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A Composite Forecast Approach for Market Demand Using Regression with Simulation to Predict the Palm Oil Market

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[ABSTRACT / EXECUTIVE SUMMARY]

There is a dearth of literature with econometric models that use a combination of different forecasting approaches to make predictions for market demand especially for commodity products. Procurement needs for many products for example bleaching earth that is used in the refinement of crude palm oil as an example depend directly on the forecast of palm oil. This research develops an econometric model to determine the market size with crude palm oil as an example in the context of Indonesian market. Key factors of market demand such as production and consumption factors, factors determining export and import of crude palm oil and biodiesel consumption factors, in the context of palm oil are identified from existing literature and case studies. A multilinear regression approach with time series analysis is used to study the interaction of these factors, modelling their behaviour and predicting their coefficients in determining the overall market size.

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A Composite Forecast Approach for Market Demand Using Regression with Simulation to Predict the Palm Oil Market

Abstract

There is a dearth of literature with econometric models that use a combination of different forecasting approaches to make predictions for market demand especially for commodity products. Procurement needs for many products for example bleaching earth that is used in the refinement of crude palm oil as an example depend directly on the forecast of palm oil. This research develops an econometric model to determine the market size with crude palm oil as an example in the context of Indonesian market. Key factors of market demand such as production and consumption factors, factors determining export and import of crude palm oil and biodiesel consumption factors, in the context of palm oil are identified from existing literature and case studies. A multilinear regression approach with time series analysis is used to study the interaction of these factors, modelling their behaviour and predicting their coefficients in determining the overall market size.

With this, fifty independent variables with ten dependent variables defining the palm oil market for Indonesia are identified initially. Using three regression techniques viz. Ordinary Linear Regression (OLS) with time, OLS without time, and 2SLS, ten multivariate regression equations were developed. Each equation captures the relationship between the independent and dependent variables to explain the market dynamics. Equations modelling production and consumption, import and export, and other equations modelling biodiesel consumption of crude palm oil in Indonesia were formulated.

Using time series analysis with Moving Average, Holtz method along with Monte Carlo Simulation a comparative analysis was then performed to determine the best prediction with least error.

It is realized that though traditional time series analysis methods can help predict the independent variables better, the simulation approach shows more consistency and higher accuracy with the control data. While the resulting model is used for forecasting upto five years, the accuracy test for robustness could be performed only for three years into the future with available data.

Keywords: Market Demand; multi-regression; Monte Carlo simulation; forecasting; Indonesia; OLS regression; 2SLS

1. Introduction

Palm oil is one of the greatest contributors to economic development. Particularly in Indonesia, the major contributor to national development is Palm oil. USD 23 billion was the export value generated by the Palm oil export in Indonesia (Purnomo et al., 2020). In 2014, to Indonesia, 17% of gross domestic product was contributed by Palm oil (Hariyadi, 2020). In 2016, the global production of Palm oil was 64.5 million metric tons, and the two countries of Indonesia and Malaysia combined accounted for about 89% of the world's production (World Bank, 2017). Palm oil production is determined by numerous factors, ranging from planting to being a commodity. It is undergoing various processing steps for by-product extraction and gets the final product. During the refining process of Palm oil, a chemical called "Blearth" is a primary ingredient.

It is manufactured and supplied by a firm called Chemicals International, also known as Chemi. Chemi is a key supplier of Blearth in Indonesia and adjoining countries. The emerging market of South East Asia represents high growth potential for Chemi because of the continued growth of Palm oil production in this region. They are supplying three grades of Blearth to the market that are differentiated by different levels of activation of the chemical. The activation process is cost-intensive. Therefore, the highest grades of Blearth are the most expensive in the market. While Chemi's sales are increasing, the scale of the market and the market share are not transparent to them. Therefore, this research aims to forecast the near-optimal demand of 'Blearth' needed for biodiesel production in Indonesia's palm oil industry.

1.1 Palm oil value chain

The Palm oil value chain starts with the growing and harvesting of Fresh Fruit Bunches (FFB) in plantations. These FFBs are sent to mills where Crude Palm oil (CPO) and Palm Kernels are extracted. Palm Kernels are further sent to crushing mills to make Crude Palm Kernel Oil (CPKO). Then the Crude Oils are refined into Refined Palm Oil (RPO) and Refined Palm Kernel Oil (RPKO) products for edible and non-edible consumption. The versatility of Palm oil extends its use in the creation of Oleochemicals and Biodiesel (Hashim, Tahiruddin, & Asis, 2012). Different levels of palm oil production are clearly explained in Figure 1.

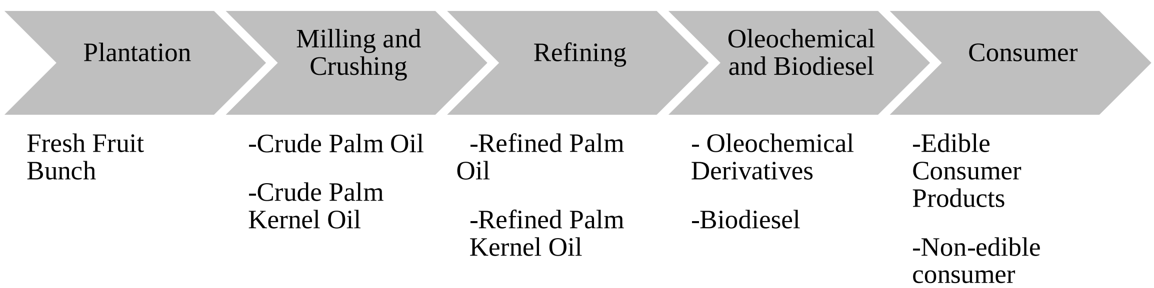


Figure 1. Palm oil value chain

The oil palm tree, *Elaeis guineensis*, produces a continuous supply of Fresh Fruit Bunches (FFB) throughout its economic life cycle. Its economic life cycle starts from two to three years after planting and lasts up to about 25 years when it is felled. The increasing difficulty in harvesting from taller trees and the decrease in yield are the factors determining felling and re-planting (Henson, 2012). During its economic life, the oil palm tree is harvested every 7 to 14-day intervals. The FFBs are transported to palm oil mills, which are usually located at the place of the plantation itself. They are milled within 24 hours of harvesting to minimize the rise of free fatty acids (FFA), which degrade the quality of the oil produced. The typical crude Palm oil extraction Rate (OER) during the milling process is in the region of 18 to 23 % by weight of the FFB. Moreover, the palm kernel OER is in the range of 4 to 6 % by weight of FFB.

2. Literature review

2.1 Palm Oil Market Dynamics

Through private businesses, state-owned companies, and smallholders, palm oil contributes significantly to the economies of Indonesia and Malaysia, with the two countries accounting for 85 percent of global palm oil output. Indonesia has 14 million hectares (ha) of oil palm, and its palm oil exports in 2017 and 2018 were worth USD 23 billion and USD 21 billion, respectively (Purnomo et al., 2020). Palm oil demand is rising to meet global cooking oil, food ingredients, biofuels, soap and other chemical requirements. Palm oil processing and use has become a controversial topic. Individual nation-states no longer have the ability to monitor and manage global flows like palm oil. In the palm oil industry, private corporations and non-governmental organizations tend to be the new ruling networks. New sources of control emerge as a result of network programming and network connectivity (switching) (Oosterveer, 2015)

Biodiesel exports have decreased dramatically over the years, despite various government incentives and subsidies. More attention is needed to a critical evaluate the biodiesel industry's challenges, as well as key policies, frameworks, and institutions. The key obstacles to biodiesel production are high feedstock costs, competition with food, engine compatibility, subsidies, and crude prices. To address the challenges and improve the biodiesel industry's long-term prospects, environmental, socioeconomic, and technological reforms are needed (Johari et al., 2015). The price of crude palm oil is causally linked to shifts in two variables that are extremely elastic in the long run. Because of the increasing competition for palm oil in food and fuel, crude oil has become a critical variable in the demand equation for palm oil in particular and vegetable oils in general. In short, the market for palm oil has grown beyond the traditional agricultural supply and demand system to include the energy sector. With the increasing interest in biofuels, crude oil is an important factor to consider when predicting palm oil's future. In short, the market for palm oil has grown beyond the traditional agricultural supply and demand system to include the energy sector (Arshad, Awad, & Hameed, 2012)

2.2 Insights from the Previous Studies

(Labys WC, 1973) developed a comprehensive approach for specifying and estimating dynamic commodity models having three parts one, to examine the market component equations for demand, supply, inventories, and price. Two, to consider the relationships between them and incorporate them into a commodity model. Third, it shows how such a model can be used in policy decision-making. The modeling approach presented forms the first pillar of this research's strategy as it deals explicitly with modeling palm oil markets. (Voituriez, 2001) studied the sources of price volatility changes of commodities considering the demand for Palm oil (1818-1999). They showed that the superimposition of operators located at a short distance to the export supply having expectations horizon restricted to limited weeks and operators at long-distance away from the export supply having expectations horizon more than a year is accountable for volatility deviations and market variability.

(Talib & Darawi, 2002) developed a model for the palm oil market of Malaysia to find the parameters affecting the industry. Domestic consumption, total oil Palm area, imports and exports from 1970 and 1999, and oil Palm yield were taken into account from the estimation of the model. The study revealed that the Palm oil industry is affected by the exchange rate, Malaysian economic activity, and the world population. Few other important factors were the price of Palm oil, Palm oil stock level, and soyabean oil price. (Hasan, Reed, & Marchant, 2001) analyzed the oil Palm industry export performance of Indonesia by time series analysis affected by the dynamic behavior of export tax. A model based on vector auto-regression was used, implying that the tax imposition led to a massive fall in exports, and it also has long-lasting effects on the Indonesian oil Palm industry. (Applanaidu, Arshad, Shamsudin, & Hameed, 2011) described the oil Palm biodiesel demand of Malaysia as affected by different factors. They formulated a market model that can represent world excess demand, palm oil production, export demand, palm oil prices, the rest of the world's excess supply, and import. Two stages (2SLS) least-squares method employing annual data between 1976-2008 domestic price equations were developed to check the relation among the Malaysian palm oil market and biodiesel demand. The world palm oil price, Malaysian ending stock, lagged domestic price, and biodiesel demand affected the domestic price.

Outcomes recommend that the demand for biodiesel has an impact on the Malaysian oil Palm internal price. (Sulistyanto & Akyuwen, 2009) studied the crude Palm oil (CPO) export of Indonesia by multiple regressions with nearly 40 years of data. CPO export was not optimally supported by the government policies, whereas export financing was a prime parameter. The black campaign and CPO price had a significant but negative influence, while the soybean and sunflower oil had a significant and positive role. Domestic consumption, domestic cost, GDP per capita of endpoint countries, CPO production volume, crude oil price, exchange rate, and government policy had no impact.

(Phitthayaphinant, Nissapa, & Somboonsuke, 2012) researched quantitatively using annual time-series data to present scenarios of the area of Palm oil plantation and related independent factors. Multiple regression and statistics were used to show that Thai oil palm plantation areas have improved. Prices of diesel oil, internal demand for CPO, farm prices of palm oil FFB, and farm prices of unsmoked rubber sheet grade 3 seemed to be the noteworthy variables affecting areas of palm oil plantation. (Dewi & Arshad, 2011) used the framework of (Labys WC, 1973) to describe important factors affecting the Malaysian Palm Oil Industry.

They formed four equations for the Malaysian palm oil market: supply, demand, price, and stock. Moreover, they also further introduced foreign trade equations (import and export). They succeeded in developing market factor equations and identifying the influencing variables for the Malaysian palm oil market. However, they did not use simulation techniques to forecast the future behavior of the same market.

(Zabid & Abidin, 2015) discussed the overview of existing modeling approaches used by researchers in studying issues of the palm oil industry. They performed their study to provide effective policy design for the Malaysian palm oil industry and were concerned with discovering accuracy in existing models. They introduce an improved system dynamic and genetic algorithm to facilitate the policy design process in the palm oil industry. Upon reviewing econometric, system dynamic, discrete event simulation, and agent-based modeling, they also conclude similar to Allen that combination methods of modeling palm oil give the best results.

Similar to the previous study (Egwuma, Serdang, Kai, & Wong, 2016) identified the principal factors that shape the Nigerian palm oil market. They used the ARDL cointegration method to form four market factor equations for production, import, demand, and price. Data used was from 1970 to 2011. Results reveal that domestic price, technological improvements, income levels are significant factors that influence the palm oil industry in Nigeria. Similar approaches but for different regions were made by (Awad Abdel-hameed, 2005). They wanted to study the demand for palm oil in MENA region countries: Algeria, Egypt, Iran, Jordan, Libya, Morocco, Saudi Arabia, Sudan, Syria, and Turkey. Moreover, they utilized the ARDL techniques and found that demand for Palm oil in these countries is explained by the world price of palm oil, the price of soybean oil, rapeseed oil, and sunflower oils, which are substitutes for palm oil. Therefore, the literature was found to be mature for making market models using autoregressive techniques of econometric literature. Looking into these studies, (Badi Baltagi, 2011) textbook on econometrics was studied, and it was found that the ARDL and cointegration techniques were more sophisticated methods of regression analysis. It was found that these studies rely on the presence of large datasets that can be lagged.

Therefore as per (Forecasting with Regression Analysis, 1993), the case was considered if more straightforward methods of regression analysis can be used for modeling the Indonesian palm oil market. A commonality was found across the studies that the palm oil world price and local government expenditures are found to be relevant factors for the demand for palm oil in most of these regions.

An issue with using regression models for forecasting a market is that the future values of the market-defining independent variables are not available in the present. They need to be forecasted. (Allen, 1994) emphasized the importance of economic forecasting in agriculture. Moreover, it mentions how agricultural forecasting is important for a nation’s food security. He says, for short-term forecasting, combining methods lead to more accurate forecasts, better than vector auto-regression. Moreover, further surprisingly, econometric models, both univariate and multivariate models, do worse than naïve methods. There has been prior evidence of using Monte Carlo Simulation (MCS) by (Davies, Coole, & Osipyw, 2014). They observe the histogram of the trajectory of shell baring consumption over some time in an internal combustion engine. And use the distribution of the histogram to generate consumption values using MCS. They performed an extensive study on the applications of MCSs to address a unique problem.

A similar MCS method is used in this palm oil time series analysis, but for different reasons, the distribution is presumed to be normal. The trend values of the independent variables are predicted instead of the full values of the array of independent variables. The implication of the literature review leading to the research motive to conduct this research is shown in Figure 2.

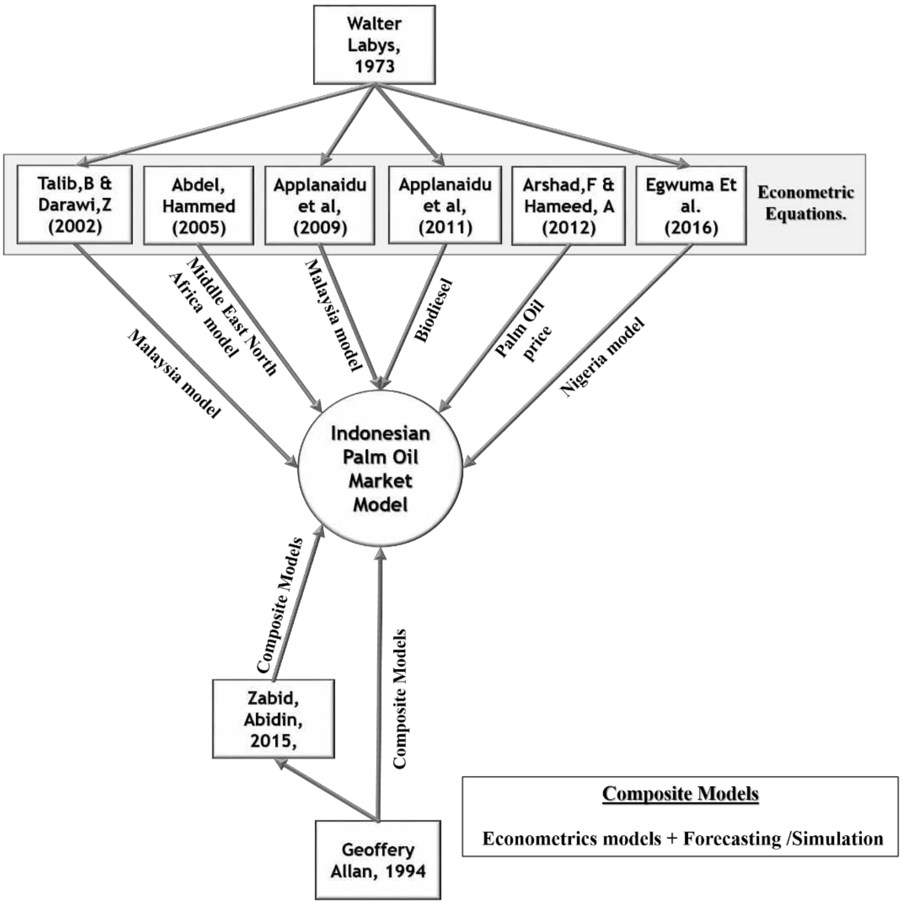


Figure 2. Literature review overview focusing on Indonesian model by (Labys WC, 1973)**,** (Talib & Darawi, 2002)**,** (Awad Abdel-hameed, 2005)**,** (Dewi & Arshad, 2011)**,** (Applanaidu et al., 2011)**,** (Arshad, Awad, & Hameed, 2012)**,** (Egwuma et al., 2016)**,** (Zabid & Abidin, 2015)**,** and (Allen, 1994)**.**

Several papers have been reviewed, and a collection of 50 market indicators have been identified as important to the palm oil industry as a whole. For this study, these metrics were listed as a set of independent variables. When such independent variables were identified, the remaining secondary data were collected by recognizing seven public databases, that are: (BPS-Statistics Indonesia, 2015), (Bank Indonesia, 2016), (Food and Agriculture Organization of the United Nations, 2017), (Index Mundi, 2016), (Ministry of Trade Indonesia, 2017) (The World Bank Group, 2017) (The World Bank Group, 2017) (United States Department of Agriculture Foreign Agricultural Service, 2017) (United States Department of Agriculture Foreign Agricultural Service, 2017), (Faostat FA, 2010; B.-S. Indonesia, 2015; B. Indonesia, 2016; United States Department of Agriculture Foreign Agricultural Service, 2017; Wright T, Rahmanulloh A, 2015). Several modelling techniques have also been described during this literature review, which has previously been used to model the markets of countries listed earlier.

It can be concluded that linear regression models form the basis of econometric study but venture into complex autoregressive lag techniques that need massive amounts of data, which can eventually provide causal inferences to the palm oil industry. The literature of modeling is quite mature in this regard, especially for the country of Malaysia because of the ready availability of agricultural statistical data. However, such modeling is nascent for Indonesia, primarily because of the absence of highly granular agricultural statistical data. With the available yearly data, this research aims to develop multivariate linear regression models that can form the basis for future research in the Indonesian region. This literature review shows that 2SLS, ARDL, OLS, Non-liner-2SLS methods have been used to develop market models and identify factors influencing market dynamics. (M Zabid & Zainal Abidin, 2015) projected that OLS is the most used modeling technique, so this research aims to start modeling with OLS and 2SLS techniques and venture into other complex types if satisfactory results do not show.

It is also noticed that econometric models are limited to data availability and are rigid when they disrupt the systemic equilibrium over the long term when obtaining input from other variables. On the other hand, simulation models are user-friendly so that non-experts can model them and can take input from variables when they encounter change. To build models for Malaysia and understand policy interactions, instances of system dynamics, agent-based modelling, and discrete event simulations have already been used. However, the limitation of system dynamics is that it only provides a snapshot of the market, and improving the system can only be done by changing critical variables in the system.

In this research, an attempt is made to understand the palm oil market of Indonesia. The latest literature reveals a thorough analysis of the Malaysian palm oil industry. Some exemplary efforts have been made by the Malaysian government in collecting agricultural statistics and perpetuating them effectively using current IT instruments. This has helped Malaysia to predict future markets efficiently. For Indonesia, on the contrary, the statistical reporting of agricultural data, especially for palm oil, is not sophisticated. This has resulted in the reduced availability of data and, therefore, has resulted in low palm oil industry market modelling maturity. Thus, with the current availability of data, understanding the complexity of the Indonesian palm oil industry is the area of concern for this study. The research orientation is therefore to discover the factors that affect the Indonesian Crude Palm Oil market and see how these factors communicate with each other.

