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Impact of Biodiesel Blend Mandate (B10) on the Malaysian Palm Oil Industry

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ABSTRACT

Over the last ten years biofuels production has increased dramatically. One of the main factors is the rise in world oil prices, coupled with heightened interest in the abatement of greenhouse gas emissions and concerns about energy security. The increment in production has been driven by governmental interventions. In the US, the world's largest fuel ethanol producer, strong financial incentives are guaranteed for biofuel manufacturers. In the European Union, the world's largest biodiesel producer, biofuel consumption is mostly driven by blending mandates in both France and Germany. In the case of Malaysia, biodiesel started to be exported since 2006. The policy mandate of B5 blend of palm oil based biodiesel into diesel in all government vehicles was implemented in February 2009 and it is expected to be implemented nationwide by 2013. It is expected that the blend of B5 will be increased to B10 in future. This paper seeks to examine the impact of B10 on the Malaysian palm oil market. A structural econometric model consisting of eight structural equations and four identities was proposed in this study. The model has been estimated by two stage least squares method using annual data for the period 1976-2011. The specification of the structural model is based on a series of assumptions about general economic conditions, agricultural policies and technological change The study indicates that counterfactual simulation of an increase from B5 to B10 predicts a positive increase (12.05 per cent) in palm oil domestic consumption, 76.36 per cent decrease in stock, 156 per cent increase in domestic price of palm oil and a marginal (1.48 percent) increase in production. An increase in domestic demand would make Malaysia more competitive regionally and globally with benefits accruing to all Malaysians.

Keywords: Biodiesel blend mandate of B5, Biodiesel blend mandate of B10, Malaysian palm oil market, Simultaneous equations, Two stage least squares

INTRODUCTION

Over a few decades of development, the Malaysian palm oil industry has succeeded to be a powerful force in the global oils and fats economy. Investments in oil palm planting have been growing, because of its economic advantage, leading to expansion in output that surpassed the average global oils and fats growth. The National Economic Action Council (NEAC), in comparing the palm oil sector to the electrical and electronics (E&E) sector, has estimated that unless the E&E sector is dramatically upgraded, the palm oil sector could become a larger component than E&E in GDP contribution, rising in nominal terms to 12.2% of GDP by 2020. In terms of high income, the sector's share of real GDP can grow to 7.6% by 2020 if the value-added gains from efficiency and innovation can be realised. Palm oil exports could also grow by 7% per annum to RM84bil by 2020, and probably more if new oil palm products and services can be successfully marketed. The sector employs 590,000 direct workers versus 316,956 in the E&E sector.

As for sustainability, better R&D will help to improve productivity, better conservation of the environment and lower net carbon impact on operations has led to a sharp increase in biofuels production and related policy measures. The demand curve for biofuels was drawn through mandatory measures such as introducing legislation and subsidies. A number of countries have numerical targets for domestic consumption or production of biofuels. Brazil and United States (U.S.) succeeded in developing biofuel industries mainly because they have backed their industries with a variety of supportive policy measures especially for the use of ethanol. For instance, the U.S. is targeting 20 percent of ethanol to be blended with gasoline by 2030. The targets set by the European Union (EU) Biofuels Direction increased from two percent in 2005 to 5.75 percent by 2010 for biodiesel. By 2020, 10 percent of all conventional motor fuels in the EU will be replaced with biofuels. All these mandates were supported with massive subsidies and non-tariff protection by the U.S. and EU. The U.S. spends about USD 5.5-7.3 billion a year to support biofuel production, while EU subsidizes biofuel production to the tune of USD 4.6 billion (Fatimah, 2008)

The Association of South East Asian Nations (ASEAN) countries have also pushed the demand for biofuels through mandates and investment into the sector. The Indonesian government plans to replace 10 percent of its petroleum consumption with biofuel by 2020. Indonesia is expected to open up two to three million hectares of oil palm by end of 2010 to achieve these plans (Mamat, 2008). Thailand, in an effort to support the domestic sugar and cassava producers and also to reduce the cost of oil imports has mandated two percent biodiesel to be blended with diesel since February 2008 and also an ambitious 10 percent ethanol mix in gasoline starting in 2007. For a similar reason, the same blend (two percent) of biodiesel has been used in Philippines to support coconut growers.

