1/VIF
LBFEP	1.894	0.528
FS	1.795	0.557
SG	1.461	0.685
LCO2	1.24	0.807
Mean VIF	1.597	

Table 4. Matrix of correlations.

Variable	LCO2	LBEFP	LNEX	FS	SG
LCO2	1.000				
LBFEP	0.138	1.000			
LNEX	0.303	0.439	1.000		
FS	-0.021	0.603	0.129	1.000	
SG	0.438	0.256	0.856	-0.118	1.000

The GMM methodology revealed a positive correlation between the production of biofuel energy and Malaysia's palm oil industry in terms of exports. Moreover, there is a favorable correlation between the increase in exports within the palm oil sector and the development observed in retail sales. The data also indicated a negative correlation between firm size and exports, whereas the level of CO_2 emissions had no significant association with the exports of the palm oil industry (see Table 5).

Table 5. GMM approach.

Variable	Beta	S.D.	T-value	P-value	Lower limit	Upper limit	Sig.
LBFEP	1.425	0.367	3.88	0.000	0.691	2.159	***
SG	0.046	0.003	16.78	0.000	0.041	0.052	***
FS	-0.451	0.136	-3.31	0.002	-0.724	-0.178	***
LCO2	0.078	0.069	1.14	0.261	-0.059	0.215	
Mean dependent variable	1.241	SD dependent variable			0.697		
Number of obs.	63.000	F-test			143.471		

Note: *** $p < 0.01$.

An analysis of the relationships between the variables of interest was also conducted with the robust standard error methodology. The results align with the GMM approach, revealing a positive link between Malaysia's biofuel energy production and the exports derived from its palm oil sector. Furthermore, a strong correlation may be shown between the growth of sales and the global trade of palm oil within the sector. Nevertheless, the data also indicated a negative correlation between company size and exports, whereas CO_2 emissions exhibited a negligible association with the exports of the palm oil business (see Table 6).

Table 6. Robust standard error approach.

Variable	Beta	S.D.	t	P > t	Lower limit	Upper limit
LBFEP	2.264	0.590	3.840	0.009	0.820	3.708
FS	-0.635	0.178	-3.560	0.012	-1.071	-0.198
SG	0.050	0.003	15.860	0.000	0.043	0.058
LCO2	-0.025	0.053	-0.470	0.655	-0.155	0.105
_Cons	1.443	0.495	2.920	0.027	0.232	2.653

5. DISCUSSION

Based on the findings, it can be inferred that the production of palm oil in Malaysia has a positive influence on the country's palm oil sector exports. The connection between exports and production is inherent, as surplus goods are subject to government evaluation to ascertain their eligibility for exportation to foreign countries after meeting domestic demand. Consequently, there is a substantial need for the extensive cultivation of palm oil in the nation,

thereby facilitating the exportation of biofuel. Moreover, a surge in sales has the potential to motivate investors and proprietors to engage in supplementary investments and generate a larger volume of biofuel. Consequently, this will lead to an increase in investors' returns and contribute to the overall economic expansion of the nation. The aforementioned findings exhibit similarity to the conclusions derived from previous research conducted by Mueller, Anderson, and Wallington (2011), who observed a positive correlation between a nation's level of production and its volume of exports. The prioritization of meeting a nation's domestic requirements precedes the government's authorization of exporting surplus goods to foreign countries. Consequently, there is a need to significantly increase the manufacturing of specific products to facilitate their sale in markets beyond the domestic market. Furthermore, the results of a study conducted by Costello, Griffin, Landis, and Matthews (2009) indicated that a rise in sales and exports serves as a catalyst for investors to engage in substantial investments within this industry. Additionally, it motivates producers to expand their product offerings, enabling them to cater to both domestic and international markets, thereby contributing to the overall economic growth of the nation.

Moreover, the results of this study align with the conclusions drawn by Schuenemann, Thurlow, and Zeller (2017), who posited that increased production has the capacity to meet not only the current domestic market demand but also the demand of foreign markets. The authors argued that sales growth motivates producers to expand their production on a larger scale. This phenomenon can be attributed to the capacity for high production to meet the demands of domestic and international markets. Hence, the substantial production of biofuel and an increase in sales within the present market incentivize manufacturers to engage in international trade, aiming to enhance the financial performance of their enterprises and contribute to the economic prosperity of their country. Furthermore, the study conducted by Van der Horst and Vermeylen (2011) uncovered that the exportation of biofuel on the global market necessitates a substantial production capacity that not only meets the domestic market's demand but also fulfils the demand on the international market. The aforementioned findings align with the results of the present study, which indicate that businesses are motivated to enter the worldwide market due to high levels of output.

6. CONCLUSION

In summary, the current study has determined that augmented biofuel production, in conjunction with heightened sales within the prevailing market, contributes to an upsurge in biofuel energy exports. Malaysian palm oil companies are experiencing significant growth in sales and exports due to their robust production of biofuel and other palm oil products, which are in high demand both domestically and internationally. This extensive level of production effectively meets the substantial demand within the country and beyond its borders. Due to the escalated production of biofuel, which has the potential to adversely impact the environment through the generation of carbon dioxide emissions, the government is concurrently implementing substantial measures to ensure environmental sustainability. In an effort to mitigate the environmental deterioration resulting from extensive biofuel production and consumption, the government has implemented measures to heighten the level of difficulty for palm oil firms in obtaining social sustainability certificates. This article aims to provide a comprehensive framework for future research in other countries. Furthermore, it will serve as a valuable resource for regulators in formulating laws pertaining to exports. It is proposed that authorities should prioritize the promotion of the palm oil industry's production of biofuel, thereby bolstering both the country's economic growth and its export capabilities.

6.1. Limitation and Recommendations for Future Research

The limitations of this paper provide guidance and opportunities for future study on this particular topic. The generalizability of the current research findings is limited to the palm oil industry in Malaysia due to the constrained scope of the study. Consequently, researchers have been advised to enhance the comprehensiveness of their papers by incorporating a wider range of nations and industries. It is suggested that forthcoming investigations should augment their temporal scope by incorporating further time series data into their analyses. The reason for this is that the social

sustainability certification was introduced in Malaysia in 2008, and the scope of the present study was limited to a decade-long period spanning from 2009 to 2018. Furthermore, this study solely considered the aspect of biofuel production in its endeavor to forecast biofuel exports. However, it failed to consider several additional factors that impact the exportation of biofuel, such as infrastructure development, market demand, and technological advancements. Therefore, future investigations should incorporate these variables.

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