Based on the previous studies made in other countries, some independent variables were identified, which were incorporated into the regression models. This list of independent variables was also confirmed with Chemi executives who expanded the list by providing their market insights. It was to be seen at the beginning of the modelling process if the variables found to be relevant in other regions would be critically crucial for Indonesia. Therefore, in this research, a few naïve methods of forecasting time series trends of the independent variables were considered, and a sophisticated way of using Monte Carlo simulation for forecasting the patterns of these variables were also considered as per (Allen, 1994) findings.

3. Modeling and simulation

The use of the normative and quantitative methodology to enhance the traditional theory of agricultural economic forecasting was decided. This led to a deductive approach where a careful literature review was conducted that revealed the formal method of commodity dynamic modeling techniques. It was found that these modeling techniques fall between multivariate regression analysis and econometrics. However, a significant limitation to perform this study was quickly identified due to the lack of secondary data from statistical databases.

Upon further investigation of the literature, an exploratory attempt was made to verify the suitability of the simulation methodology to compensate for the missing results. As the essence of this research question is process-oriented, the research architecture of this study can be categorized as 'modelling and simulation.' Simulation plays a dual role not only in the generation of secondary data but also in the experimentation of developed models. It was decided that due to the limitation of the data availability, a descriptive type of problem could be solved. In the research, the level of analysis is the entire palm oil network with the unit of observation as events. As the actor of analysis is the country of Indonesia, the events become the years of study. This converts to a longitudinal time dimension for the research. Firstly, multiple multivariate linear regression models were run to identify which factors were governing the dynamics of the CPO market. This can be seen in Figure 3 at the ‘create models’ stage.

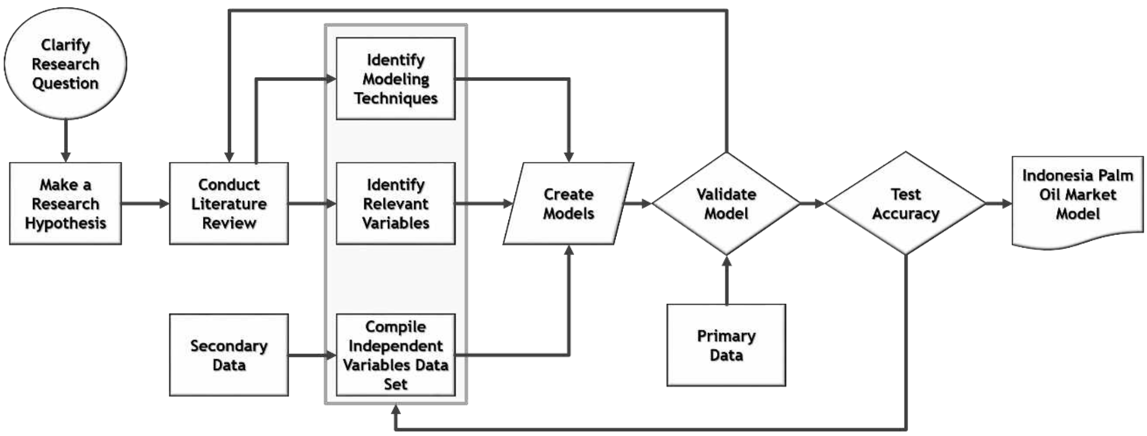


Figure 3. Research process flowchart

Moreover, this research would address few critical research questions such as RQ 1: what are the key influencing factors for the market of CPO in Indonesia? RQ 2: What are probable demand scenarios for the future? RQ 3: What adjustments to the supply chain are required to be able to match supply and demand? RQ 4: What factors influence the market of CPO in Indonesia, and how do they interact with each other?.

The literature review revealed that Indonesia does not have a market model, and by investigating question 4, this research was able to contribute a practical model and understand the Indonesian market. This further expands the literature in the direction of modeling commodity markets and provides forecasts in an environment of fewer data and high uncertainty. Based on some preliminary interviews with Chemi executives, their interpretation of the palm oil market was captured and, during the literature review process, important independent variables considered necessary were captured. This list of independent variables was further generalized by examining previous studies from other countries. To the best of the authors' abilities, it was discovered that there was no research on Indonesia explaining the market behavior. Whereas for the regions of Malaysia, Nigeria, the Middle East, and North Africa, many studies were found describing the dynamics of the palm oil markets of their respective countries.

The process of describing the Indonesian model commenced with ordinary least squares regression without time trend, then ordinary least squares regression with time trend, and two-stage least squares regressions. The previously mentioned secondary data were used in these models by compiling data from 2007 to 2016, as shown in Appendix 5 to 10. Further details of the multivariate regression analysis are provided in the forthcoming section. The established models were then tested for relevance based on the parameters laid out in the statistical analysis literature, and then the results from the experiment were correlated with the primary sales and the company's expert data to see if the behaviour of the developed model made sense. If they did, the simulations were checked for consistency to see if the expected values reflected the real values that had transpired for the variables. If this stage had yielded satisfactory outcomes, it was believed that a reliable model had been developed. The acceptance of the model validity depended on statistical significance, the parameters of which are discussed in subsection 3.3.1. The forecast accuracy tests have been done using MAPE comparison, which can be seen in section 4.2.2. A model that complied with both the criteria was ultimately accepted, else rejected.

3.1 Relevant Factors

According to (Labys WC, 1973), the market for the palm oil industry should be divided into its constituents of Production, Demand, and Price to be effectively modeled. Studies since his earliest publications say that foreign trade components of Import and Export should also be included to explain the market. So, all these five market constituents have been studied, and another constituent, Biodiesel, has also been taken into consideration. Biodiesel has a unique influence on the Indonesian palm oil market because of certain mandates by the government. The Indonesian government is attempting to cultivate the Biodiesel industry at home and supply it to markets in Europe to encourage demand for palm oil producers. Since this industry component has its influencers separate from the regular demand, this research attempts to capture its dynamics separately. These market components have been referred to as Market Factors in this study. In regression terms, they should be considered as dependent variables, and the 50 identified variables should be considered as independent variables.

3.2 Secondary Data

The requirement for secondary data is that the databases be publicly available from well-known and well-respected authorities, which also publicly disclose their methods for data collection and analysis. In this research, the seven primary databases that were identified are Palm Oil Agribusiness Strategic Policy Institute, Index Mundi (Index Mundi is a data portal that gathers facts and statistics from multiple sources and turns them into easy to use visuals), Bank Sentral Republik Indonesia, Food and Agriculture Organization of the United Nations –FAOSTAT, World Bank Group, United States - Department of Agriculture Foreign Agricultural Service, and International Monetary Fund.

The granularity of the data for each of the identified independent variables is yearly and is collected from the years 1964-2016. Some variables like Production and Price have data ranging from 1964, but variables such as Biodiesel Demand and Levies have had data only from 2007. This resulted in forming a homogenous data set is from 2007 through 2016. This subset of the data range was separated and analyzed so that all the variables identified in the previous research works and the ones identified through the industry expert's information could be studied together.

3.3 Multiple Regression Analysis

(Badi Baltagi, 2011) provides a rigorous framework of econometric models, and it was inferred that applying linear regression models could be contemplated as econometric models. Still, due to the lack of the author's formal exposure to econometrics, they refrain from calling these descriptive models econometric. When mentioning the history and evolution of econometrics, (Badi Baltagi, 2011) says classical econometrics uses single equations and simultaneous equations, while modern econometrics shows a link between current and past values of time series variables. It is often argued that the use of the econometric modeling methodology has its difficulties in presenting a useful model, based on the historical data available for each of the independent variables. This represents a significant limitation not in the method itself but instead in the variables that can be used, or which were identified as relevant for each of the factors that determine the model.

The analysis of historical data available for each independent variable determines if the variable will be used or not due to the shortage of information. The regression analysis methods that were identified as most used in previous researches are Ordinary Least Squares (OLS), Two-Stage Least Squares (2SLS), and Autoregressive Distributed Lag (ARDL). Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS) were identified as the most-used analysis techniques for the Palm oil market models. Thus, they were selected as the methods used for this current research. The use of both ways will allow comparing which of them allows for a more significant estimation of the values.

3.3.1 Modeling Process

It has been established that there isn't enough data available for developing structural econometric equations that can provide for causal inferences on the palm oil market for Indonesia. Therefore, an attempt is being made to create a measurement model using multiple linear regression analysis to identify the relevant independent variables that influence the market factors. Although the approach of (Applanaidu et al., 2011), (Egwuma et al., 2016), and (Labys WC, 1973) cannot be introduced for Indonesia at the moment, they do endorse the fact that the market should be divided into component factors. These factors are used as a basis to perform a regression analysis for Indonesia with the hope that significant variables will emerge in the results that measure the market possible and hopefully allow the use of time series techniques for forecasting.

These market component factors are Production Crude Palm Oil (quantity of Crude Palm Oil produced per year), Domestic Demand Crude Palm Oil (quantity of Crude Palm Oil consumed domestically), Domestic Food Demand Crude Palm Oil (quantity of Crude Palm Oil consumed domestically in the food industry), Domestic Industrial Demand Crude Palm Oil (quantity of Crude Palm Oil consumed domestically in the industrial applications), Export Palm Oil (the total quantity exported as Crude and Refined Palm Oil), Export Crude Palm Oil (the total quantity exported as Crude Palm Oil), Export Refined Palm Oil (the total quantity exported as refined Palm Oil), Imports Palm Oil: the total quantity of Crude Palm Oil imported, CPO Demand for Biodiesel: quantity of Crude Palm Oil used for Biodiesel production, and World Price: average world price of Crude Palm Oil

The six factors, Demand, Production, World Price, Import, Export, and Biodiesel, are considered the primary market factors. It is hoped that their models can measure the Palm oil market movements but, the elements for Demand and Export are further divided into Demand Food, Demand Industrial, Export Crude, and Export Refined. The following equations Eq.1 to Eq.4 can explain the relationship between the market factors and independent variables. Moreover, the behavior of the market factors can be represented using multiple linear equations of the form in Eq.5.

Eq.1	$\boldsymbol{Indonesian\ palm\ oil\ marke} = (\boldsymbol{production} + \boldsymbol{demand} + \boldsymbol{import} + \boldsymbol{export})\ \forall\ \boldsymbol{world\ price}.$
Eq.2	$Demand = demand\ food + demand\ industrial$
Eq.3	$Demand\ industrial = other\ industrial\ uses + biodiesel.$
Eq.4	$Export = export\ crude + export\ refined$
Eq.5	$Market\ Factor = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$

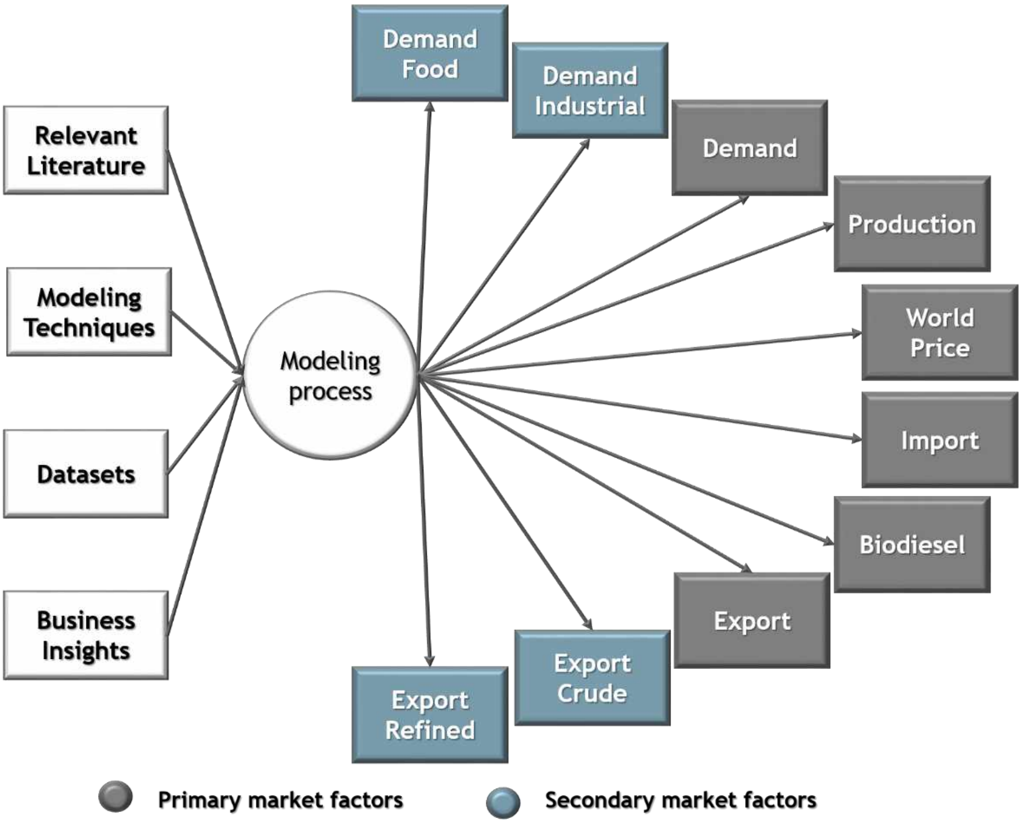


Figure 4 Econometric Modelling Process

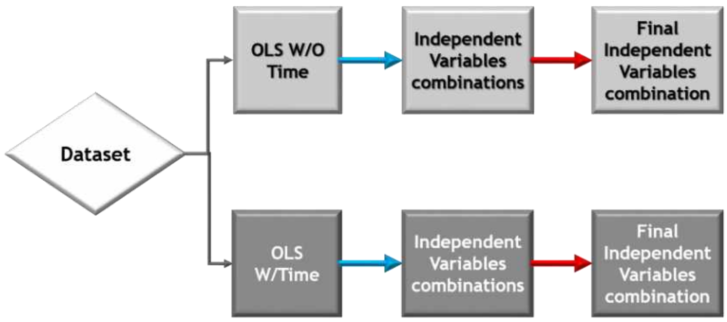
The demand for palm oil is defined by the dependent variables, namely a series of ten factors. For and dependent variable, the corresponding independent variables were allocated either based on the variables defined on the basis of previous research and the inputs given by Chemi executives. Table 1 displays the palm oil market dependent variables, as well as the indicators and their corresponding independent variables. These were gathered from all earlier models established in the various researches, plus the variables identified during the Chemi executive interviews.

The variables are separated as either endogenous or exogenous based on the classification of previous research. This nature of the variables was evaluated based on an *Argumentum ad populum* logic. The analysis of the variable coefficients will be done using OLS and 2SLS methods. To account for the time-series nature of the independent variables in the level of analysis, the OLS was considered on two regressions forms, one including Time as a new variable and the second not considering it as a new relevant factor. This was decided by taking into consideration, and (Wooldridge, 2002) stated that some economic time series tend to grow over time. Therefore, to avoid the conclusion that - the changes in the variable are caused by another variable and not because both variables are correlated as they trend over time. Hence time should be considered as a relevant factor.

Table 1 Market factors and relevant variables

Market Factor	Variable Description	Type of Variable
Production	Production palm oil lagged one year	Endogenous
	Producer Price of CPO	Endogenous
	World Price of Substitute (Soybean Oil)	Endogenous
	Average lending rate %	Exogenous
	Government Expenditure on agricultural development	Exogenous
	The relative price of palm oil to soybean oil	Exogenous
	Rubber World Price	Exogenous
	The relative price of palm oil to rubber lagged three years	Exogenous
	Rainfall Lagged one Year	Exogenous
Demand	Crude Palm Oil Domestic Demand lagged one year	Endogenous
	Crude Palm Oil Food Domestic Demand lagged one year	Endogenous
	Crude Palm Oil Industrial Domestic Demand lagged one year	Endogenous
	Domestic price palm oil	Endogenous
	World Price of Substitute (Soybean Oil)	Exogenous
	Country population	Endogenous
	Country GDP	Exogenous
	Country GDP per capita	Exogenous
	Real domestic price of coconut oil	Exogenous
	Industrial production index	Exogenous
Export	Crude Palm Oil export demand	Endogenous
	Refined Palm Oil export demand	Endogenous
	The export demand for palm oil lagged	Endogenous
	Exchange rate	Exogenous
	World GDP	Exogenous
	World Price of Substitute (Soybean Oil)	Exogenous
	World price palm oil	Endogenous
	World population	Exogenous
	Producer Price of CPO	Endogenous
	Industrial production index (industrialized countries)	Exogenous
	Petroleum price	Exogenous
	World stock of palm oil	Exogenous
Import	Import demand for palm oil lagged one year	Endogenous
	World price palm oil	Endogenous
	Country GDP	Exogenous
	Initial stocks palm oil (MT)	Endogenous
	Ending stocks palm oil (mt)	Endogenous
	World Price of Substitute (Soybean Oil)	Exogenous
	Relative Price Ratio (import prices/domestic prices)	Exogenous

	Producer Price of CPO	Endogenous
	Industrial production index	Exogenous
World price	World Price of Substitute (Soybean Oil)	Endogenous
	World GDP	Exogenous
	World stock of palm oil	Exogenous
	Petroleum price	Exogenous
	World price palm oil lagged one year	Endogenous
Biodiesel	CPO demand for Biodiesel lagged one year	Endogenous
	Biodiesel production	Endogenous
	Biodiesel export	Exogenous
	Biodiesel blend rate	Exogenous
	Diesel consumption	Exogenous
	Refine palm oil export levy	Endogenous
	Crude palm oil export levy	Endogenous



PROCESS	CONSTRAINTS
OLS regression	Automated selection of best nine subset with highest R^2 values
OLS regression	Manual selection of best subset with: • Coefficients P-Value: Less or equal than 0.05 • ANOVA P-Value: Less or equal than 0.05 • R2: Equal or Higher than 0.8 • R2 Adj: Equal or Higher than 0.8

Figure 5. OLS regression process

Figure 5 shows the OLS regression process. Once the equations and the initial set of independent variables were set, a two-stage process was defined, using the ANALYTIC SOLVER Software and XLMINNER PLATFORM tool. The software was set up in the first phase to evaluate all possible combinations of independent variables for stage one, with the constraints set to recognize the combinations with the maximum R2. This lead to the arrival of a combination of independent factors relevant to the variables. Then a manual procedure was conducted in the second stage, where full regression analysis was performed on each of the best combinations found in the previous stage. The selection criteria for significant variables were such that all models must comply with the following constraints: R^2 equal to or higher than 0.8, R^2 Adj equal to or higher than 0.8, independent variables coefficients p-value less or equal than 0.05, and ANOVA p-value is less or similar than 0.05.

The resulting equations will forecast each of the market conditions, and the data for the present year or next year will be needed to forecast the prices in the future. This culminated in the development of a competitive calculation model for the Indonesian palm oil industry. The causal inference cannot be created and thus an alternate approach for estimating the future values of independent variables for the upcoming years needs to be investigated. Thus, this approach sets a new interrogative - how can the values for the next period be estimated? Moreover, how can these estimations be input into the model equations to determine the values of the next period? Five forecasting methods were employed, to identify a solution to this set of interrogatives, and to estimate the t+1 values of the independent variables; for this, it was decided to use two of the techniques most used to forecast time series data:

3.3.2 Moving average

This was selected due to is easily understood, doesn't require complex calculations and provides a stable forecast. But they require a lot of past data points, lags behind a trend, and complex relationships in data maybe not be represented by this method. Moving an average of three years and five years were selected for testing during this research due to this was the time horizon of interest for the sponsor company.

3.3.3 Double exponential smoothing

Holt's method is the most common example of this methodology, is used to forecast when there is a linear trend present in the data. The smoothing factors are chosen to trade off the stability and responsiveness of the forecast.