In Malaysia, on 1st June 2011 biodiesel blending mandate, was launched in the federal administrative capital of Putrajaya. The mandate, requires diesel to contain 5 percent of biodiesel. The mandate is being implemented in Malaysia's central region initially, with Putrajaya to be followed by Malacca on July 1, Negeri Sembilan on August 1, Kuala Lumpur on September 1 and Selangor on October 1. The government, has allocated RM43.1 million (USD 14.3 million) to finance the development of in-line blending facilities at six petroleum depots in the region owned by Petronas, Shell, Esso, Chevron and Boustead Petroleum Marketing, through its Malaysian Palm Oil Board. The implementation of the B5 blending policy is expected to go nationwide by 2013, giving oil companies plenty of time to install blending facilities. B5, which was recently launched in Kuala Lumpur will be supplied to 247 petrol stations and 890 tonnes or 1.03 million litres of palm biodiesel would be used. B5 is selling for the same price as standard diesel (Platts, 2011).

Malaysia consumes 25,300,000 tonnes of petroleum in 2010 (Indexmundi, 2013). The production of palm oil is 16,993,717 tonnes whereas the export figure stood at 16,640,680 in 2010. By adding 5 percent biodiesel to diesel at pumps will cut about 1,265,000 tonnes of diesel (MPOB, 2013). Malaysia is poised to benefit from prospective implementation of B10 given her position as second major producer of palm oil. What happens if 10 percent of biodiesel blended with diesel at pumps? This study, therefore seeks to contribute to our understanding of the impact of B10 on the Malaysian palm oil market model especially on supply, demand and price.

Many studies have been conducted to investigate the palm oil market. As monitoring of any commodity market is an evolutionary procedure, especially the Malaysian palm oil market which has witnessed many recent developments, it is realized that a timely study to investigate the changes in market variables and the impact of these changes on the industry is very important. Thus, this paper reports the findings of an empirical study using a structural simultaneous equations model on the impact of changes in biodiesel blend mandate on the Malaysian palm oil market and to provide an updated tool for policy makers.

The remainder of the paper is organized as follows: In the literature review section, briefly reviews the literature on previous studies on palm oil industry and the methodologies used for examining the market variables behaviour, The following section are the model specification and results. While summary and some conclusions are presented in the last section.

LITERATURE REVIEW

The relatively simple generalized theoretical model widely has been applied to most of the agricultural commodities (such as palm oil, soybean oil, rubber and cocoa). In Malaysia, it also been applied to analyze and model the palm oil, rubber and cocoa markets. Previous work of Malaysian palm oil market was done by Mohamed (1988), Au and Boyd (1992), Mad Nasir and Fatimah (1992) and Basri and Zaimah (2002). There is also a study on factors affecting palm oil prices and forecasting palm oil prices using various techniques (Fatimah and Roslan, 1987; Mad Nasir, Mad Nasir, Zainal Abidin and Fatimah, 1988 and Mad Nasir et al., 1994). Mohamed (1988) incorporated export tax and exchange rate in his work. Later a study by Ramli, Mohd Nasir and Ahmad (1993) simulate the Malaysian palm oil market using the factors affecting palm oil in Malaysia. Mad Nasir et al. (1994) expanded the earlier works on palm oil model by differentiating supply response of estate and smallholder sectors and diversify nature of export market. Mohammd, Mohd Fauzi and Ramli (1999) have done a simulation of the impact of liberalization of crude palm oil imports from Indonesia. Basri and Zaimah (2002) carried out an economic analysis of the Malaysian palm oil market using annual data for the period 1970 and 1999. They identified the important factors that affect the market. The domestic features as well as imports and exports are included to measure its performance in the international trade. Mohammad and Tang (2001) have analysed the supply response of the Malaysian palm oil market using Engle and Granger (1987) cointegration and error correction approach. A study by Ramli, Rahman and Ayatollah (2007) on the impact of palm oil based biodiesel demand on palm oil price is a new attempt to include biodiesel demand in the price equation by using time varying parameter. The most recent study by Shri Dewi et al., (2011a) analysed the link between biodiesel demand and Malaysian palm oil market by using econometric method using annual data for the period 1976-2008. This study included the role of stationarity and cointegration as a prerequisite test before proceeding to the simultaneous equation estimation procedure. Further, Shri Dewi et al., (2011b) have extended the study by examining the link between biodiesel demand, petroleum prices and palm oil market.

A simulation study on the impact of the exchange rate variation was done by Mohammad, Shri Dewi and Anizah (2006). There is also a study on the impact of structural change of the Indonesian production on the Malaysian palm oil market (Shri Dewi, Mohammad and Anizah (2007) between 1976 and 2005. The study of the impact of liberalizing trade on Malaysian palm oil was done by Basri et al. (2007). Later, Shri Dewi and Mohammad (2009) analysed the rising importance of Indonesian palm oil production with the impact on the Malaysian palm oil market extending the previous study period in Shri Dewi et al. (2007) from 2005 till 2008. The latest study on the impact of biodiesel demand on the Malaysian palm oil industry by using simultaneous equations approach was done by Shri Dewi et al. (2011c) There are also studies using the application of a system dynamics approach to the Malaysian palm oil industry but it has been limited with the exception of Kennedy (2006) and Jahara et al. (2006). Both these studies examine the biodiesel, crude palm oil and petroleum price linkages.

In terms of biofuel mandates impact studies, mostly focused in European Union and United States. According to FAPRI (2007), examines the impact of increase in biofuel mandate to the level specified in Energy Saving Act of 2007 through 2015. The 15 billion gallon biofuel mandate results in a 2.6 billion gallon average increase in U.S. ethanol use in 2015, relative to the baseline. Most of the increase is supplied by an increase in production of U.S. corn-based ethanol. The mandate also leads to an increase in the producer prices for ethanol to generate the required level of ethanol supplies. The estimated increases are small in early years, as the required changes in ethanol supplies are modest relative to the baseline. While, in corn market the mandate caused an increase in corn used for ethanol production in 2015 relative to the baseline. This increase in corn demand results in higher corn prices, with the increase relative to the baseline reaching USD0.20 per bushel (6.6 percent) by 2015. Meanwhile, in soybean market, the mandate increases the demand for soybean oil to make biodiesel. This in turn reduces domestic demand for soybean meal. The net effect of the reduction in soybean production and the changes in product markets increases soybean price. Higher soybean prices, in turn contribute to reduction in soybean domestic use and export. In 2015, soybean crush reduces by 14 million bushel relative to the baseline, while export reduces by 32 million bushels.

Birur, Hertel and Tyner (2007), concludes that development in the U.S. and European Union (EU) biofuels market with the 5.75 percent biofuel mandate, were likely had significant and lasting impact on the global pattern of agricultural production and trade. Anderson and Coble (2010), investigate the potential impact of ethanol mandates on equilibrium corn prices and quantity, which focused on how the mandates influence market participant expectations. Results showed that due to the stochastic nature of supply and demand shocks, even a mandate that was technically nonbinding can have substantial impact on corn prices and quantities through the mandate's impact on the price responsiveness of demand from ethanol sector. The more responsive the corn quantity demanded is to the price of corn, the greater the impact on the market of restricting that response via a mandate. Results suggest that on average for the simulated outcomes, the price response associated with the Renewable Fuels Standard (RFS) mandate was about 6.5 percent greater with the elasticity of -2.75 than with the elasticity of -1.75.

Acheampong, Dicks and Adam, (2010) studied the impact of biofuel mandates and switchgrass production on hay markets. The RFS mandates will require 36 billion gallons of ethanol to be produced in 2022, 16 billion gallons of which is to be produced from cellulosic feedstocks. To meet the mandate, it is estimated that 24.7 million acres would be used to produced 109 millions tonnes of switchgrass in 2025. Since the majority of these acres likely would be converted from land currently producing hay, cattle production will be reduced. Thus the chronological impact of biofuel mandates on cattle market were linked by hay production and price.