Monte Carlo Simulation has been used to incorporate the volatility of the independent variables, the majority of the independent variables are subject to the associated risk that will influence the result, including energy costs, interest and exchange rates, as well as the impact of particular events such as the introduction of a law restricting the output of palm oil, also this approach tries to compensate the lack of historical data for particular variables that could affect the performance of the time series methods. The drawback is that it requires an assumption of the probability distribution of the data. Figure 6 shows the time series analysis methods and the combinations with the multivariate models

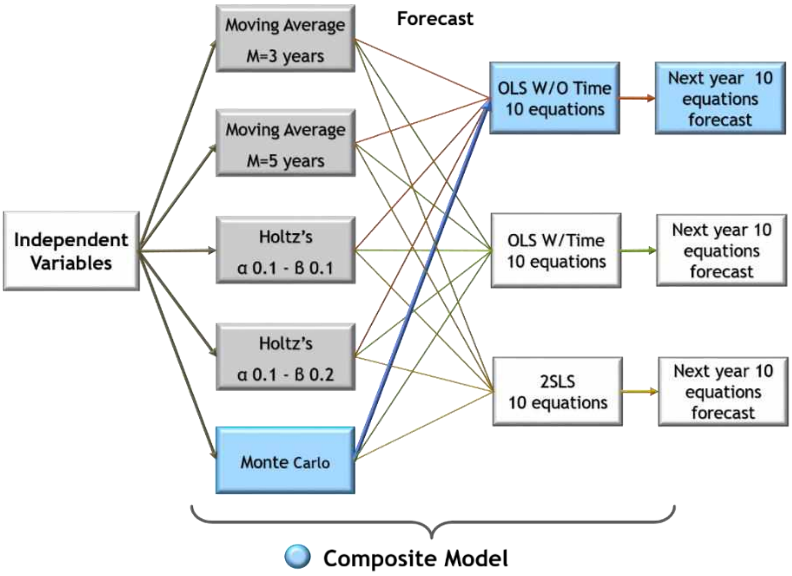


Figure 6. Composite modelling process flowchart

4. Data analysis and results

4.1 Data grouping

The data was collected from the seven databases mentioned in section 3.3, in each of them, the information contained for each of the relevant factors selected for each area of the Indonesian Palm Oil Market. Every factor was assigned a variable code; Table 2 below shows the list of Market Factors per market area. Appendix 5 to 10 shows the data collected for each factor and the Palm Oil Market factor.

4.2 Data Analysis Results

For each area, a correlation matrix was calculated before attempting the multiple linear regression processes. The data in spreadsheets provided with this manuscript shows the results of the correlation matrix for all the market areas that can be referred for further clarity.

Table 2 List of market factors per market area

Market Factor	Variable Description	Variable
Production	Production palm oil lagged one year	CPOPL
	Producer Price of CPO	CPOPRI
	World Price of Substitute (Soybean Oil)	SOPRI
	Average lending rate %	ALENDR
	Government Expenditure on agricultural development	GEADEV
	The relative price of palm oil to soybean oil	RPPOSO
	Rubber World Price	RUBPR
	The relative price of palm oil to rubber lagged three years	RPPORU
	Rainfall Lagged one Year	RAINL
Demand	Crude Palm Oil Domestic Demand lagged one year	CPODDL
	Crude Palm Oil Food Domestic Demand lagged one year	CPOFOODL
	Crude Palm Oil Industrial Domestic Demand lagged one year	CPOINDL
	Domestic price palm oil	RBDPO
	World Price of Substitute (Soybean Oil)	SOPRI
	Country population	POPUL

	Country GDP	CGDP
	Country GDP per capita	CGDPPC
	Real domestic price of coconut oil	COCOPRI
	Industrial production index	INDPI
Export	Crude Palm Oil export demand	EXPCPO
	Refined Palm Oil export demand	EXPREFPO
	Export demand for palm oil lagged one year	EXDPOL
	Exchange rate	EXCRT
	World GDP	WGDP
	World Price of Substitute (Soybean Oil)	SOPRI
	World price palm oil	WPRIPO
	World population	WPOPUL
	Producer Price of CPO	CPOPRI
	Industrial production index (industrialized countries)	WINDPI
	Petroleum price	PEPRI
	World stock of palm oil	WSTCKPO

Market Factor	Variable Description	Variable
Import	Import demand for palm oil lagged one year	IMPOL
	World price palm oil	WPRIPO
	Country GDP	CGDP
	Initial stocks palm oil (MT)	INISTCKS
	Ending stocks palm oil (mt)	ENDSTCKS
	World Price of Substitute (Soybean Oil)	SOPRI
	Relative Price Ratio (import prices/domestic prices)	RPRIPXP
	Producer Price of CPO	CPOPRI
	Industrial production index	INDPI
World price	World Price of Substitute (Soybean Oil)	SOPRI
	World GDP	WGDP
	World stock of palm oil	WSTCKPO
	Petroleum price	PEPRI
	World price palm oil lagged one year	WPRIPOL
Biodiesel	CPO demand for Biodiesel lagged one year	CPOBIOL
	Biodiesel production	BIOPRO
	Biodiesel export	BIOEXP
	Biodiesel blend rate	BIOBLE
	Diesel consumption	DIECO
	Refine palm oil export levy	REFEXPOLEV
	Crude palm oil export levy	CRUEXPOLEV

Model parameter estimation

The OLS for both with and without time as variables were done using ANALYTIC SOLVER Software and XLMINNER PLATFORM tool. The program was configured using the available options to determine the best combination of subsets of independent variables that provide the most statistically significant. Only the highest R^2 value was used to determine these subsets. The subsets are set for the specific number of variables between the one variable and the maximum number of factors for each equation—for example, two variables, three variables, four variables, and so on. The subsets belonging to the mentioned variables are provided in the datasheets.

Each equation subset was reviewed, and the parameters evaluated using the following criteria:

i. Coefficients P-Value: Less or equal than 0.05.
ii. ANOVA P-Value: Less or equal than 0.05.
iii. R^2: Equal or Higher than 0.8.
iv. R^2 Adj: Equal or Higher than 0.8.

The subset that didn´t comply with these requirements was discarded.

OLS with and without Time Trend

The results for OLS without time trend subsets results, OLS without time trend best subset regression, OLS with time trend subsets results, OLS with time trend best subset regression are provided in the datasheets. They are not added here for the sake of brevity. It was noticed that for the Import equation for OLS with time trend this model does not satisfy the criteria previously established. It was kept included to test the accuracy of the results between the two methods.

2SLS

The 2SLS was done using IBM SPSS Statistics software due to Analytical Solver did not have to provide this feature; a cursory check was done in SPSS to verify the consistency of results between the software. Once it was confirmed, SPSS was decided to be used for 2SLS and Analytical Solver for OLS. The values of the regression are provided in datasheets. The equations for Import and World price were rejected due to not complying with the minimum requirements criteria, however for the use of comparison between methods, they were kept.

4.2.1 Factors for forecast calculation

As mentioned before, the model requires the current cycle period data from the current year (t_0) to forecast for the next cycle period or the next year (t_1). The data from 2016 was considered as the last cycle period (t_0), information upon which the next cycle (t_1) would be forecasted. The following methods were selected for next cycle forecast calculations:

- Moving Average M=3 years
- Moving Average M=5 years
- Holt's Method with α= 0.1 β= 0.1
- Holt's Method with α= 0.1 β= 0.2
- Monte Carlo Simulation:

Firstly, the mean and standard deviation of the last ten years trend was calculated, then 15,000 data points were simulated assuming a normal distribution. This resulted in mean, maximum, and minimum trend values for each market factor such that the next cycle period value can be calculated using the expected trend calculated. For calculating the past trend of the individual variables, data were only considered for the last ten years. The simulation assumed normal distribution because some equations such as Price showed normality. However, for some equations such as the Biodiesel equation, the errors did not agree with regularity. It was assumed that this is occurring because of the short data set and the yearly granularity of the data and not because of the absence of normality in the error values. If the dataset was highly granular with a long-range, it was assumed that all the variables might be agreeing with regularity but since there was insufficient data available, going back only ten years and with yearly granularity, the normality tests were not turning positive.

Further, a sensitivity analysis was conducted in the length of data range to be taken for calculating the standard deviation and average of a trend for the independent variables. This was done so that an understanding could be arrived at as to which range values are providing the best forecast accuracy. It was observed that when the maximum amount of historical data was used the calculate the standard deviation and only the latest ten years of data were used to calculate the trend of the variables. The final forecast for the factor was converging towards the real values of these factors. This phenomenon was associated with the law of large numbers, wherein the 15,000 simulated values of the independent variables, the trend, and standard deviations arrived at the real mean of the series. Table 3 shows the results of the 2017 Forecast of each factor.

Table 3 Factors Forecast for 2017

Variable Description	Units	Variable	M=3	M=5	Holtz α=0.1 β=0.1	Holtz α=0.1 β=0.2	Monte Carlo Trend Avg	Monte Carlo Trend Max	Monte Carlo Trend Min
Export Split (Refined)		EXPOSPLIT	0.73	0.69	0.69	0.76	6.08%	40.97%	-32.15%
Refined Palm Oil export demand	1000 MT/year	EXPREFPO	18,354.23	16,316.49	13,222.10	15,393.77	10.71%	70.49%	-46.74%
Goverment Expenditure in agricultural development	Million US$	GEADEV	1,727.75	1,613.10	1,957.05	1,957.05	8.22%	14.51%	1.48%
Refine palm oil export levy	1000 MT/year	IMPO	8.00	17.80	7.19	(34.27)	-37.56%	399.05%	-409.62%
Import demand for palm oil lagged one year	1000 MT/year	IMPOL	14.33	22.30	11.94	(32.68)	-28.87%	410.79%	-402.21%
Industrial production index		INDPI	125.87	120.17	115.68	117.90	-0.12%	42.72%	-44.82%
Initial stocks palm oil (MT)	1000 MT	INISTCKS	2,953.33	3,006.80	2,507.24	2,966.73	6.45%	79.60%	-73.80%
Petroleum price	$/bbl	PEPRI	62.25	75.38	78.55	73.22	-13.09%	106.49%	-138.78%
Country population	# Thousand people	POPUL	258,136.00	255,064.60	264,941.77	270,336.59	1.25%	1.51%	0.96%
Rainfall Lagged one Year	Avg mm/year	RAINL	227.72	238.20	248.98	250.47	-3.17%	45.39%	-51.51%
Domestic price palm oil	$/MT	RBDPO	672.77	758.93	1,180.66	1,138.19	-7.08%	83.28%	-109.37%
Refine palm oil export levy	$/year	REFEXPOLEV	540,103.54	540,103.54	540,103.54	540,103.54	20.66%	20.70%	20.62%
Refine palm oil export levy	$/TM	REFXPOLEV	30.00	30.00	30.00	30.00	49.48%	299.42%	-257.38%

Variable Description	Units	Variable	M=3	M=5	Holtz α=0.1 β=0.1	Holtz α=0.1 β=0.2	Monte Carlo Trend		
							Avg	Max	Min
The relative price of palm oil to rubber lagged three years	Price PO/Price Rubber	RPPORU	0.41	0.37	0.16	0.18	-0.04%	82.97%	-76.90%
The relative price of palm oil to soybean oil	Price PO/Price Soybean Oil	RPPOSO	0.85	0.87	1.05	1.04	-0.32%	39.27%	-50.52%
Relative Price Ratio (import prices/domestic prices)		RPRIPXP	1.02	0.98	0.84	0.85	1.34%	30.47%	-28.75%
Rubber Price	$/MT	RUBPR	1,709.44	2,260.00	2,744.29	2,458.85	-11.42%	112.27%	-158.99%
World Price of Substitute (Soybean Oil)	$/year	SOPRI	826.63	911.15	914.08	1,037.36	-5.77%	66.42%	-76.07%
World GDP	Million US$	WGDP	76,307,793.65	76,130,063.63	77,496,478.10	68,780,976.44	2.00%	26.89%	-24.36%
Industrial production index (industrialized countries)		WINDPI	104.70	103.77	111.68	110.79	-0.49%	25.68%	-26.07%
World population	# Thousand people	WPOPUL	7,355,447.39	7,269,320.59	7,525,806.90	7,519,454.99	1.19%	1.26%	1.12%
World price palm oil	$/MT	WPRIPO	715.03	766.59	773.04	844.01	-3.82%	67.56%	-71.24%
World price palm oil lagged one year	$/MT	WPRIPOL	726.41	820.04	755.67	823.87	-4.16%	67.13%	-68.80%
World stock of palm oil	1000 MT	WSTCKPO	9,423.67	9,341.40	8,789.25	9,816.00	3.99%	46.86%	-41.24%

As mentioned in section 3 in Figure 6, for every independent variable the next period (t_1) value will be forecasted using the methods for time series analysis and simulation and later feed into the ten equations of each of three models, the result of each equation was later compared with the control data provided by Chemi to estimate the relative error from each model and the mean average percentage error (MAPE). The estimated values for each equation are shown in Table 4: The colour code for error percentage is as shown in the Figure below.

	-10% > Error < 10%
	-15% > Error < 15%
	-15% < Error > 15%

Table 4 Market Area 2017 forecast

OLS W/O TIME TREND

Dependent Variable	Units	Actual Data 2017	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Monte Carlo Trend		
							Avg	Max	Min
Production	1000 MT/year	38,500.00	33,083.60	31,421.00	38,396.93	38,279.73	36,706.45	4 1,213.77	31,346.82
Demand	1000 MT/year	9,350.00	8,434.15	8,268.65	6,306.03	7,326.36	9,395.28	10,831.98	8,331.02
Demand Food	1000 MT/year	5,400.00	5,249.01	5,129.76	6,156.70	5,564.48	5,580.89	2,578.72	9,161.22
Demand Industrial	1000 MT/year	3,600.00	3,044.64	3,041.18	-	1,267.57	3,904.88	5,933. 19	2,464.26
Export	1000 MT/year	28,000.00	24,786.77	23,351.95	25,296.32	23,073.12	26,141.81	38,249. 15	13,641.14
Export Crude PO	1000 MT/year	7,000.00	6,689.50	7,4 16.62	5,873.17	6,843.43	6,673.40	5,268.04	8,062.93
Export Refined PO	1000 MT/year	21,000.00	18,120.05	16,035.88	18,67 1.79	16,855.25	19,991.15	34,68 1.30	4,908.03
Import	1000 MT/year	-	158.89	17.28	473.81	241.40	-	456.67	-
World price	$/MT	7 14.67	672.52	743.72	744.26	860.03	660.07	1,156.38	178.93
Biodiesel	1000 MT/year	2,668.00	2,403.46	2,362.28	3,072.35	3,116. 10	3,275.01	13,505.57	-

OLS WITH TIME TREND

Equation	Units	Control Data 2017	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Monte Carlo Trend		
							Avg	Max	Min
Production	1000 MT/year	38,500.00	33,246.67	31,4 13.33	36,913.33	36,913.33	37,501.81	39,354.60	35,514.74
Demand	1000 MT/year	9,350.00	8,434.15	8,268.65	6,306.03	7,326.36	9,395.28	10,831.98	8,331.02
Demand Food	1000 MT/year	5,400.00	5,209.99	5,118.62	5,153.19	4,840.97	5,509. 19	6,512.33	4,479.29
Demand Industrial	1000 MT/year	3,600.00	3,044.64	3,04 1.18	-	1,267.57	3,904.88	5,933. 19	2,464.26
Export	1000 MT/year	28,000.00	24,786.77	23,351.95	25,296.32	23,073. 12	26,14 1.81	38,249.15	13,64 1.14
Export Crude	1000 MT/year	7,000.00	227,74 1.12	342,592.74	-	6,422.81	865.89	10,029.23	-
Export Refined	1000 MT/year	21,000.00	-	-	-	-	26,098.76	43,342.53	8,585.53
Import	1000 MT/year	-	128.11	5.99	383.70	194.25	-	404.55	-
World price	$/MT	7 14.67	671.06	739.77	742.15	842.35	660.02	1,166.26	166.97
Biodiesel	1000 MT/year	2,668.00	2,403.46	2,362.28	3,072.35	3,116. 10	3,275.01	13,505.57	-

2SLS

Equation	Units	Control Data 2017	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Monte Carlo Trend		
							Avg	Max	Min
Production	1000 MT/year	38,500.00	30,288.44	28,498.40	24,367.43	28,426.20	33,346.59	35,887.10	29,516.18
Demand	1000 MT/year	9,350.00	8,677.61	8,376.86	7,818.75	8,316.72	9,753.45	12,904.43	6,313.36
Demand Food	1000 MT/year	5,400.00	5,282.32	5,094.83	5,697.77	6,027.09	5,663.08	5,705.35	5,616.93
Demand Industrial	1000 MT/year	3,600.00	3,184.36	3,057.93	2,295.34	2,642.33	3,965.07	8,099.62	-
Export	1000 MT/year	28,000.00	24,724.17	23,161.73	21,375.21	24,483.21	25,380.83	33,050.75	17,581.82
Export Crude	1000 MT/year	7,000.00	6,495.23	7,246.79	6,453.26	5,931.11	5,901.47	3,017.60	8,778.41
Export Refined	1000 MT/year	21,000.00	20,789.25	20,789.25	20,789.25	20,789.25	21,216.08	53,486.15	-
Import	1000 MT/year	-	24.21	18.13	64.92	50.83	5.18	-	2.17
World price	$/MT	7 14.67	730.13	806.76	754.08	809.89	635.91	1,008.03	298.52
Biodiesel	1000 MT/year	2,668.00	2,403.41	2,363.08	3,128.53	3,156.62	3,285.05	13,460.15	-

Table 5 - Error Analysis Market Area 2017 Estimation

OLS W/O Time Trend						Monte Carlo Trend		
Equation	Units	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Avg	Max	Min
Production	1000 MT/year	-14.07%	-18.39%	-0.27%	-0.57%	-4.66%	7.05%	-18.58%
Demand	1000 MT/year	-9.80%	-11.57%	-32.56%	-21.64%	0.48%	15.85%	-10.90%
Demand Food	1000 MT/year	-2.80%	-5.00%	14.01%	3.05%	3.35%	-52.25%	69.65%
Demand Industrial	1000 MT/year	-15.43%	-15.52%	-100.00%	-64.79%	8.47%	64.81%	-31.55%
Export	1000 MT/year	-11.48%	-16.60%	-9.66%	-17.60%	-6.64%	36.60%	-51.28%
Export Crude	1000 MT/year	-4.44%	5.95%	-16.10%	-2.24%	-4.67%	-24.74%	15.18%
Export Refined	1000 MT/year	-13.71%	-23.64%	-11.09%	-19.74%	-4.80%	65.15%	-76.63%
Import	1000 MT/year	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate
World price	$/MT	-5.90%	4.07%	4.14%	20.34%	-7.64%	61.81%	-74.96%
Biodiesel	1000 MT/year	-22.47%	-23.80%	-0.89%	0.52%	5.65%	335.66%	-100.00%

OLS with Time Trend **"+"Overestimate "-"Underestimate**

						Monte Carlo Trend		
Equation	Units	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Avg	Min	Max
Production	1000 MT/year	-13.65%	-18.41%	-4.12%	-4.12%	-2.59%	2.22%	-7.75%
Demand	1000 MT/year	-9.80%	-11.57%	-32.56%	-21.64%	0.48%	15.85%	-10.90%
Demand Food	1000 MT/year	-3.52%	-5.21%	-4.57%	-10.35%	2.02	20.60%	-17.05%
Demand Industrial	1000 MT/year	-15.43%	-15.52%	-100.00%	-64.79%	8.47%	64.81%	-31.55%
Export	1000 MT/year	-11.48%	-16.60%	-9.66%	-17.60%	-6.64%	36.60%	-51.28%
Export Crude	1000 MT/year	3153.44%	4794.18%	-100.00%	-8.25%	-	43.27	-100.00%
Export Refined	1000 MT/year	-100.00%	-100.00%	-100.00%	-100.00%	24.28%	106.39%	-59.12%
Impo1t	1000 MT/year	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate
World price	$/MT	-6.10%	3.51%	3.84%	17.87%	-7.65%	63.19%	-76.64%
Biodiesel	1000 MT/year	-22.47%	-23.80%	-0.89%	0.52%	5.65	335.66%	-100.00%