Roberts and Schlenker (2010) used estimated elasticities to evaluate the impact of ethanol subsidies and mandates on world food commodity prices, quantities and food consumers' surplus. The U.S. ethanol mandate required about 5 percent of world caloric production from corn, wheat, rice and soyabeans used for ethanol generation. The results indicate that world food prices are predicted to increase by about 30 percent and global consumer surplus from food consumption is predicted to decrease by 155 billion dollars annually. The resulting expansion of agricultural growing area potentially offsets the CO_2 emission benefits from biodiesel.

Chen et al., (2011) examined the effect of biofuel mandates under the RFS alone and biofuel mandates with volumetric tax credits. This paper uses a dynamic, spatial, multimarket equilibrium model, Biofuel and Environmental Policy Analysis Model (BEPAM) to estimate the effect of these policies on cropland allocation, food and fuel prices and the mix of biofuels from corn and cellulosic feedstocks over the 2007–2022 period. The RFS leads to a 6 percent increase in total cropland (6.86 M ha); most of this is to enable an increase in corn production to produce the additional corn ethanol. The RFS also significantly effect production, exports and prices of crop and livestock commodities. The increase in demand for corn results in an increase in corn production in 2022 by 18 percent relative the Business As Usual (BAU). However, corn price in 2022 is still 24 percent higher than under the BAU because 38 percent of corn production in 2022 is used for biofuel production. Soybean and wheat prices in 2022 are also 20 percent and 7 percent higher than the BAU due to 8 percent reduction in their production level. The production of rice and cotton in 2022 would decrease by 8 percent and 2 percent, respectively, relative to the BAU due to the acreage shifts to the production of corn. This increases rice and cotton prices in 2022 by 5 percent and 2 percent relative to BAU.

Meanwhile, Betina and David (2012) investigate the impact of biofuel mandates in the EU and the U.S. agricultural market and on the environment were assessed under three trade scenario assumptions using a global general equilibrium model. The study found that the biofuel mandates resulted in important adjustments in global agricultural market sector and on the environment in terms of reduced carbon dioxide (CO2) emission. Those benefit were further enhanced if the mandate policy was accompanied by liberalization in biofuel trade. Trade liberalization then brought greater benefits to consumers in terms of lower fuel prices and greater reductions in CO2 emission, when sugarcane ethanol was traded. While, in agricultural sector it is beneficial for agricultural sector and farm producers.

To date, little research has specifically addressed biodiesel mandate impact in the Asian context especially in Malaysia. The former studies did not take into account Malaysian biofuel mandates and paid no attention on the impact of this mandate on the main endogenous Malaysian palm oil market variables. We will incorporate these factors into our analyses. Finally, we are unaware of any studies using more recent data in a simultaneous equation models to examine this mandate impact.

MODEL SPECIFICATION

The impact of biodiesel blend mandate on Malaysian palm oil market is measured by a system of equations that consists of structural econometric model of eight behavioral equations and four identities. A further explanation of the model are given in Mohammad et al., (1999), Shri Dewi et al., (2007), Shri Dewi et al., (2011a) and Shri Dewi et al., (2011c). The behavioural equations describe the determination of Malaysian palm oil supply, domestic consumption, palm oil exports, palm oil import and palm oil domestic prices. From the world perspective; rest of the world excess supply, world excess demand and world palm oil price are included. This model is closed with an identity defining ending period stock level, Malaysian excess supply, world excess supply and world stock (see TABLE 1).

It is useful to check the order and rank conditions of a model. Once the order and rank conditions are fulfilled, then the stationarity and cointegrating test will be carried out. All the variables in each of the equations are tested for stationarity and order of integration using Augmented Dickey-Fuller (1979), Phillips and Perron (1988) and Kwiatkowski, Phillips, Schmidt and Shin (1992) test. The cointegration and nonstationarity do not call for new estimation method or statistical inference. The conventional 2SLS methods for estimating and testing simultaneous equation models are still valid for structural models (Hsiao, 1997). Since the long run equilibrium is observed in the real world, there must be a cointegration when the time series are integrated together with the satisfaction in rank and order condition. As such, the Malaysian palm oil market model will be estimated using the procedures mentioned.