2SLS "+" Overestimate "-" Underestimate

Equation	Units	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Monte Carlo Trend		
						Avg	Max	Min
Production	1000 MT/year	-21.33%	-25.98%	-36.71%	-26.17%	-13.39%	-6.79%	-23.33%
Demand	1000 MT/year	-7.19%	-10.41%	-16.38%	-11.05%	4.31%	38.02%	-32.48%
Demand Food	1000 MT/year	-2.18%	-5.65%	5.51%	11.61%	4.87%	5.65%	4.02%
Demand Industrial	1000 MT/year	-11.55%	-15.06%	-36.24%	-26.60%	10.14%	124.99%	-100.00%
Export	1000 MT/year	-11.70%	-17.28%	-23.66%	-12.56%	-9.35%	18.04%	-37.21%
Export Crude	1000 MT/year	-7.21%	3.53%	-7.81%	-15.27%	-15.69%	-56.89%	25.41%
Export Refined	1000 MT/year	-1.00%	-1.00%	-1.00%	-1.00%	1.03%	154.70%	-100.00%
Import	1000 MT/year	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate	Unable to Calculate
World price	$/MT	2.16%	12.89%	5.51%	13.32%	-11.02%	41.05%	-58.23%
Biodiesel	1000 MT/year	-22.47%	-23.77%	0.92%	1.83%	5.97%	334.20%	-100.00%

Table 6 MAPE Analysis Market Area six years estimation

OLS W/O Time trend

Equation	Units	Moving Average M=3	Moving Average M =S	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Monte Carlo Trend		
						Avg	Max	Min
Production	1000 MT/year	14.07%	18.39%	0.27%	0.57%	4.66%	7.05%	18.58%
Demand	1000 MT/year	9.80%	11.57%	32.56%	21.64%	0.48%	15.85%	10.90%
Demand Food	1000 MT/year	2.80%	5.00%	14.01%	3.05%	3.35%	*52.25%*	69.65%
Demand Industrial	1000 MT/year	15.43%	15.52%	100.00%	64.79%	8.47%	64.81%	31.55%
Export	1000 MT/year	11.48%	16.60%	9.66%	17.60%	6.64%	36.60%	51.28%
Export Crude	1000 MT/year	4.44%	5.95%	16.10%	2.24%	4.67%	24.74%	15.18%
Export Refined	1000 MT/year	13.71%	23.64%	11.09%	19.74%	4.80%	65.15%	76.63%
Import	1000 MT/year							
World price	$/MT	5.90%	4.07%	4.14%	20.34%	7.64%	61.81%	74.96%
Biodiesel	1000 MT/year	22.47%	23.80%	0.89%	0.52%	5.65%	335.66%	100.00%
MAPE		12.62%	14.26%	22.00%	16.13%	5.20%	69.32%	48.68%

OLS with time trend

Equation	Units	Moving Average M=3	Moving Average M=S	Holtz 0.1 Alpha 0.2	Holtz 0.1 Alpha 0.2	Monte Carlo Trend		
						Avg	Max	Min
Production	1000 MT/year	13.65%	18.41%	4.12%	4.12%	2.59%	2.22%	7.75%
Demand	1000 MT/year	9.80%	11.57%	32.56%	21.64%	0.48%	15.85%	10.90%
Demand Food	1000 MT/year	3.52%	5.21%	4.57%	10.35%	2.02%	20.60%	17.05%
Demand Industrial	1000 MT/year	15.43%	15.52%	100.00%	64.79%	8.47%	64.81%	31.55%
Export	1000 MT/year	11.48%	16.60%	9.66%	17.60%	6.64%	36.60%	51.28%
Export Crude	1000 MT/year	3153.44%	4794.18%	100.00%	8.25%	87.63%	43.27%	100.00%
Export Refined	1000 MT/year	100.00%	100.00%	100.00%	100.00%	24.28%	106.39%	59.12%
Import	1000 MT/year							
World price	$/MT	6.10%	3.51%	3.84%	17.87%	7.65%	63.19%	76.64%
Biodiesel	1000 MT/year	22.47%	23.80%	0.89%	0.52%	5.65%	335.66%	100.00%
MAPE		335.97%	500.72%	37.93%	25.47%	15.07%	72.64%	50.21%

2SLS

Equation	Units	Moving Average M=3	Moving Average M=5	Holtz Alpha 0.1 Beta 0.1	Holtz Alpha 0.1 Beta 0.2	Monte Carlo Trend		
						Avg	Max	Min
Production	1000 MT/year	21.33%	25.98%	36.71%	26.17%	13.39%	6.79%	23.33%
Demand	1000 MT/year	7. 19%	10.4 1%	16.38%	11.05%	4.31%	38.02%	32.48%
Demand Food	1000 MT/year	2.18%	5.65%	5.51%	11.61%	4.87%	5.65%	4.02%
Demand Industrial	1000 MT/year	11.55%	15.06%	36.24%	26.60%	10.14%	124.99%	100.00%
Export	1000 MT/year	11.70%	17.28%	23.66%	12.56%	9.35%	18.04%	37.21%
Export Crude PO	1000 MT/year	7.21%	3.53%	7.81%	15.27%	15.69%	56.89%	25.4 1%
Export Refined PO	1000 MT/year	1.00%	1.00%	1.00%	1.00%	1.03%	154.70%	100.00%
Import	1000 MT/year							
World price	$/MT	2.16%	12.89%	5.51%	13.32%	11.02%	41.05%	58.23%
Biodiesel	1000 MT/year	22.47%	23.77%	0.92%	1.83%	5.97%	334.20%	100.00%
MAPE		10.03%	13.36%	15.77%	13.37%	8.34%	78.53%	50.52%

Table 7 MAPE Analysis six-year time series for main components for OLS without time trend

OLS WO Time

Production		2012	2013	2014	2015	2016	2017	MAPE
	M=3	14.82%	13.31%	14.49%	6.08%	12.33%	14.07%	12.52%
	M=5	21.97%	20.85%	20.80%	11.62%	16.91%	18.39%	18.42%
	Holtz α=0.1 β=0.2	0.26%	0.43%	1.08%	8.45%	1.58%	0.27%	2 .01%
	Holtz α=0.1 β=0.2	0.26%	0.41%	1.13%	8.35%	1.39%	0.57%	2.02%
Monte Carlo	Avg	3.02%	0.27%	2.68%	8.87%	3.09%	4.64%	3.76%
	Max	14.89%	14.80%	8.14%	19.57%	10.11%	8.80%	12.72%
	Min	7.20%	11.84%	13.69%	3.39%	17.25%	17.41%	11.80%

Demand		2012	2013	2014	2015	2016	2017	MAPE
	M=3	19.20%	17.25%	2.92%	9.12%	9.00%	9.80%	11.21%
	M=5	29.02%	27 .24%	5.54%	14.08%	12.38%	11.57%	16.64%
	Holtz α=0.1 β=0.2	49.62%	48.87%	34.32%	39.34%	35.72%	32.56%	40.07%
	Holtz α=0.1 β=0.2	45.24%	43.52%	26.32%	30.99%	26.00%	21.64%	32.28%
Monte Carlo	Avg	3.65%	1.12%	21.83%	0.02%	1.05%	0.79%	4.74%
	Max	6.53%	2.48%	39.10%	17.92%	16.10%	17.15%	16.55%
	Min	17.15%	1.53%	16.32%	13.65%	18.82%	13.15%	13.44%

Export		2012	2013	2014	2015	2016	2017	MAPE
	M=3	15.75%	14.55%	21.31%	2.55%	13.71%	11.48%	13.22%
	M=5	19.91%	18.90%	27 .68%	10.54%	19.94%	16.60%	18.93%
	Holtz α=0.1 β=0.2	18.30%	15.57%	22.58%	4.08%	14.24%	9.66%	14.07%

	Holtz α=0.1 β=0.2	3.66%	1.87%	11.22%	8.61%	3.95%	0.13%	4.91%
Monte Carlo	Avg	3.17%	2.67%	10.02%	13.08%	6.00%	6.57%	6.92%
	Max	65.23%	50.96%	37.01%	65.23%	39.68%	35.89%	49.00%
	Min	68.27%	52.98%	53.37%	43.78%	48 .14%	52.33%	53.14%

Import		2012	2013	2014	2015	2016	2017	MAPE
	M=3	79.81%	100.00%	100.00%				93.27%
	M=5	29.94%	18.02%	319.70%				122.55%
	Holtz α=0.1 β=0.2	1634.14%	2226.99%	7327 .96%				3729.70%
	Holtz α=0.1 β=0.2	1319.85%	1702.31%	5267.58%				2763.24%
Monte Carlo	Avg	66.48%	71.16%	13.17%				50.27%
	Max	2647.09%	2551.45%	8667.75%				4622.10%
	Min	100.00%	100.00%	100.00%				100.00%

World Price		2012	2013	2014	2015	2016	2017	MAPE
	M=3	15.20%	5.70%	8.22%	27.55%	0.04%	5.90%	10.43%
	M=5	13.01%	4.59%	3.32%	34.42%	13.70%	4.07%	12.18%
	Holtz α=0.1 β=0.2	35.23%	19.57%	12.96%	16.81%	4.63%	4.14%	15.56%
	Holtz α=0.1 β=0.2	29.91%	11.74%	3.30%	31.01%	18.03%	17.65%	18.61%
Monte Carlo	Avg	7.57%	1.96%	11.35%	0.34%	17.39%	7.32%	7.66%
	Max	95.62%	103.37%	72.65%	81.06%	47.61%	58.23%	76.42%
	Min	100.00%	96.23%	89.14%	81.22%	79.91%	82.95%	88.24%

Biodiesel		2012	2013	2014	2015	2016	2017	MAPE
	M=3	56.52%	43.66%	24.48%	126.04%	36.27%	22.47%	51.57%
	M=5	64.98%	59.02%	47.53%	78.58%	39.92%	23.80%	52.30%
	Holtz α=0.1 β=0.2	23.55%	27.06%	18.83%	138.42%	19.11%	0.89%	37.98%

	Holtz α=0.1 β=0.2	23.55%	26.82%	18.12%	14 1.82%	17.99%	0.52%	38.14%
Monte Carlo	Avg	11.89%	12.99%	5.10%	181.71%	72.17%	4.88%	48.12 %
	Max	313.91%	222.76%	211.15%	687.44%	24.36%	321.47%	296.85%
	Min	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 8 MAPE Analysis six-year time series for main components for OLS with time trend

OLS WITH TIME

Production		2012	2013	2014	2015	2016	2017	MAPE
	M=3	6.18%	6.42%	8.05%	0.45%	5.71%	7.15%	5.66%
	M=5	12.50%	12.33%	13.51%	5.15%	10.71%	11.53%	11.01%
	Holtz α=0.1 β=0.2	6.46%	5.39%	2.86%	11.71%	4.30%	2.21%	5.49%
	Holtz α=0.1 β=0.2	6.46%	5.39%	2.86%	11.71%	4.30%	2.21%	5.49%
Monte Carlo	Avg	7.15%	6.30%	3.95%	13.08%	5.71%	3.72%	6.65%
	Max	9.97%	9.62%	7.69%	17.16%	10.39%	8.96%	10.63%
	Min	4.62%	3.04%	0.23%	8.43%	0.52%	0.53%	2.90%

Demand		2012	2013	2014	2015	2016	2017	MAPE
	M=3	19.20%	17.25%	2.92%	9.12%	9.00%	9.80%	11.21%
	M=5	29.02%	27.24%	5.54%	14.08%	12.38%	11.57%	16.64%
	Holtz α=0.1 β=0.2	49.62%	48.87%	34.32%	39.34%	35.72%	32.56%	40.07%
	Holtz α=0.1 β=0.2	45.24%	43.52%	26.32%	30.99%	26.00%	21.64%	32.28%
Monte Carlo	Avg	3.65%	1.12%	21.83%	0.02%	1.05%	0.79%	4.74%
	Max	6.53%	2.48%	39.10%	17.92%	16.10%	17.15%	16.55%
	Min	17.15%	1.53%	16.32%	13.65%	18.82%	13.15%	13.44%

Export		2012	2013	2014	2015	2016	2017	MAPE
	M=3	15.75%	14.55%	21.31%	2.55%	13.71%	11.48%	13.22%
	M=5	19.91%	18.90%	27.68%	10.54%	19.94%	16.60%	18.93%
	Holtz α=0.1 β=0.2	18.30%	15.57%	22.58%	4.08%	14.24%	9.66%	14.07%
	Holtz α=0.1 β=0.2	3.66%	1.87%	11.22%	8.61%	3.95%	0.13	4.91%
Monte Carlo	Avg	3.17%	2.67%	10.02%	13.08%	6.00%	6.57%	6.92%
	Max	65.23%	50.96%	37.01%	65.23%	39.68%	35.89%	49.00%
	Min	68.27%	52.98%	53.37%	43.78%	48.14%	52.33%	53.14%

Import		2012	2013	2014	2015	2016	2017	MAPE
	M=3	91.56%	100.00%	100.00%				97.19%
	M=5	61.52%	26.33%	174.21%				87.35%
	Holtz α=0.1 β=0.2	1337.01%	1821.19%	6009.54%				3055.91%
	Holtz α=0.1 β=0.2	1081.68%	1394.52%	4332.85%				2269.68%
Monte Carlo	Avg	53.20%	41.89%	67.18%				54.09%
	Max	2234.74%	2205.56%	7614.86%				4018.39%
	Min	100.00%	100.00%	100.00%				100.00%

World Price		2012	2013	2014	2015	2016	2017	MAPE
	M=3	15.92%	5.11%	7.96%	27.67%	0.10%	6.10%	10.48%
	M=5	14.12%	3.43%	2.41%	33.69%	13.18%	3.51%	11.73%
	Holtz α=0.1 β=0.2	36.09%	20.45%	13.68%	16.19%	4.23%	3.84%	15.75%
	Holtz α=0.1 β=0.2	30.46%	12.25%	3.63%	30.93%	18.14%	17.87%	18.88%
Monte Carlo	Avg	7.15%	2.52%	10.21%	2.34%	16.83%	7.33%	7.73%
	Max	96.40%	104.03%	74.43%	84.18%	49.74%	59.21%	78.00%
	Min	100.00%	95.59%	88.35%	80.02%	80.77%	84.40%	88.19%

Biodiesel		2012	2013	2014	2015	2016	2017	MAPE
	M=3	56.52%	43.66%	24.48%	126.04%	36.27%	22.47%	51.57%
	M=5	64.98%	59.02%	47.53%	78.58%	39.92%	23.80%	52.30%
	Holtz α=0.1 β=0.2	23.55%	27.06%	18.83%	138.42%	19.11%	O.59%	37.98%
	Holtz α=0.1 β=0.2	23.55%	26.82%	18.12%	141.82%	17.99%	0.52%	38.14%
Monte Carlo	Avg	13.33%	13.95%	4.53%	180.88%	72.05%	4.88%	48.17%
	Max	311.86%	221.08%	210.16%	685.06%	24.47%	321.10%	295.62%
	Min	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 9 MAPE Analysis six-year time series for main components for 2SLS

2SLS

Production		2012	2013	2014	2015	2016	2017	MAPE
	M=3	29.48%	28.55%	27.15%	18.09%	20.20%	21.33%	24.13%
	M=5	36.11%	34.68%	33.02%	25.08%	26.60%	25.98%	30.24%
	Holtz α=0.1 β=0.2	48.37%	46.49%	44.96%	37.05%	37.80%	36.71%	41.90%
	Holtz α=0.1 β=0.2	39.19%	37.07%	35.41%	26.28%	27.35%	26.17%	31.91%
Monte Carlo	Avg	20.98%	14.27%	10.97%	1.32%	2.17%	13.32%	10.50%
	Max	36.30%	21.36%	14.22%	3.91%	0.45%	5.82%	13.68%
	Min	8.13%	3.70%	6.67%	1.19%	2.27%	22.56%	7.42%

Demand		2012	2013	2014	2015	2016	2017	MAPE
	M=3	25.75%	23.87%	0.10%	6.60%	7.30%	7.19%	11.80%
	M=5	30.37%	29.94%	10.24%	15.82%	12.99%	10.41%	18.29%
	Holtz α=0.1 β=0.2	29.33%	30.70%	13.32%	20.89%	18.83%	16.38%	21.57%
	Holtz α=0.1 β=0.2	24.69%	26.39%	8.05%	16.03%	13.74%	11.05%	16.66%
Monte Carlo	Avg	9.56%	6.85%	21.05%	10.42%	8.49%	4.39%	10.13%
	Max	12.86%	7.71%	41.29%	26.09%	24.55%	40.62%	25.52%
	Min	27.06%	25.36%	1.15%	4.61%	38.61%	30.49%	21.21%

Demand		2012	2013	2014	2015	2016	2017	MAPE
	M=3	12.22%	14.04%	23.46%	5.93%	13.43%	11.70%	13.46%
	M=5	18.98%	17.S5	26.60%	12.03%	20.63%	17.28%	18.90%
	Holtz α=0.1 β=0.2	31.30%	29.56%	35.62	20.62%	27.64%	23.66%	28.07%
	Holtz α=0.1 β=0.2	21.36%	19.19%	26.08%	8.87%	17.08%	12.56%	17.52%
Monte Carlo	Avg	7.87%	2.93%	10.92%	6.76%	5.24%	9.52%	7.21%
	Max	11.40%	16.24%	4.56%	24.65%	24.53%	20.32%	16.95%
	Min	28.88%	22.81%	27.48%	10.60%	15.60%	36.08%	23.57%

Import		2012	2013	2014	2015	2016	2017	MAPE
	M=3	32.59%	28.52%	122.34%				61.15%
	M=5	32.18%	1.87%	225.77%				86.61%
	Holtz α=0.1 β=0.2	93.75%	172.48%	807.68%				357.97%
	Holtz α=0.1 β=0.2	81.81%	150.13%	710.50%				314.15%
Monte Carlo	Avg	12.78%	13.42%	136.34%				54.18%
	Max	56.61%	0.93%	206.94%				88.16%
	Min	39.17%	100.00%	72.52%				70.56%

World Price		2012	2013	2014	2015	2016	2017	MAPE
	M=3	17.33%	0.67%	10.22%	40.16%	14.76%	2.16%	14.21%
	M=5	22.87%	0.84%	5.22%	35.10%	21.37%	12.89%	16.38%
	Holtz α=0.1 β=0.2	37.53%	21.66%	13.94%	17.13%	6.84%	5.51%	17.10%
	Holtz α=0.1 β=0.2	35.44%	18.28%	9.35%	24.45%	14.27%	13.32%	19.19%
Monte Carlo	Avg	12.06%	16.22%	7.18%	21.96%	5.97%	11.23%	12.44%
	Max	88.72%	106.70%	S0.63%	98.64%	68.66%	36.05%	79.90%
	Min	87.21%	72.07%	60.39%	50.78%	52.85%	64.29%	64.60%

Biodiesel		2012	2013	2014	2015	2016	2017	MAPE
	M=3	56.11%	43.34%	24.32%	126.09%	36.25%	22.47%	51.43%
	M=5	65.29%	59.00%	47.32%	78.95%	39.82%	23.77%	52.36%
	Holtz α=0.1 β=0.2	22.23%	25.68%	17.30%	142.79%	17.53%	0.92%	37.74%
	Holtz α=0.1 β=0.2	22.23%	25.5 1%	16.75%	145.48%	16.77%	1.83%	38.09%
Monte Carlo	Avg	11.93%	13.12%	4.81%	181.53%	71.58%	5.21%	48.03%
	Max	311.53%	221.50%	210.09%	685.45%	25.49%	320.42%	295.74%
	Min	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

This accuracy analysis is performed using the mean average percentage error (MAPE) as an indicator. Table 6 shows the MAPE analysis for all the dependent variables and methods. This analysis shows the deviation of the market factors from the actual values. The MAPE is used to see how the forecast of the market deviates from the actual values. This test is useful in identifying the best forecasting method of the five tested.
Additional accuracy analysis was conducted for a six years' time series for the main components of the market; all the estimations were calculated using the previous year's independent variable values with that the next year's data was calculated and compared against the control data available. Appendix 2 to Appendix 4 shows the importance of the analysis. Table 7 shows the six years MAPE study for the OLS without time trend method

In section 3 Figure 6, for every independent variable, the next period (t1) value will be forecasted. This accuracy analysis is performed using the mean average percentage error (MAPE) as an indicator. The MAPE is used to see how the forecast of the market deviates from the actual values. This test was useful in identifying the best forecasting method of the five tested. Additional accuracy analysis was conducted for a six years' time series for the main components of the market; all the estimations were calculated using the previous year's independent variable values with that the next year's data was calculated and compared against the control data available. Appendix 2 to Appendix 4 shows the values of the analysis. Six years of MAPE analysis for the OLS without time trend method is also attached in the data files.

5. Results and Analysis

The market demand model for CPO for Indonesia is structured upon the six primary factors of Production, Demand, Export, Import, World Price, and Biodiesel consumption. Among others, these were selected as most relevant to the CPO market after detailed analysis.

5.1.1 The production factor

The palm oil production in Indonesia indicates a stable relationship between the Government expenditure on agricultural progress and the relative price of palm oil to soybean oil for OLS with no time trend. It indicates the relationship between government expenditure on agricultural development for the OLS with a time trend. Moreover, it shows a relationship with Production Palm oil lagged one year and Producer Price of CPO for 2SLS. Table 3 shows the production equation coefficients.

The substitution effect of the two vegetable oils plays a critical factor in agricultural incentives in Indonesia. Farmers are motivated to sell and produce the oil whichever gives more profit in the market. The difference between the independent variables selections between the OLS and 2SLS methods can be linked to the intricacies of the modeling methods used. According to (World Bank, 2010), once the government endorses agricultural development, the farmers tend to contribute more the economy.

5.1.2 The Demand Factor

The Domestic price of palm oil, Country GDP explains the Domestic Demand of Palm Oil, for OLS without time trend; Country GDP for OLS with time trend and Crude Palm Oil demand lagged one year for 2SLS. Table 10 shows the Demand Equation Coefficients. These sets of equations reflect the belief that the local economic status, in general, will drive the domestic demand. The past performance of the economy will influence the future of the industry because the consumers in the country are mainly influenced by Palm Oil’s price and could very quickly switch to a substitute if the price of Palm oil becomes too expensive. Further, the GDP being an indicator confirms the notion that when economic production and consumption increase in a country, then that effect influences the purchase of a product. In general, the good health of the country's economy will help to drive the domestic demand for palm oil in Indonesia.

Table 10 Demand equation coefficients

OLS W/O Time

Market Factor	Variable Description	Variable	Coefficients Values	P Value
Demand	Domestic Price palm oil	RBDPO	-2686E+00	2.273E-02
	Country GDP	CGDP	8.067E-03	1.980E-05
	Intercept		3.023E+03	1.523E-02

OLS W Time

Equation	Factor	Variable	Coefficients Values	P Value
Demand	Country GDP	CGDP	8.067E-03	1.980E-05
	Intercept		3.023E+03	1.523E-02

SLS

Equation	Factor	Variable	Coefficients Values	P Value
Demand	Crude Palm Oil Domestic Demand Lagged one Year	CPODDL	9.15E-01	2.84E-04
	Intercept		9.94E+02	3.53E-01

5.1.3 The Export Factor

The Export of Palm Oil equation explains that these are primarily influenced by the gains made due to favorable exchange rates and the World GDP. The more the exchange rate between the Indonesian Rupiah and US Dollar, the more the export of CPO will be from Indonesia. So, if we track that the local currency is getting stronger, then the exporters are taking advantage to ship more CPO to foreign locations. Table 11 shows Export Equation Coefficients

Table 11 Export Equation Coefficients

OLD W/O Time

Market Factor	Variable Description	Variable	Coefficients Values	P Value
Export	Exchange rate	EXCRT	1.169E+00	1.373E-03
	World GDP	WGDP	3.643E+04	2.081E-04
	Intercept		1.804E+04	8.455E-04

OLS W Time

Equation	Factor	Variable	Coefficients Values	P Value
Export	Exchange rate	EXCRT	1.169E+00	1.37E-03
	World GDP	WGDP	3.643E-04	2.08E-04
	Intercept		-1.804E+04	8.45E-04

2SLS

Equation	Factor	Variable	Coefficients Values	P Value
Demand	The export demand for palm oil lagged	EXDPOL	9.49E-01	3.62E-04
	Intercept		2.40E+03	4.51E-01

Like the Demand equation, the Export equation is driven by the health of the economy, for the OLS methods by the overall GDP of the country, and the Exchange rate of Indonesian Rupiah vs. USD. For the 2SLS, the overall behavior of the previous year will determine the future exports of palm oil. The critical insight here is that the growth of the world economy explains that the consumers will have more resources to spend on palm oil products that will translate directly into more Indonesian Palm Oil demand.

5.1.4 The Import Factor

The Import equation is defined by the world price of palm oil, the world price of substitute (Soybean oil), the Relative price ratio between import prices and domestic prices, and the producer price of CPO and in the effect of the past information in the form of Import demand lagged one year for the OLS without time trend and 2SLS or the time trend itself as in OLS with time trend. Table 12 shows the Import Equation Coefficients. Here we can see that the Lagged demand from the previous year has a residual influence on the import level for the current year. Further, the word price of palm oil negatively influences the import levels.

Table 12 Import Equation Coefficients

OLS W/O Time

Market Factor	Variable Description	Variable	Coefficients Values	P Value
Import	Import demand for palm oil lagged one year	IMPOL	1.136E+00	1.123E-02
	World price palm oil	WPRIPO	-1.923E+04	1.338E-02
	Country GDP	CGDP	-7.029E+04	2.649E-02
	World Price of Substitute (Soybean Oil)	SOPRI	1.133E-01	5.908E-02
	Relative Price Ratio (import prices/domestic prices)	RPRIPXP	1.328E+03	1.625E-02
	Producer Price of CPO	CPOPRI	1.708E+00	1.580E-02
	Intercept		-1.279E+03	1.730E-02

OLS W Time

Equation	Factor	Variable	Coefficients Values	P Value
Import	World price palm oil	WPRIPO	-1.692E+00	2.20E-02
	World Price of Substitute (Soybean Oil)	SOPRI	1.230E-01	6.58E-02
	Relative Price Ratio (import prices/domestic prices)	RPRIPXP	1.202E+03	2.77E-02
	Producer Price of CPO	CPOPRI	1.450E+00	2.68E-02
	Time Trend	YEAR	-3.881E+00	4.12E-02
	Intercept		6.672E+03	5.35E-02

2SLS

Equation	Factor	Variable	Coefficients Values	P Value
Import	World Price pail oil	WPRIPO	-1.08E-01	7.05E-01
	Initial stocks palm oil (MT)	INISTCKS	-6.76E-03	6.38E-01
	Import demand for palm oil lagged one year	IMPOL	-1.98E-02	9.72E-01
	Producer price of CPO	CPOPRI	1.13E-01	5.75E-01
	Intercept		3.18E+01	7.65E-01

There is a negative but statistically significant influence of Indonesia's GDP on the import level of CPO into Indonesia. The relative cost of import and export will be the independent variable that will most affect CPO imported by the market. Once the foreign production becomes more affordable than local production, the market will decide to use one or the other. If the import CPO prices are lower than the export CPO, then naturally, they will be imported for domestic utilization. The world soybean price seems to influence the import quantity of C PO into Indonesia.

5.1.5 The World Price of CPO Factor

The World Price equation is defined by the world price of a substitute (Soybean oil) and World GDP for OLS without time trend, the world price of an alternative (Soybean oil), and the time trend for OLS with time trend and World Price lagged one year for 2SLS. Table 13 shows the World Price Equation Coefficients. The relationship between crude oil and the world price of palm oil is widely accepted, but this study found that it is not so evident. Instead, for the OLS methods, the relationship has been between the palm oil price and the soybean oil price.

Table 13 World Price Equation Coefficients

OLS W/O TIME

Market Factor	Variable Description	Variable	Coefficients Values	P Value
World Price	World Price of Substitute (Soybean Oil)	SOPRI	8.395E-01	1.405E-29
	World GDP	WGDP	-1.409E-06	3.448E-03
	Intercept		8.612E+01	2.200E-02

OLS W Time

Equation	Factor	Variable	Coefficients Values	P Value
World Price	Time Trend	YEAR	-2.658E+00	1.10E-03
	Intercept		5.360E+03	1.04E-03

2SLS

Equation	Factor	Variable	Coefficients Values	P Value
World Price	World price palm oil lagged one year	WPRIPOL	8.18E-01	8.37E-07
	Intercept		1.36E+02	2.61E-01

5.1.6 The Biodiesel Factor

The Biodiesel equation is defined by the biodiesel production, biodiesel blend rate, and diesel consumption for OLS without time trend, the biodiesel production and diesel consumption for OLS with time trend, and biodiesel production for 2SLS. Table 14 shows the Biodiesel Equation Coefficients. This equation is explaining the quantity of CPO that is going into the production of Biodiesel in the country. In recent years, Indonesia has used crude palm oil as the primary feedstock for making Biodiesel. Unsurprisingly, diesel consumption negatively impacts the quantity of CPO used for Biodiesel. If the government can incentivize more production of Biodiesel through the establishment of laws or mandates, then more CPO will be used to make it.

Table 14 Biodiesel Equation Coefficients

OLS W/O TIME

Market Factor	Variable Description	Variable	Coefficients Values	P Value
Biodiesel	Biodiesel production	BIOPRO	9.309E-01	4.918E-12
	Biodiesel blend rate	BIOBLE	-3.001E+02	2.064E-02
	Diesel Consumption	DIECO	-2.501E+03	2.717E-04
	Intercept		7.414E+01	1.575E-04

OLS W Time

Equation	Factor	Variable	Coefficients Values	P Value
Biodiesel	Biodiesel blend rate	BIOBLE	-3.001E+02	2.06E-02
	Diesel consumption	DIECO	-2.501E-03	2.72E-04
	Intercept		7.414E+01	1.58E-04

2SLS

Equation	Factor	Variable	Coefficients Values	P Value
Biodiesel	Biodiesel production	BIOPRO	9.16E-01	7.52E+15
	Intercept		1.15E+01	2.14E-01

5.2 A Conceptual framework for Indonesian Crude Palm Oil Market

The palm oil market factor equations contribute to statistical validity in the Indonesian palm oil market. Predictive models were applied to the known demand variables for palm oil. A collection of market forecasts has been developed, as well as a comparative accuracy study. This gives the information needed to make informed business decisions. The macroeconomic variables are being monitored to keep the historical data up to date. A predictive analytics framework to assist the practitioner is suggested as follows.

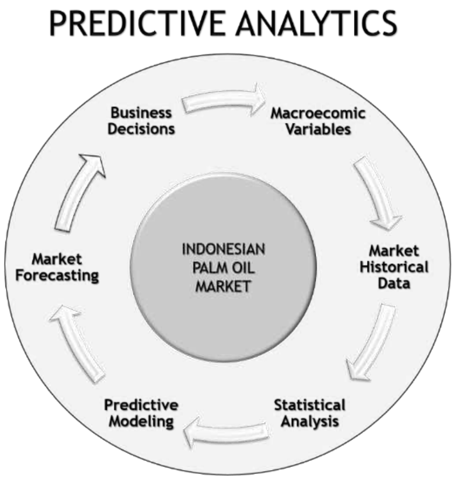


Figure 7 Predictive Analytics framework of Indonesian Palm Oil Market

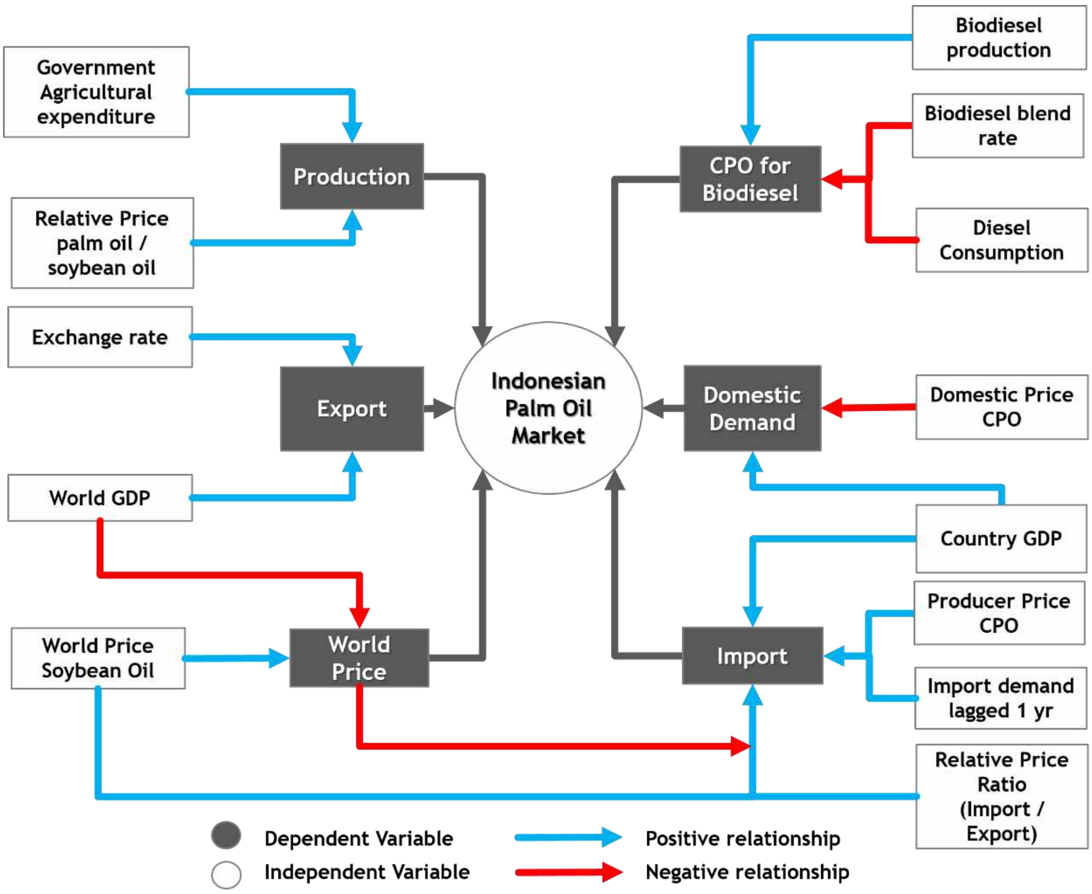


Figure 8 Indonesian Palm Oil Market Relationships Diagram

After the development of such a framework for the market, it can be utilized towards our primary purpose of forecasting and prediction. This conceptual framework of the market allows the researchers to apply various forecasting techniques to predict independent macroeconomic variables, iteratively test various regression techniques, and build a foundation for future econometric studies. This is the primary solution requirement for Chemi to take strategic decisions of capacity building of their specialty chemical product Blearth. Figure 8 shows the measurement model developed that displays the relationship between various industry variables and primary market factors.

5.3 Analysis of the various composite methods

As mentioned in (Allen, 1994), an econometric model of the market will not be enough to perform forecasting the agricultural economics of Crude Palm Oil. The established proposes that composite methods are needed to improve the forecasting to allow for feedback from the market and increase reliability. Attempts to form hybrid models for Indonesia were made by trying a few established time series forecasting methods for the independent variables. Monte Carlo simulation was developed where these trends could be forecasted.

Therefore, these five combinations of composite models were compared and tested for forecast error levels. Although composite forecast techniques are prevalent in the forecasting literature, as far as the authors of this research could find, composite techniques have not been much used since the 1970s as mentioned by (Allen, 1994). It is hoped that with this research, the composite technique of forecasting in literature could be revived and checked for validity in the palm oil agricultural industry. Two types of time series forecasting methods were used Moving Average: 3 years, 5 years, Holt's Winter Method: $\alpha = 0.1$, $\beta = 0.1$; Holt's Winter Method: $\alpha = 0.1$, $\beta = 0.2$. Monte Carlo Simulation was separately applied to the market model, using 15,000 random variables assumed to be in the normal distribution, and estimation of the trend was made.

These composite forecasting methods were applied to the three multilayered regression models. Each method provided estimates for the value of 2017 for which we possessed control data. For the OLS without Time Trend, the MAPE from the Time series forecast was less than 10% for Production, Demand, Export, and World Price Equations. Monte Carlo simulation provided us with the Maximum, Minimum, and Average of the trend estimate, and it is the average that has stayed within the 10% error range.

The Import and Biodiesel equations did not provide significant results for any of the forecasting techniques. This suggests that the equations for these two business constructs have a structural flaw. The Monte Carlo method of forecasting has the lowest error in estimating market constructs, and the Ordinary Least Squares regression with no time trend has the most reliable results. This finding corroborates the literature, indicating that the econometric model can be used to model the actions of the Palm Oil market in Indonesia, just as it can in Malaysia and Nigeria.

5.4 Long-term Forecasting

Moreover, just as the literature tells us, a composite model can be used to improve the forecast accuracy and reliability of agricultural economic forecasts. In this research, a composite model was developed to forecast the outcome of the Palm Oil Market. The first component of the composite is Monte Carlo Simulation, although (Zabid & Abidin, 2015) doesn't mention the use of Monte Carlo simulation, it was assumed that a technique was needed to account for the inflexibility of regression models to the dynamic changes of the system. Moreover, the second component is the Multivariate Linear Regression Model, which is a measurement model which is specifying how the variables are coming together in the ten-factor equations for the Palm Oil Market.

The Monte Carlo simulation approach was used to predict the potential values of the independent variables from the most recent known dataset. Since the variables for the world price equation component had data from 1964, they showed normality, and if the other factor equations had such comprehensive data, they would also show normality. These potential values were incorporated into the measurement regression models, which helped to predict the demand conditions for the following year.

Figure 9 shows the proposed flow for such a five-year forecast; the process requires a selection of a dataset that is to be used as a baseline from which the forecasts will be calculated. Once this baseline is established, data is needed to be collected for all the corresponding independent variables at that baseline. The trends and the standard deviations are calculated for each of the independent variables using this method. This process is akin to the differencing concept that is used in Time Series Analysis to eliminate the trends in the series to measure fluctuations. The trends and standard deviations will be the inputs for the Monte Carlo simulation from which an estimated pattern is calculated for each of the independent variables. This predicted trend is arrived at by simulating 15,000 possible outcomes for the variables if every variable follows a Normal Distribution. Once the simulation is completed, the values calculated represent the expected range of trend for every independent variable for the next period (t_n+1); these will be used to calculate the maximum, average, and minimum values for the factors. These three values will be used as inputs for the palm oil econometric model for the period (t_n+1). This will result in the calculation of dependent variables, which would be the forecasted values for the period (t_n+1).