The direct effect of an increase from B5 to B10 on the Malaysian industry is through the palm oil domestic demand (DCCPO). We postulate a positive relationship between biodiesel blend mandate (BDDMAND) and domestic consumption. With an increase in the biodiesel blend mandate, indirect effects on the Malaysian palm oil industry are through the market clearing equation (ending stock). The increase in domestic consumption demand in turn decrease the Malaysian palm oil stock. A decrease in palm oil stock will lead to an increase in the palm oil prices which in turn leading to an increase in current CPO production. At the same time a decrease in Malaysian palm oil stock would also lead to a decrease in world ending stock. These changes resulted in an increase in the world CPO prices. The price for CPO is determined in the world market and the inclusion of BDDMAND is to test the significance of increasing in the biodiesel blend mandate on Malaysian palm oil market model. Dynamic responses are modelled using partial adjustment mechanisms.

This study utilised secondary data obtained from publications of the Department of Statistics of Malaysia, Malaysian Palm Oil Board (MPOB), Oil World and International Financial Statistics (IFS) of the International Monetary Fund (IMF) various editions. Annual data from 1976-2011 were used in this study.

ANALYSIS OF RESULTS

All the behavioural equations satisfied the order and condition for identification. The test of stationarity ADF, PP and KPSS showed that the residuals of the equations are stationary. The simultaneous equation framework was carried out to estimate the coefficients. The non-linear 2SLS estimates obtained from this study are quite satisfactory in terms of high R^2, significance of the coefficients of the variables and the correct signs (see TABLE 3). A modified 2SLS-Cochrane Orcutt procedure (see Pindyck and Rubinfeld, 1991 and Ramanathan, 1992) was subsequently used to estimate all equations because autocorrelation was found to be present. To detect heteroscedasticity, autocorrelation, non-normality other possible forms of model mis-specification were conducted in the various test. Disturbance terms in all equations were homoscedastic. Finally, the relevant Durbin Watson statistics (DW) and h-statistics showed that there was no autocorrelation problem.

The results suggest that the production of crude palm oil in Malaysia was determined by the ratio of its price with rubber, interest rate, government development expenditure on agriculture, time trend and lagged palm oil production. All of the estimated coefficients in the supply equation of palm oil have the expected signs. The relative price of palm oil and rubber lagged three years was significant at the ten percent level even though relative price was found not to be an important determinant of the palm oil production. An increase of one percent in the relative price of lagged three years leads to a 0.0001 percent increase in palm oil production. This finding is consistent with the finding in Mohammad et al., (2001), Mohammad and Tang (2005) and Shri Dewi et al., (2011a) study on supply response of Malaysian palm oil producers and a study by Remali et al., (1998) on Malaysian cocoa supply response. This reflects the importance of this variable at the time the investment was made. The interest rate variable was included to account for the cost of borrowing and it was found to be negative according to the theory.

The estimates obtained for the import demand are consistent with *a priori* expectations. As expected, Malaysian imports of CPO negatively related to the price of world palm oil but positively related to the price of soybean. The coefficient of the price of soybean was found to be negative and statistically significant. The coefficient of the Malaysian GDP was found to be positive and significant. The empirical estimates of world excess demand (world import) suggested that the primary factors affecting changes in world imports were world price, world price of soybean, world income and lagged one year of world import. The own price elasticity was estimated at 0.1050. This value was similar to the elasticity estimated by Mad Nasir et al., (1997) at 0.278. The world income was significant at five percent level and had the expected sign.

The domestic demand equation (domestic consumption) was based on Marshallian demand function. The domestic demand was empirically affected by the own price, Malaysian GDP and biodiesel blend mandate. All of the variables were significant at least at the five percent level. An examination of these results indicated that the export demand function has a reasonably good fit and all the variables have expected signs and significant coefficients. The coefficients for own and substitute prices and exchange rate were significant at least at five percent level. An increase in the price of rape seed oil by one percent would increase the palm oil export by 1.41 percent. This coefficient suggested that it is a substitute for export compared to price of soybean.