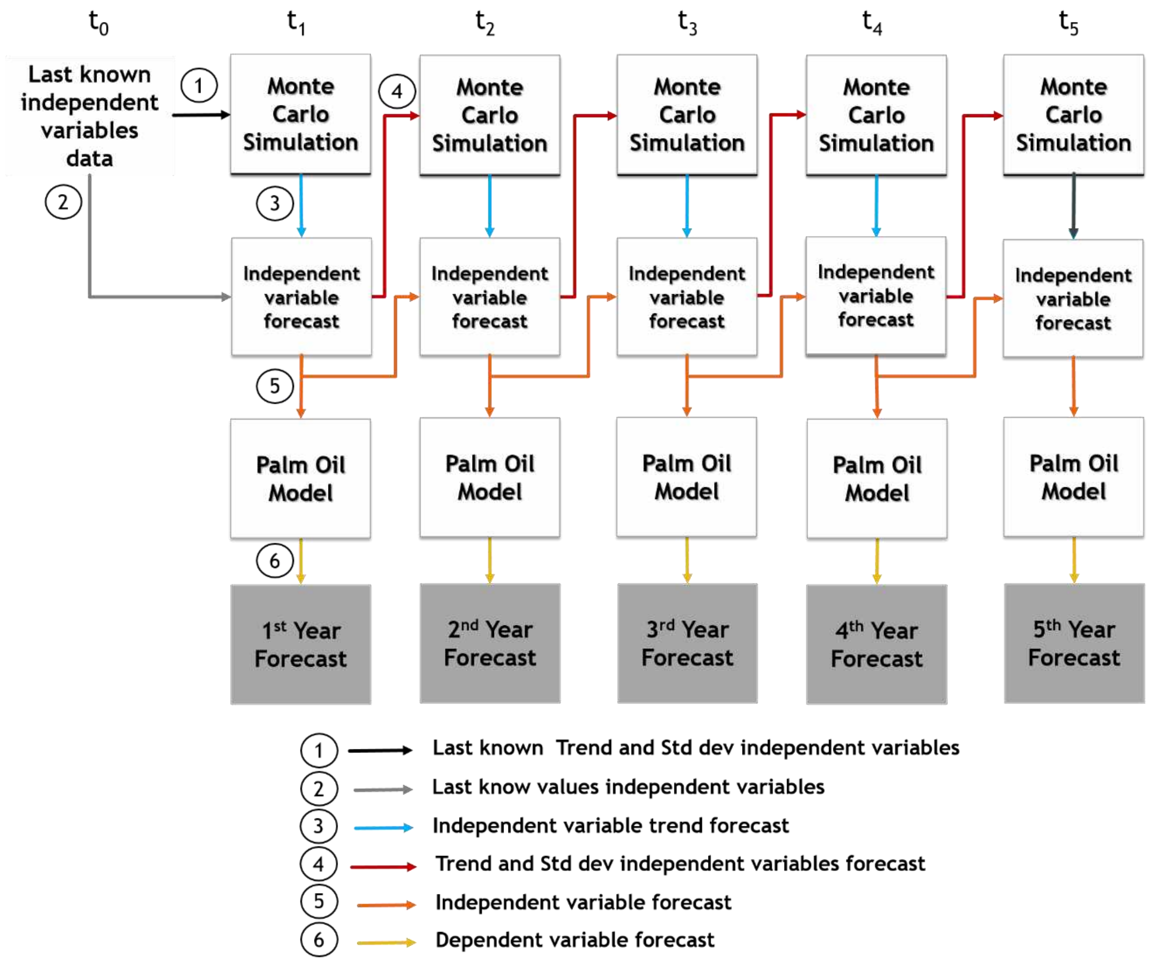


Figure 9 Forecast Method Flowchart

For the next period, (t_{n+1}+1) average values of the independent variables determined in the previous Monte Carlo simulation will be used as a baseline. These new independent variables are used to forecast the new trend. This will result in the forecast for the independent variables for (t_{n+1}+1). These new independent variable sets will be input again into the econometric model to give the forecast for market factor (t_n+1+1), this would be the Palm Oil Market for the next year. This loop of forecasting the independent variables and then the dependent variables by calculating the trend for each independent variable is made five times to get a five-year forecast.

A five-year forecast was made using data from 2012 as a baseline of last know data to validate the accuracy of this method. This gives an outlook from 2013 to 2017. The values forecasted of the market factors are compared with the actual data for the same period. Table 14 shows the results of this five years forecast. Such a long-term forecast method has been tested for all the three regression techniques applied in this research, viz. OLS Without Time Trend, OLS With Time Trend, and 2SLS regression. Table 14 gives the values of the forecast for the Palm Oil Market factors using the prescribed forecasting methodology. The significance of these values is displayed in Table 10, where their accuracy is compared to the actual values of the Palm Oil market factors.

	-10% > Error < 10%
	-15% > Error < 15%
	-15% < Error > 15%

Table 14. 5 Year forecast through 2012

OLS W/O time trend

Equation	**Units**	**2013**	**2014**	**2015**	**2016**	**2017**
Production	1000 MT/year	29542.70	31221.02	33122.77	35263 .53	37660.55
Demand	1000 MT/year	8362.47	8885.11	9371.02	9826.20	10255.86
Demand Food	1000 MT/year	5169.60	5449.01	5749.23	6079.54	6445.29
Demand Industrial	1000 MT/year	3559.33	4141.98	4633 .92	5048.95	5399.09
Export	1000 MT/year	21526 .35	22938.36	24420 .32	25976 .42	27611.28
Export Refined	1000 MT/year	13302.75	15111.13	17016.78	19025.76	21144 .75
Export Crude	1000 MT/year	8564.52	8146.06	7744.69	7359.48	6989.64
Import	1000 MT/year	0.00	0.00	0.00	0.00	0.00
World price	$/MT	864.49	817.42	772.56	729.80	689.03
Biodiesel	1000 MT/year	2453 .66	2983.32	3618.62	4371.93	5248.29

Equation	Units	2013	2014	2015	2016	2017
Production	1000 MT/year	29746 .66	31926.82	34304.00	36895.99	39722.18
Demand	1000 MT/year	8362.47	8885.11	9371.02	9826.20	10255.86
Demand Food	1000 MT/year	5122.76	5370.84	5634.91	5916.03	6215.35
Demand Industrial	1000 MT/year	3559.33	4141.98	4633 .92	5048.95	5399.09
Export	1000 MT/year	21526 .35	22938.36	24420 .32	25976.42	27611.28
Export Refined	1000 MT/year	13782.01	17405.59	22240 .70	28302.15	35604.88
Export Crude	1000 MT/year	6323.98	2896 .51	0.00	0.00	0.00
Import	1000 MT/year	5.14	3.46	2.40	1.87	1.75
World Price	$/MT	867.69	821.67	777.84	736.09	696.32
Biodiesel	1000 MT/year	2453 .66	2983 .32	3618.62	4371.93	5248.29

2SLS

Equation	Units	2013	2014	2015	2016	2017
Production	1000 MT/year	27113 .75	30750.96	34691.78	38980.33	43664.45
Demand	1000 MT/year	8380.09	9374.91	10503.78	11784.63	13238.03
Demand Food	1000 MT/year	4913 .74	5112.57	5313.96	5517.96	5724.60
Demand Industrial	1000 MT/year	3190.61	3965.65	4956 .13	6221.98	7839.74
Export	1000 MT/year	22074 .02	24507 .57	27242.09	30314.84	33767.62
Export Refined	1000 MT/year	10797.08	11607.23	12874.38	14585.97	16734.18
Export Crude	1000 MT/year	8300.16	7850.23	7368.84	6853.82	6302.80
Import	1000 MT/year	19.09	10.38	0.09	0.00	0.00
World Price	$/MT	1070.88	1189.02	1322.08	1471.95	1640.75
Biodiesel	1000 MT/year	2460 .53	2995.42	3647.39	4441.70	5409.49

Table 15. 5 Year Forecast - Accuracy Analysis

OLS W/ O time trend **"+" Overestimate** **"-" Underestimate**

Equation	Units	2013	2014	2015	2016	2017
Production	**1000 MT/year**	-3.14%	-5.39%	3.51%	-2.05%	-2.18%
Demand	**1000 MT/year**	-4.43%	18.15%	5.65%	8.34%	9.69%
Demand Food	**1000 MT/year**	3.39%	4.79%	9.51%	14.71%	19.36%
Demand Industrial	**1000 MT/year**	1.70%	107.10%	40.42%	46.35%	49.97%
Export	**1000 MT/year**	-0.89%	-11.65%	6.61%	-5.99%	-1.39%
Export Refined	**1000 MT/year**	-9.35%	-20.70%	6.83%	-5.24%	0.69%
Export Crude	**1000 MT/year**	21.60%	17.92%	- 11.01%	24.27%	-0.15%
Import	**1000 MT/year**	-100.00%	-100.00%	Unable to Calculate	Unable to Calculate	Unable to Calculate
World price	**$/MT**	0.89%	-0.49%	24.07%	4.23%	3.59%
Biodiesel	**1000 MT/year**	-4.75%	8.09%	233.21%	30.00%	69.30%

OLS With Time Trend "+" Overestimate "-" Underestimate

Equation	Units	2013	2014	2015	2016	2017
Production	1000 MT/year	-2.47%	-3.25%	7.40%	2.49%	3.17%
Demand	1000 MT/year	-4.43%	18.15%	5.65%	8.34%	9.69%
Demand Food	1000 MT/year	2.46%	3.29%	7.33%	11.62%	15.10%
Demand Industrial	1000 MT/year	1.70%	107.10%	40.42%	46.35%	49.97%
Export	1000 MT/year	-0.89%	-11.65%	6.61%	-5-99%	-1.39%
Export Refined	1000 MT/year	-6.09%	-8.66%	39.62%	40.96%	69.55%
Export Crude	1000 MT/year	-10.22%	-58.07%	-100.00%	-100.00%	-100.00%
Import	1000 MT/year	-80.94%	-56.80%	Unable to Calculate	Unable to Calculate	Unable to Calculate
World price	$/MT	1.26%	0.03%	24.92%	5.13%	-2.57%
Biodiesel	1000 MT/year	-4.75%	8.09%	233.21%	30.00%	69.30%

2SLS

Equation	Units	2013	2014	2015	2016	2017
Production	**1000 MT/year**	-11.10%	-6.82%	8.41%	8.28%	13.41%
Demand	**1000 MT/year**	-4.23%	24.67%	18.42%	29.93%	41.58%
Demand Food	**1000 MT/year**	-1.73%	-1.68%	1.11%	4.11%	6.01%
Demand Industrial	**1000 MT/year**	-8.84%	98.28%	50.19%	80.35%	117.77%
Export	**1000 MT/year**	-1.63%	-5.61%	18.93%	9.71%	20.60%
Export Refined	**1000 MT/year**	-26.43%	-39.09%	-19.18%	-27.35%	-20.31%
Export Crude	**1000 MT/year**	17.84%	13.64%	5.62%	15.73%	-9.96%
Import	**1000 MT/year**	-29.31%	29.81%	Unable to Calculate	Unable to Calculate	Unable to Calculate
World price	**$/MT**	24.97%	44.75%	112.33%	110.22%	129.58%
Biodiesel	**1000 MT/year**	-4.48%	8.53%	235.86%	32.08%	74.50%

5.4.1 Analysing for Accuracy

This accuracy analysis provided in Table 15 shows a trend of increasing the level of errors. In the next year past the baseline, the errors are within +/-10% for all three econometric models. In the subsequent years, the uncertainty increases, and the errors build to greater than +/-15%. There are exceptions to this observation, especially the forecast of the Market factor Import. The estimates for the Import equation are unable to be calculated because the historical trend for The Import has been in the sinking and reducing and in fact, had reached zero in the immediate past. This is causing an *undefined* error in the calculations. In the future, if the market conditions change such that there have had been significant imports, then this model will be able to capture such Import's trend and forecast it accordingly.

It is to be observed that the OLS Without Time Trend is giving an overall higher level of accuracy in the forecast for five years than the other two methods. For forecasts past two years, there has been a significant degradation in the accuracy of the other two models. Such an observation gives us an indication that OLS Without Time Trend could be the most appropriate econometric method for the designed composite model. Such a five-year forecast was done again with 2013 as the baseline resulting in an estimate for years 2014 through 2018. We observed a similar trend in the increase in errors past two/ three years. It was again seen that the OLS Without Time provided less error-prone accuracy than the OLS With Time Trend and 2SLS methods. Such a five-year forecast was repeatedly done for the subsequent years up to 2018 for which the latest baseline data exists.

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The confidence zone for the five-year forecast settled up to three years in all these iterations of projections. Therefore, it can be prescribed that the Composite method of using OLS Without Time Trend and Monte Carlo Simulation as the forecasting method, can provide a robust forecast for one year in the short term and a reliable forecast for three years in the medium term. This method of estimating trends is, in a way differencing the time series of the independent variables, capturing their descriptive statistics, and then integrating them in the next year to re-display the trends. It has been capable of capturing the growth and decline of the system, but it has been unable to account for the shocks in the system. El Nino's influence during 2015/16 significantly affected the market in that period causing a blow in the system by reducing all market factors. The prescribed composite model with Monte Carlo simulation has been unable to account for this shock.

5.5 Model validation

Further, this approach's outlook was compared with those of various current industry experts and the model was found to be within 5% forecasted values. It outperformed these expert forecasts when compared to historical forecasts. Table 16 shows the accuracy analysis done comparing the projections of Demand, Production, and Price of Palm Oil by the Economist Intelligence Unit (EIU)– Palm Oil Outlook vs. the forecast did use this identified method for the years of 2013 to 2018. When compared to the actual values, it was determined that the results from the composite forecasting method developed in this research were closer to the real values than the values forecasted from The Economist Intelligence Unit. For the Demand forecast, the MAPE of the Economist Intelligence Unit (EIU) provided an error of 7.06%, whereas this Model provided an error of 5.49%. For the Production Equation, EIU had a MAPE of 5.28% for an average of 5 years of the forecast, whereas this research's Model had a MAPE of 3.16%. Moreover, lastly, for the forecast of Price, EIU had a MAPE of 17.08%, whereas this Model had a MAPE of 9.69%. This comparison imparts credibility to this approach for a long-term forecast and further supports the robustness of the method for the prescribed three-year forecast utility.

The import and biodiesel equations from these models have been rejected because of the lack of either control data or sample data. This model has been discovered through the systematic review of previous researches related to palm oil market modeling that included models for Malaysia and Nigeria. Fifty independent variables were identified, and the research has been able to confirm 24 of those independent variables as "regional variables"; this means that these variables should be considered part of any future palm oil modeling effort. Appendix 7 shows the variables identified as "regional variables."

To check for accuracy and robustness of this identified model, OLS Without Time Trend and Using Monte Carlo Simulation, a 5-year forecast using this model was made and tested for accuracy using the past five years of data. When predicted from 2011 to 2015, it had level 1 accuracy for three years. When predicted from 2012 to 2016, it had level 1 accuracy for four years; this was continued stepwise till 2017. It was discovered that on average, the first three years of forecast stayed within the Level 1 accuracy, while volatility increased in the fourth and fifth years. It was also observed that the volatility was due to the shock to the system in 2015 caused by the very strong El Nino. As this model has not modeled the prediction of shocks in the system due to El Nino, it would be advised that this composite model of OLS without Time trend with Monte Carlo Average can be considered robust for a Three-Year Forecast and that any forecast further should be used with caution.

Table 16 Accuracy analysis CSS research vs. The Economist forecast

2018	CSS Research	Industry Expert 1	GAPKI	Industry Expert 2
Production	36.987	38.800	38.170	37.500
Difference		4.67%	3.10%	1.37%

	2013/2014	2014/2015	2015/2016	2016/2017
Actual Data	32,375.00	32,250.00	35,000.00	37,875.00
The Economist	29,463 .00	3 1,600.00	34,200.00	34,960.00
CSS-1Year Forecast	31,691.21	34,156.81	34,874.94	36,256.29
CSS-5 Year Forecast (2012)	30,821.06	32,674.60	34,763.76	37,105.50

	2013/2014	2014/2015	2015/2016	2016/2017	MAPE
The Economist	8.995%	2.016%	2.286%	7.696%	5.248%
CSS-1Year Forecast	2.112%	5.913%	0.357%	4.274%	3.164%
CSS-5 Year Forecast (2012)	4.800%	1.317%	0.675%	2.032%	2.206%

Demand (Consumption)

	2013/2014	2014/2015	2015/2016	2016/2017
Actual Data	7,827.50	8,532.50	9,020.00	9,280.00
The Economist	8,135.00	9,735.00	9,505.00	8,830.00
CSS-1Year Forecast	9,083.54	8,941.90	8,948.41	9,311.68
CSS-5 Year Forecast (2012)	8,759.68	9,253.96	9,714.94	10,148.23

	2013/2014	2014/2015	2015/2016	2016/2017	MAPE
The Economist	3.928%	14.093%	5.377%	4.849%	7.062%
CSS-1Year Forecast	16.047%	4.798%	0.794%	0.341%	5.495%
CSS-5 Year Forecast (2012)	11.909%	8.455%	7.704%	9.356%	9.356%

Price

	2014	2015	2016	2017
Actual Data	821.44	622.67	700.19	714.67
The Economist	792.00	777.00	540.00	659.00
CSS-1Year Forecast	728.1	624.76	578.43	662.32
CSS-5 Year Forecast (2012)	817.72	772.94	730.26	689.55

	2014	2015	2016	2017	MAPE
The Economist	3.584%	24.786%	22.878%	7.789%	14.759%
CSS-1Year Forecast	11.353%	0.337%	17.389%	7.325%	9.101%
CSS-5 Year Forecast(2012)	0.453%	24.134%	4.294%	3.514%	8.099%

This research has been concluded after identifying relevant variables for the Palm Oil market of Indonesia, developing a working econometric model that explains the behavior of these variable interactions, and providing a simulation tool to the sponsor company that can convert these industry findings into useable product market information. Having discussed the limitations and possible future work in this field, the authors would like to thank the reader for committing the time needed to comprehend the findings and hope they can positively influence the world through this study of the palm oil industry.

5.6 General Application of the Approach

The use of forecasting methods for assessing the future demand for products or services is one of the most critical activities for companies. A good forecast will allow a company to sell more, minimize safety stock for every product they carry, or allow for identifying a strategic location for cost-effective sourcing. This capability of forecasting demand will allow companies to make tactical decisions to configure their supply chains the best way possible to comply with their business requirements.

Chemi is a Speciality Chemical industry and is an important supplier to the Palm Oil industry. Their product Blearth is used to refine CPO into RPO. If Chemi can forecast the demand from the Palm Oil Industry, then they will be able to align their supply chain effectively such that they can source their special chemical Blearth and supply it most strategically. The developed Composite Model will be able to forecast the market area factors which would provide important information to Chemi to calculate the demand for their product Blearth accurately. Figure 10 shows the demand forecasting process for Chemi’s specialty chemical Blearth in the Indonesian Palm Oil Market. The process requires four inputs viz. Last known Independent Variable Data (trend forecast from the Monte Carlo component of Composite

Model), Blearth's Dosage in the Palm Oil Industry, the Blearth's Market Share targeted by Chemi, and the product Blearth's portfolio split (in case they have multiple SKUs of the product). These four inputs are incorporated into the Composite Market Model that has been developed in this research.

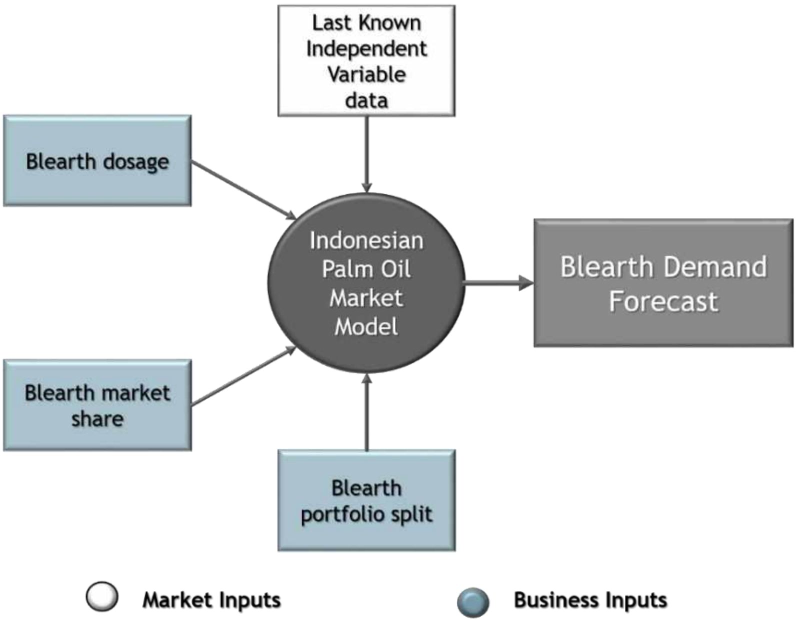

Figure 10 Specialty Chemical's Demand Forecast

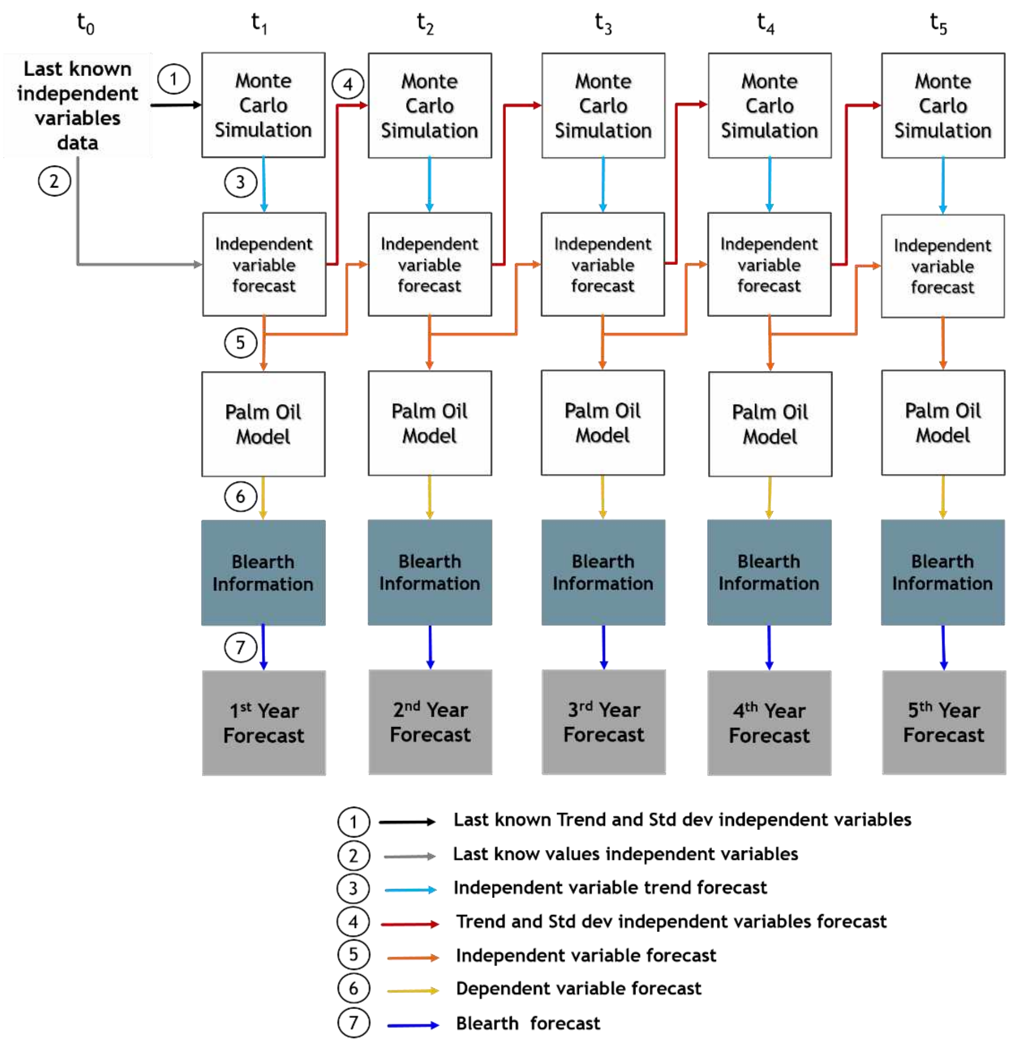

Figure 11 Specialty Chemical's Forecast Process

The Forecast Method Flowchart from Figure 9 has been modified here in Figure 11 to show how the process introduced in Figure 10 is used to calculate a demand forecast for any specialty chemical, like Blearth, used in the Palm Oil industry. In figure 12, the Dependant variable forecast, which is the prediction of the Market Area Factors, is mixed with the Speciality Chemical's Information to produce the First Year Forecast. This method is repeated five times to produce the Market forecast of the Speciality Chemical for five years.

Equation 6 shows the formula for converting the Palm Oil Market Size into the Speciality Chemical, Blearth's Market Size. Two inputs that go into Figure 10, viz. Independent Variable Data and Speciality Chemical Dosage. In Equation 7, the components of Palm Oil Market Forecast, Speciality Chemical's Dosage, and the Speciality Chemical's Targeted Market Share are used to generate the Market demand for special chemical Blearth. This demand is further split into the need of the Speciality Chemical's portfolio of SKUs by multiplying with the Portfolio Split, which is input into the forecasting model.

Eq.6	$\boldsymbol{Specialty\ Chemical's\ Market\ Size = (Production\ PO - Export\ Crude\ PO) * Chemical's\ Dosage}$
Eq.7	$(Market_{Specialty\ Chemical\ Demand}) = Market_{PO\ Forecast} * Chemical\ Dosage * Market\ Share$

6. Conclusions

Two significant market parameters for Crude Palm Oil have been calculated as a part of this study i.e. CPO production and export quantity for a given year. This allows to estimate the CPO remaining in Indonesian market that would need to be refined. When the remaining amount of CPO in Indonesia is multiplied by the Blearth dosage factor, an estimation of the market size of Blearth in Indonesia is calculated. While this method produces results with a high degree of precision for CPO market factors, it is a function of data that has been available to predict the two factors. The data set used for all 50 independent variables was constructed using the data available from 2009 to 2016 for all the variables used to explain the market factors, except for the World Price factor. The dataset for this equation included information that was available from 1964 to 2016, this equation complies with the normality test of the residuals, the remaining factors due to the data constraint didn't show the normality of the residuals during the test. It was assumed that with the missing data set added the entire data set would still follow the normal distribution.

In this research, a composite approach of forecasting has been developed, using Monte Carlo simulation. It is observed that the long-term forecast for the factors is failing when a considerable weight is given to the influence of El Nino from 2015. If this could be ignored or, then the present technique also improves for longer term forecasting i.e. beyond five years. Another limitation of this model is not enough data to model the biodiesel factor. As this equation had only a few data points, it needs to be tested if there could be an alternative method to model the behaviour of the market only due to biodiesel.

With a low MAPE for the short-term and longer term predictions, this research provides the value of using a composite approach of forecasting for commodity markets influenced by similar factors as palm oil and extends the discussion into exploring the causality of these interrelated variables which was not the scope of this study. The accuracy of the results validates the findings of (Allen, 1994) to this setting in Indonesia. This composite model for Palm Oil could be tested in the second most important country after Indonesia i.e. Malaysia where both production and export factors are influenced by different national policy and challenges.

References

W. B. (2017). *Commodity Markets Outlook January 2017. Washington DC: World Bank Group.*

Allen, P. G. (1994). Economic forecasting in Agriculture. *International Journal of Forecasting*, 81–135.

Applanaidu, S. D. A., Arshad, F. M., Shamsudin, M. N., & Hameed, A. A. A. (2011). An Econometric Analysis of the Link between Biodiesel Demand and Malaysian Palm Oil Market. *International Journal of Business and Management*, *6*(2). https://doi.org/10.5539/ijbm.v6n2p35

Arshad, F. M., Awad, A., & Hameed, A. (2012). Crude Oil, Palm Oil Stock and Prices: How They Link. *Review of Economics & Finance, 3,* 48–57.

Awad Abdel-hameed, A. (2005). Universiti Putra Malaysia an Econometric Study of Palm Oil Import Demand in the Middle East and North African Countries Amna Awad Abdel-Hameed .

Badi Baltagi. (2011). *Econometrics*. Springer-Verlag Berlin Heidelberg. https://doi.org/10.1007/978-3-642-20059-5

Davies, R., Coole, T., & Osipyw, D. (2014). The Application of Time Series Modelling and Monte Carlo Simulation: Forecasting Volatile Inventory Requirements. *Applied Mathematics*, *05*(08), 1152–1168. https://doi.org/10.4236/am.2014.58108

Dewi, S., & Arshad, F. M. (2011). The Relationship among Petroleum Prices, Biodiesel Demand, and Malaysian Palm Oil Prices: Evidence from Simultaneous Equation Approach. *BANWA Archives (2004-2013), 8*(1&2), 64–83.

Egwuma, H., Serdang, U. P. M., Kai, K., & Wong, S. (2016). A Model for the Palm Oil Market in Nigeria: an Econometrics Approach. *International Journal of Food and Agricultural Economics*, *4*(2), 69–85.

Faostat FA, P. A. (2010). *Food and agriculture organization of the united nations*.

Hariyadi, P. (2020). Food safety & nutrition issues: challenges and opportunities for Indonesian palm oil. In *IOP Conference Series: Earth and Environmental Science* (Vol. 418, p. 12003). IOP Publishing.

Hasan, M. F., Reed, M. R., & Marchant, M. A. (2001). Effects of an Export Tax on Competitiveness: The Case of the Indonesian Palm Oil Industry. *Journal of Economic Development*, *26*(2), 77–90.

Hashim, K., Tahiruddin, S., & Asis, A. J. (2012). Palm and palm kernel oil production and processing in Malaysia and Indonesia. In *Palm Oil* (pp. 235–250). Elsevier.

Henson, I. E. (2012). Ripening, harvesting, and transport of oil palm bunches. In *Palm Oil* (pp. 137–162). Elsevier.

Indonesia, B.-S. (2015). *Indonesian Oil Palm Statistics*.

Indonesia, B. (2016). *Anual Report 2016*.

Johari, A., Nyakuma, B. B., Mohd Nor, S. H., Mat, R., Hashim, H., Ahmad, A., … Tuan Abdullah, T. A. (2015). The challenges and prospects of palm oil based biodiesel in Malaysia. *Energy*, *81*, 255–261.

Labys WC. (1973). *Dynamic commodity models: specification, estimation, and simulation*.

Oosterveer, P. (2015). Promoting sustainable palm oil: viewed from a global networks and flows perspective. *Journal of Cleaner Production*, *107*, 146–153.

Phitthayaphinant, P., Nissapa, A., & Somboonsuke, B. (2012). Factors Influencing Oil Palm Plantation Areas in Thailand. In *Proceedings-Management, Agroindustry and Tourism Industry-006 4th International Conference on Humanities and Social Sciences* (pp. 1–11).

Purnomo, H., Okarda, B., Dermawan, A., Ilham, Q. P., Pacheco, P., Nurfatriani, F., & Suhendang, E. (2020). Reconciling oil palm economic development and environmental conservation in Indonesia: A value chain dynamic approach. *Forest Policy and Economics*, *111*, 102089.

Sulistyanto, A., & Akyuwen, R. (2009). Factors affecting the performance of Indonesia's crude palm oil export. *Development*, *4*, 281–289.

Talib, B. A., & Darawi, Z. (2002). An economic analysis of the Malaysian palm oil market. *Oil Palm Industry Economic Journal*, *2*(1), 19–27.

The World Bank Group. (2017). (n.d.). *Commodity Markets Outlook January 2017. Washington DC: The World Bank Group*.

The World Bank Group. (2017, N. 4). C. M. (n.d.). *Retrieved from The World Bank Group: http://www.worldbank.org/en/research/commodity-markets#1*.

The World Bank Group. (2017, O. 26). (n.d.). *Historical and future climate data*.

United States Department of Agriculture Foreign Agricultural Service. (2017, N. 4). (n.d.). *Production, Supply and Distribution- Market and Trade Data. Retrieved from United States Department of Agriculture Foreign Agricultural Service: https://apps.fas.usda.gov/psdonline/app/index.html#/app/downloads*.

Voituriez, T. (2001). What explains price volatility changes in commodity markets? Answers from the world palm-oil market. *Agricultural Economics*, *25*(2–3), 295–301. https://doi.org/10.1016/S0169-5150(01)00086-X

Wooldridge, J. M. (2002). *Introductory Econometrics: A Modern Approach*. *Wiley*. https://doi.org/10.1002/jae.665

World Bank, G. (2010). *Indonesia - Public Expenditure Review. Washington, DC: Public Expenditure Review.*

Wright T, Rahmanulloh A, A. A. (2015). *Indonesia biofuels annual report 2017. Global Agricultural Information Network (GAIN).*

Zabid, M. F. M., & Abidin, N. Z. (2015). Palm oil industry: A review of the literature on the modelling approaches and potential solution. *AIP Conference Proceedings*, *1691*. https://doi.org/10.1063/1.4937023

APPENDIX

Appendix 1 Relevant Factor for Palm Oil Market

Equation	Factor	Applanaidu, Arshad, Shamsuddin & Yusop (2011)	Applanaidu.S, Abdel Hameed.A, Mohammed Arshad.F, & Shamsudin M (2009)	Egvuma, Shamsudin, Mohammed, Kamarulzamam. & Seng wong (2016)	Talib B & Darawi. Z (2002)	Arshad .F & Abdul Hameed .A (2012)
Production	Production palm oil lagged one year					
	Produce Price of CPO					
	Producer Price of Substitute					
	Average lending rate %					
	Government Expenditure In agricultural development					
	Time trend as a proxy of Technological chance					
	Relative price of palm oil to rubber					
	Relative price of palm oil to rubber lagged three years					
	Rainfall					
	Relative price of palm oil to soybean oil					
Demand	Crude Palm Oil Domestic Demand Lagged one year					
	Domestic price palmoil					
	World price of soybean oil					
	Country population					
	Country GDP					
	Countrv GDP p*er* capita					
	Real domestic price of coconut oil					
	Industrial production index					

Export	Export Demand of Palm Oil Lagged					
	Exchange Rate					
	World GDP					
	World Price of Soybean Oil					
	World Price of Palm Oil					
	World Population					
	Domestic price palm oil					
	Industrial Production Rate					
Import	World Price Palm Oil					
	Country GDP					
	Initial Stocks palm oil					
	World Price of Soybean Oil					
	Import Demand of Palm Oil Lagged					
	Relative Price Ratio (Import prices/Domestic Prices)					
	Domestic Price Palm Oil					
	Country Production Index					
World Price	World price of soybean					
	World GDP					
	World stock of palm oil					
	Petroleum Price					
	World Price Palm oil Lagged one year					
Biodiesel	Biodiesel Production					
	Biodiesel Blend Rate					
	Diesel Consumption					

A1. Six-year time series analysis for main components for OLS with time trend

Production		2012	2013	2014	2015	2016	2017
	M=3	24277.321	26440.313	28218.639	30054.945	31560.462	33083.604
	M=5	22238.998	24140.455	26137.232	28282.077	29911.700	31421.002
	Holtz α=0.1 β=0.1	28573 .838	30630.622	32643.552	34705.042	36567.382	38396.927
	Holtz α=0.1 β=0.2	28573.838	30625.638	32625.663	34672.567	36501.300	38279.726
Monte Carlo	Avg	29360.935	30418.410	32115.483	34837.259	34887.500	36712.551
	Max	32743.178	35015.449	35685.882	38261.482	39639.370	41887.828
	Min	26449.117	26889.680	28482.213	30914.935	29789.759	31796.612

Demand		2012	2013	2014	2015	20 16	2017
	M=3	6492.374	7240.291	7739.682	8061178	8253.507	8434. 147
	M=5	5703.348	6366.125	7103.587	7621.401	7947.230	8268.652
	Holtz α=0.1 β=0.1	4047.84 1	4473.739	4939.346	5380.356	5830.312	6306.031
	Holtz α=0.1 β=0.2	4400.323	4942.355	5540.807	6121.382	6712.127	7326.356
Monte Carlo	Avg	8328.502	8848.352	9161.942	8868.555	8975.025	9423.901
	Max	7510.354	8967.26 1	10460.103	10459.833	10529.866	10953.167
	Min	9412.811	8615.995	8747.138	7659.508	7362.888	8120.799

Export		2012	2013	2014	2015	2016	2017
	M=3	17163.780	18559.809	20431.918	22321.178	23845.208	24786.771
	M=5	16316.852	17613.551	18778.153	20491.574	22123.409	23351.948
	Holtz α=0.1 β=0.1	16643.973	18336.779	20102.004	21970.305	23698.952	25296.320
	Holtz α=0.1 β=0.2	19627.610	21312.555	23049.966	24878.896	26541.805	28036.553
Monte Carlo	Avg	19727.085	21138.481	23363.20 1	25902.245	25976.235	26159.809
	Max	33662.989	32787.132	35573.392	37848.238	38598.960	38048.653
	Min	6464.194	10212.919	12108.278	12878.259	14330.397	13347.857

A2 Six-year time series analysis for main components for OLS without time trend

Import		2012	2013	2014	2015	2016	2017
	M=3	7.673	0.000	0.000	105.046	219.871	158.894
	M=5	26.623	31.867	33.576	25.190	22.900	17.277
	Holtz α=0.1 β=0.1	658.972	628.288	594.237	555.111	515.483	473.811
	Holtz α=0.1 β=0.2	539.542	486.622	429.406	366.825	304.441	241.402
Monte Carlo	Avg	12.736	7.786	6.946	0.000	0.000	0.000
	Max	1043.896	715.891	701.420	619.894	724.542	413.598
	Min	0.000	0.000	0.000	0.000	0.000	0.000

World Price		2012	2013	2014	2015	2016	2017
	M=3	847.459	905.751863	888.944523	794.218	699.918	672.517
	M=5	869.278	896.248	848.689	837.000	796.085	743.724
	Holtz α=0.1 β=0.1	647.300	689.170	i14.949	727.359	732 .616	744.256
	Holtz α=0.1 β=0.2	700.474	756.317	794.298	815.769	826.460	840.828
Monte Carlo	Avg	923.729	873.722	728.176	624.76326	578.432693	662.319
	Max	1954.903	1742.646	1418.214	1127.427	1033.54 1	1130.826
	Min	0.000	32.280991	89.1801129	116.909533	140.641273	121.829

Biodiesel		2012	2013	2014	2015	2016	2017
	M=3	880.029	1451.20694	2084.47813	2454.814	2143.160	2403.463
	M=5	708.706	1055.751	1448.222	1939.380	2020.612	2362.282
	Holtz α=0.1 β=0.1	1547.353	1879.022	2240.401	2589.228	2720.42 1	3072.355
	Holtz α=0.1 β=0.2	1547.353	1885.083	2259.808	2626.207	2757.850	3116.102
Monte Carlo	Avg	1783.294	2241.346	2900.819	3059.33983	935.981971	3251.377
	Max	8377.639	8314.357	8587.848	8551.650	4182.229	13065.491
	Min	0.000	0.000	0.000	0.000	0.000	0.000

A3 Six-year time series analysis for main components for OLS with time trend

Production		2012	2013	2014	2015	2016	2017
	M=3	26738.801	28540.404	30342.007	32143.609	33945.212	35746.815
	M=5	24937. 198	26738.801	28540.404	30342.007	32143.609	33945.212
	Holtz α=0.1 β=0.1	30342.007 1	32143.609	33945.212	35746.815	37548.418	39350.021
	Holtz α=0.1 β=0.2	30342.007	32143.609	33945.212	35746.815	37548.418	39350.021
Monte Carlo	Avg	30536.740	32422.925	34303.525	36186.318	38057.045	39931.982
	Max	31342.372	33433.696	35537.951	37492.271	39741.565	4 1949.37 5
	Min	29816.827	31427.899	33074.524	34699.006	36185.917	38294.037

Demand		2012	2013	2014	2015	2016	2017
	M=3	6492.374	7240.291	7739.682	8061.178	8253.507	8434.147
	M=5	5703.348	6366.125	7103.587	7621.401	7947.230	8268.652
	Holtz α=0.1 β=0.1	4047.841	4473.739	4939.346	5380.356	5830.372	6306.031
	Holtz α=0.1 β=0.2	4400.323	4942.355	5540.807	6121.382	6712.127	7326.356
Monte Carlo	Avg	8328.502	8848.352	9161.942	8868.555	8975.025	9423.901
	Max	7510.354	8967.261	10460.103	10459.833	10529.866	10953.167
	Min	94 12.811	8615.995	8747.138	7659.508	7362.888	8120.799

Export		2012	2013	2014	2015	2016	2017
	M=3	17163.780	18559.809	20431.918	22321.178	23845.208	24786.771
	M=5	16316.852	17613.551	18778.153	20491.574	22 123.409	23351.948
	Holtz α=0.1 β=0.1	16643.973	18336.779	20102.004	21970.305	23698.952	25296.320
	Holtz α=0.1 β=0.2	19627.610	21312.555	23049.966	24878.896	26541.805	28036.553
Monte Carlo	Avg	19727.085	21138.481	23363.201	25902.245	25976.235	26159.809
	Max	33662.989	32787.132	35573.392	37848.238	38598.960	38048.653
	Min	6464.194	10212.919	12108.278	12878.259	14330.397	13347.857

Import		2012	2013	2014	2015	2016	2017
	M=3	3.208	0.000	0.000	85.166	181.458	128.110
	M=5	14.623	19.891	21.937	13.611	11.448	5.993
	Holtz α=0.1 β=0.1	546.063 1	518.721	488.763	454.117	419.747	383.704
	Holtz α=0.1 β=0.2	449.037	403 .520	354.628	300.762	247.765	194.249
Monte Carlo	Avg	17.785	15.691	13.374	0.000	1.6 19	0.000
	Max	887.202	622.501	617.189	539.583	640.912	368.987
	Min	0.000	0.000	0.000	0.000	0.000	0.000

World Price		2012	2013	2014	2015	2016	2017
	M=3	840.238	900.718	886.798	794.977	700.877	671.059
	M=5	858.187	886.287	841.273	832.423	792.495	739.765

	Holtz $\alpha=0.1$ $\beta=0.1$	638.663	681.703	709.105	723.462	729.835	742.145
	Holtz $\alpha=0.1$ $\beta=0.1$	694.902	751.942	791.648	815.250	827.220	842.353
Monte Carlo	Avg	927.919	878.482	737.556	637.229	582.355	662.274
	Max	1962.730	1748.337	1432.823	1146.821	1048.437	1137.821
	Min	0.000	37.768	95.665	124.380	134.666	111.503

Biodiesel		2012	2013	2014	2015	2016	2017
	M=3	880.029	1451.207	2084.478	2454.814	2143.160	2403.463
	M=5	708.706	1055.751	1448.222	1939.380	2020.612	2362.282
	Holtz $\alpha=0.1$ $\beta=0.1$	1547.353	1879.022	2240.401	2589.228	2720.421	3072.355
	Holtz $\alpha=0.1$ $\beta=0.1$	1547.353	1885.083	2259 .808	2626.207	2757.850	3116.102
Monte Carlo	Avg	1754.188	2216.702	2884.958	3050.342	939.857	3251.138
	Max	8336.053	8271.001	8560.357	8525.755	4185.941	13054.131
	Min	0.000	0.000	0.000	0.000	0.000	0.000

Appendix 2 Six-year time series analysis for main components for 2SLS

Production		2012	2013	2014	2015	2016	2017
	M=3	20097.848	21793.505	24038.932	26210.134	28726.614	30288.439
	M=S	18207.994	19923.614	22102.497	23974.251	26424.187	28498.402

	Holtz α=0.1 β=0.1	14714.338	16319.841	18163.456	20145.396	22390.302	24367.427
	Holtz α=0.1 β=0.2	17329.795	19193.177	21315.126	23591.390	26153.317	28426.201
Monte Carlo	Avg	22521.079	26149.108	29380.659	31578.282	35219.410	33371.236
	Max	18153.679	23984.122	28308.017	30748.921	35837.000	36258.694
	Min	26182.068	29372.273	30798.355	32381.544	35181.711	29814.303

Demand		2012	2013	2014	2015	2016	2017
	M=3	5966.033	6661.465	7527-400	8284.140	8407.671	8677.608
	M=5	5595.136	6130-435	6749.919	7466.397	7891.709	8376.864
	Holtz α=0.1 β=0.1	5678.549	6064.156	6518.211	7017.113	7362.158	7818.748
	Holtz α=0.1 β=0.2	6051.240	6441.312	6914.667	7447.838	7823.692	8316.723
Monte Carlo	Avg	7266.797	8151.015	9102.940	9794.678	8299.549	9760.471
	Max	9068.165	9424.243	10625.114	11184.040	11297.115	13147.968
	Min	5860.862	6530.939	7433.720	8461-405	5568.464	6499.313

Export		2012	2013	2014	2015	2016	2017
	M=3	17883.280	18670.509	19872.386	21547.422	23923.025	24724. 171
	M=5	16507.069	17841.910	19057.197	20149.323	21931.453	23161.731
	Holtz α=0.1 β=0.1	13997.160	15298.502	16716.194	18182.731	19993.914	21375.205

	Holtz α=0.1 β=0.2	16021.337	17550.369	19192.248	20873 .932	22913.436	24483.210
Monte Carlo	Avg	18768.775	21083. 104	23129.396	24454.167	29079.976	25335.383
	Max	22695.607	25245.386	27146.739	28552.854	34412.095	33689.458
	Min	14489.696	16764.734	18829.218	20478.780	23323.309	17898.746

Import		2012	2013	2014	2015	2016	2017
	M=3	25.617	19.299	17.788	28.181	32.264	24.215
	M=5	25.772	27.506	26.062	25.296	23.017	18.128
	Holtz α=0.1 β=0.1	73.625	73.569	72.614	71.025	68.427	64.924
	Holtz α=0.1 β=0.2	69.087	67.535	64.840	61.315	56.600	50.827
Monte Carlo	Avg	33.145	23.378	18.907	17.533	11.487	5.395
	Max	59.513	27.252	24.555	24.426	15.305	0.000
	Min	23.117	0.000	13.802	9.278	10.825	7.722

World Price		2012	2013	2014	2015	2016	2017
	M=3	826.120	851.130	905.423	872.726	803.529	730.129
	M=5	770.823	849.737	864.351	841.203	849.803	806.757
	Holtz α=0.1 β=0.1	624.295	671.308	706.914	729.331	748.112	754.077

	Holtz α=0.1 β=0.1	645.124	700.246	744.636	774.885	800.088	809.890
Monte Carlo	Avg	878.838	995.857	880.421	759.413	741.987	634.384
	Max	1885.920	1771.167	1483.761	1236.880	1180.965	972.336
	Min	127.772	239.350	325.388	306.470	330.120	255.185

Biodiesel		2012	2013	2014	2015	2016	2017
	M=3	888.238	1459.481	2088.765	2455.338	2143.751	2403.406
	M=5	702.507	1056.250	1453.982	1943.357	2024 .003	2363.083
	Holtz α=0.1 β=0.1	1574.035	1914.444	2282.429	2636.727	2773.368	3128.534
	Holtz α=0.1 β=0.1	1574.035	1918.980	2297.588	2665.928	2799.183	3156.617
Monte Carlo	Avg	1782.533	2238.100	2892.720	3057.451	955.610	3261.649
	Max	8329.384	8281.782	8558.387	8529.969	4220.151	13032.868
	Min	0.000	0.000	0.000	0.000	0.000	0.000

Appendix 3 Production Equation Data

Units	1000 MT/year	1000 MT/year	$/MT	$/year	%	$/MT	Million US$	Price PO/Price Soybean Oil	Price PO/Price Rubber	Avg mm-month/year
YEAR	**CPOP**	**CPOPL**	**Cl. 'OPRI**	**SOPRI**	**ALINDR**	**RUBPR**	**GIADIV**	**RPPOSO**	**RPPORU**	**RAINL**
2007	18000.000	16600.000	775.742	923.642	0.139	2262.500	810.545	0.840	0.343	222.648
2008	20500 .000	18000.000	945.842	1223.575	0.136	2586.667	925.196	0.773	0.366	251.180
2009	22000.000	20500 .000	679.075	879.814	0.145	1919.167	1039.846	0.772	0.354	264.891
2010	23600 .000	22000.000	898.767	1004.604	0.133	3654.167	1154.496	0.895	0.246	242.820
2011	26200.000	23600.000	1123.208	1170.797	0.124	4822.500	1269.147	0.959	0.233	300.448
2012	28500.000	26200.000	999.267	1112.836	0.118	3376.667	1383.797	0.898	0.296	254.830
2013	30500 .000	28500.000	853.758	963.039	0.117	2795.000	1498.448	0.887	0.305	252.982
2014	33000.000	30500 .000	817.708	841.728	0.126	1951.667	1613.098	0.971	0.419	257. 178
2015	32000.000	33000 .000	616.117	775.354	0.127	1571.667	1727.749	0.795	0.392	219.511
2016	34000.000	32000.000	681.056	862.799	0.119	1605.000	1842.399	0.789	0.424	206.481

Appendix 4 Demand Equation Data

Units	1000 MT/year	1000 MT/year	I 000 MT/year	I 000 MT/year	I000 MT/year	1000 MT/year	$/MT	$/year	#Thousand people	Million US$	US $	$/MT	
YEAR	**CPODD**	**CPODDL**	**CPOIND**	**CPOINDL**	**CPOFOOD**	**CPOFOODL**	**RBDPO**	**SOPRI**	**POPUL**	**CGDP**	**CGDPPC**	**COCOPRI**	**INDPI**
2007	4650.000	4190.000	650.000	400.000	3900.000	3700.000	754.342	923.642	232989.000	432216.738	1855.094	918.875	123.436
2008	4835.000	4650.000	800.000	650.000	3900.000	3900.000	961.658	1223.575	236159.000	510228.635	2160.528	1224.000	127.151
2009	5196.000	4835.000	1250.000	800.000	3800.000	3900.000	678.375	879.814	239340.000	539580.089	2254.446	725.375	128.702
2010	6269.000	5196.000	1800.000	1250.000	4300.000	3800.000	882.058	1004.604	242524.000	755094.160	3113.481	1123.583	100.000
2011	7115.000	6269.000	2300.000	1800.000	4600.000	4300.000	1135.000	1170.797	245708.000	892969.108	3634.277	1730.083	104.094
2012	8035.000	7115.000	2900.000	2300.000	4900.000	4600.000	979.242	1112.836	248883.000	917869.910	3687.954	1110.833	108.379
2013	8750.000	8035.000	3500.000	2900.000	5000.000	4900.000	797.100	963.039	252032.000	912524.137	3620.664	940.583	114.888
2014	7520.000	8750.000	2000.000	3500.000	5200.000	5000.000	769.383	841.728	255131.000	890814.755	3491.596	1279.896	120.359
2015	8920.000	7520.000	3300.000	2000.000	5250.000	5200.000	594.325	775.354	258162.000	861256.351	3336.107	1109.500	126.089
2016	8570.000	8920.000	3450.000	3300.000	5300.000	5250.000	654.590	862.799	261115.000	932259.178	3570.295	1474.667	131.149

Appendix 5 Import Equation Data

Units	1000 MT/year	1000 MT/year	$/MT	Million US$	1000 MT	1000 MT	$/MT		$/MT	
YEAR	**IMPO**	**IMPOL**	**WPRIPO**	**CGDP**	**INISTCKS**	**INDSTCKS**	**SOPRI**	**RPRIPXP**	**CPOPRI**	**INDPI**
2007	7.000	3.000	817.617	432216.738	2069.000	1457.000	923.642	1.054	775.742	123.436
2008	21.000	7.000	922.402	510228.635	1457.000	1179.000	1223.575	0.975	945.842	127.151
2009	49.000	21.000	707.877	539580.089	1179.000	1459.000	879.814	1.042	679.075	128.702
2010	23.000	49.000	900.833	755094.160	1459.000	2390.000	1004.604	1.002	898.767	100.000
2011	30.500	23.000	1014.085	892969.108	2390.000	3022.000	1170.797	0.903	1123.208	104.094
2012	38.000	30.500	906.906	917869.910	3022.000	3152.000	1112.836	0.908	999.267	108.379
2013	27.000	38.000	780.969	912524.137	3152.000	3210.000	963.039	0.915	853.758	114.888
2014	8.000	27.000	760.419	890814.755	3210.000	2734.000	841.728	0.930	817.708	120.359
2015	8.000	8.000	637.834	861256.351	2734.000	2916.000	775.354	1.035	616.117	126.089
2016	8.000	8.000	746.827	932259.178	2916.000	2346.000	862.799	1.097	681.056	131.149

Appendix 6 Export Equation Data

Units	I000 MT/year	1000 MT/year	1000 MT/year	I000 MT/year	LCU per US$, period average	Million US$	$/MT	$/MT	# Thousand people	$/MT	%	
YEAR	**IXDPO**	**IXDPOL**	**IXPRIFPO**	**IXPCPO**	**IXC."RT**	**WGDP**	**SOPRI**	**WPRIPO**	**WPOI'UL**	**CPOPRI**	**IXPOSPLIT**	**WINDPI**
2007	13969.000	11419.000	7262.603	6706.397	9141.000	57793330.573	923.642	817.617	6680423.047	775.742	0.520	109.942
2008	15964.000	13969.000	7159.444	8804.556	9698.963	63386360.636	1223.575	922.402	6763745.673	945.842	0.448	107.368
2009	16573.000	15964.000	7043.988	9529.012	10389.938	60086989 .443	879.814	707.877	6847214.549	679.075	0.425	92.556
2010	16423.000	16573.000	6929.328	9493.672	9090.433	65906150.721	1004.604	900.833	6930656.699	898.767	0.422	100.000
2011	18453.000	16423.000	8640.106	9812.894	8770.433	73241717.918	1170.797	1014.085	7012843.635	1123.208	0.468	101.904
2012	20373.000	18453.000	11844.222	8528.778	9386.629	74802287.630	1112.836	906.906	7097400.665	999.267	0.581	102.301
2013	21719.000	20373.000	14675.529	7043.471	10461.240	76924649.545	963.039	780.969	7182860.115	853.758	0.676	102.457
2014	25964.000	21719.000	1'9055.799	6908.201	11865.211	78870119.014	841.728	760.419	7268986.176	817.708	0.734	104.488
2015	22906.000	25964.000	15929.134	6976.866	13389.413	74509719.336	775.354	637.834	7355220.412	616.117	0.695	104.752
2016	26000.000	22906.000	20077.769	5922.231	13308.327	75543542.614	862.799	746.827	7442135.578	681.056	0.772	104.845

Appendix 7 Biodiesel Equation Data

Units	1000 MT/year	1000 MT/year	Million Liters	Million Liters	%	Million Liters	$/year	$/year
YEAR	**CPOBIO**	**CPOBIOL**	**BIOPRO**	**BIOEXP**	**BIOBLE**	**DIECO**	**REFEXPOLEV**	**CRUEXPOLEV**
2008	619.000	265.000	630.000	610.000	0.002	17001.000		
2009	304.000	619.000	330.000	204.000	0.002	29237.000		
2010	681.000	304.000	740.000	563.000	0.008	32220.000		
2011	1656.000	681.000	1800.000	1440.000	0.011	37617.000		
2012	2024.000	1656.000	2200.000	1515.000	0.022	37743.000		
2013	2576.000	2024.000	2800.000	1800.000	0.035	36124.000		
2014	2760.000	2576.000	3000.000	1350.000	0.056	34651.000		
2015	1086.000	2760.000	1180.000	343.000	0.032	30716.000	477874.016	348843.307
2016	3363.000	1086.000	3650.000	478.000	0.102	32228.000	602333.061	296111.564

Appendix 8 World Price Equation Data

Units	$/MT	S/MT	$/MT	Million US$	1000 MT	$/bbl
YEAR	**WPRIPO**	**WPRIPOL**	**SOPRI**	**WGDP**	**WSTCKPO**	**PEPRI**
1965	1364.066	1210.072	1351.444	1961944.495	53.000	7.108
1966	1137.522	1364.066	1262.358	2128619.428	49.000	6.565
1967	1069.282	1137.522	1037.615	2264793.680	85.000	6.364
1968	815.009	1069.282	859.674	2443345.944	75.000	6.372
1969	829.877	815.009	903.431	2690870.792	47.000	5.819
1970	1120.182	829.877	1233.419	2956885.262	84.000	5.212
1971	1068.791	1120.182	1244.130	3265917.077	97.000	6.922
1972	815.759	1068.791	903.340	3766131.376	141.000	6.834
1973	1222.337	815.759	1411.615	4589203.445	113.000	9.090
1974	1777.509	1222.337	2210.861	5292853.388	236.000	29.158
1975	1038.612	1777.509	1347.596	5893742	298.000	24.956
1976	960.711	1038.612	1035.858	6412245.309	319.000	27.484
1977	1158.720	960.711	1268.520	7252968.307	324.000	27.469
1978	1129.344	1158.720	1141.885	8537753.757	470.000	24 .299
1979	1102.611	1129.344	1116.692	9919046.090	610.000	52.218
1980	894.898	1102.611	916.235	11166003.84	609.000	56.526
1981	873.931	894.898	776.201	11457611.76	495.000	54.342
1982	702.535	873.931	705.954	11355656.42	770.000	51.531
1983	813.026	702.535	854.305	11616289.84	549.000	48.088
1984	1208.346	813.026	1200.333	12058393.95	843.000	47.346
1985	838.672	1208.346	958.323	12681690.89	1035.000	45.543
1986	374.359	838.672	498.781	15014218.23	1463.000	20.903
1987	455.380	374.359	444.303	17083141.77	1372.000	24 .120
1988	545.687	455.380	578.453	19129417	14 12.000	18.372
1989	440.039	545.687	541.860	20080076.89	1619.000	22.401
1990	350.480	440.039	541.092	22579759.70	1699.000	27.675
1991	413.858	350.480	554.049	23909829.10	1424.000	23.648

1992	471.579	413.858	514.023	25389800.98	1469.000	22.795
1993	437.603	471.579	556.536	25834735	1786.000	19.510
1994	631.097	437.603	735.20 1	27740746.94	1316.000	18.974
1995	683.474	631.097	680.029	30840585.35	1468.000	18.694
1996	588.804	683.474	611.632	31518975.35	1830.000	22.646
1997	635.265	588.804	657.281	31403319.22	2048.000	22.3 12
1998	816.692	635.265	761.725	31314851.25	1813.000	15.899
1999	541.001	816.692	530.247	32486113.87	2663.000	22.423
2000	389.959	541.001	424.943	33543172.51	2907.000	35.482
2001	373.046	389.959	462.28 1	33335981.79	3227.000	31.800
2002	515.639	373.046	600.202	34612407.54	3306.000	32.937
2003	556.721	515.639	695.718	38867460.63	3683.000	36.297
2004	554.340	556.721	724.484	43770743	4432.000	44.379
2005	481.257	554.340	621.311	47385623.69	4618.000	60.876
2006	531.941	481.257	665.608	51306757	5480.000	71.490
2007	817.617	531.941	923.642	57793330.57	6042.000	74.522
2008	922.402	817.617	1223.575	63386360.63	5921.000	94.318
2009	707.877	922.402	879.814	60086989.44	6244.000	64.022
2010	900.833	707.877	1004.604	65906150.72	6684.000	79.041
2011	1014.085	900.833	1170.797	73241717	8226.000	93.720
2012	906.906	1014.085	1112.836	74802287	9405.000	95.297
2013	780.969	906.906	963.039	76924649.54	9031.000	94.856
2014	760.419	780.969	841.728	78870	9566.000	89.086
2015	637.834	760.419	775.354	74509719.33	10152.000	51.989
2016	746.827	637.834	862.799	75543542.61	8553.000	45.663

Appendix 9 Comparison Relevant Factor for Palm Oil Market

Equation	Factor	Applanaidu, Arshad, Shamsuddin & Yusop (2011)	Applanaidu.S, Abdel Hameed.A, Mohammed Arshad.F, & Shamsudin M (2009)	Egvuma, Shamsudin, Mohammed, Kamarulzamam. & Seng wong (2016)	Talib B & Darawi. Z (2002)	Arshad .F & Abdul Hameed .A (2012)	
Production	Production palm oil lagged one year						
	Produce Price of CPO						
	Producer Price of Substitute						
	Average lending rate %						
	Government Expenditure In agricultural development						
	Time trend as a proxy of Technological chance						
	Relative price of palm oil to rubber						
	Relative price of palm oil to rubber lagged three years						
	Rainfall						
	Relative price of palm oil to soybean oil						
Demand	Crude Palm Oil Domestic Demand Lagged one year						
	Domestic price palmoil						
	World price of soybean oil						
	Country population						
	Country GDP						
	Countrv GDP *per* capita						
	Real domestic price of coconut oil						
	Industrial production index						
	Export Demand of Palm Oil Lagged						

Export	Exchange Rate						
	World GDP						
	World Price of Soybean Oil						
	World Price of Palm Oil						
	World Population						
	Domestic price palm oil						
	Industrial Production Rate						
Import	World Price Palm Oil						
	Country GDP						
	Initial Stocks palm oil						
	World Price of Soybean Oil						
	Import Demand of Palm Oil Lagged						
	Relative Price Ratio (Import prices/Domestic Prices)						
	Domestic Price Palm Oil						
	Country Production Index						
World Price	World price of soybean						
	World GDP						
	World stock of palm oil						
	Petroleum Price						
	World Price Palm oil Lagged one year						
Biodiesel	Biodiesel Production						
	Biodiesel Blend Rate						
	Diesel Consumption						