The rest of the world export was mainly determined by the production in the rest of the world. The production variable was significant at the five percent level. Eventhough the world price variable having the expected sign but it was not statistically significant. The coefficient of rest of the world export lagged one year also has the expected sign and statistically significant. The speed of adjustment shows that the adjustment to the desired level of rest of the world exports was 0.3267.

All the estimated coefficients in the domestic price equation have the expected signs. The price flexibilities with respect to stock and world price were -0.2878 and 7.9875, respectively. In the case of the equation for the palm oil world price, it was found that all the variables could explain the variation; price of soybean, world GDP, world stock and lagged dependent variable. All the variables are significant at least at 10 percent level.

Overall, the estimation results of the Malaysian palm oil market model were statistically acceptable. Some of the coefficients were found not to be significant but we retained them on a priori ground, *i.e*. we believe that the variables were relevant, but because of possible data and econometric problem, accurate estimates were not possible.

Simulation On An Increase In The Biodiesel Blend Mandate From B5 To B10

A counterfactual simulation of our model has been carried out to analyze the impact of an increase in the biodiesel blend demand on the Malaysian palm oil domestic demand. To gauge the impact of increasing trend in Malaysian biodiesel blend mandate, a counterfactual of 10 percent blend of Malaysian biodiesel demand from year 2006 to 2011 was imposed on the model. The counterfactual simulation of the model was carried out. The simulated values of all the endogeneous variables were compared to the baseline solutions. The counterfactual results are given in TABLE 4.

The model is able to simulate the impact of increase from B5 to B10 in palm-based biodiesel demand. The directions of response are in general, consistent with the predictions of the theory. The increase in biodiesel blend demand leads to an increase in domestic consumption about12.05 percent. The Malaysian palm oil stock (stock availability) would decrease by 76.36 percent. The domestic price increase is expected to be about 156 percent. Despite the significant increase in the CPO prices, the production response was low. The relatively low response was because of low price elasticity of supply (see also Fuad, 2004). As shown in Table 2, the production increased only by 1.48 percent. World stock is expected to decrease about 37.75 percent. A decrease in the world stock would increase the palm oil world price by 78.95 percent. An increase in palm oil world price would decrease export of palm oil by 5.02 percent.

CONCLUSIONS AND POLICY IMPLICATIONS

The econometric simulations suggest that the increase in the biodiesel blend demand does bring positive economic impact on selected sub-sectors of the palm oil industry especially the producers because of the significant increase in the domestic price of palm oil. It cannot be denied that the results in the counterfactual simulation of an increase in the blend mandate predicts a positive increase (12.05 per cent) in palm oil domestic consumption, 156 per cent increase in domestic price of palm oil and a marginal increase in production.

The high price was a boon to the industry participants, in particularly farmers who are smallholder palm oil producers. They will benefit from the high prices of palm oil. Since the smallholder sector which makes up 40 percent of oil palm planted areas in Malaysia, it is among crucial components in the country's palm oil industry. The efforts to improve productivity and income are in line with the goal of the Economic Transformation Programme to transform Malaysia into a high-income nation by 2020.

In terms of environment, the increase in the biodiesel mandate will improve air quality. Biodiesel helps to lower the greenhouse gas emissions compared to those of fossil fuels. Moreover, Malaysia is one of the signatory countries of the Kyoto Protocol and has ratified to reduce greenhouse gas emissions. The use of palm biodiesel would lower emissions of greenhouse gases by decreasing the use of fossil fuel.

The development of biodiesel industry not only serves as a method to reduce carbon emissions but also could promote economic growth in rural areas. It can be related to job creation. The biodiesel industry does not only need farmers, but also requires a broad range of expertise, including engineers, scientists, policy makers, economists and labourers.

However, the increase in the biodiesel blend mandate will encourage the upward pressure on the cooking oil prices. Using palm oil for fuel creates concerns over competition with food uses and raises this question of how far along that path Malaysia and the rest of the world can move.

The study also suggests that production of palm oil as a feedstock to biodiesel in Malaysia increases in response to the increase in the biodiesel blend mandate. However future expansion may be hindered because of land constraint and increasing cost of inputs such as labour, fertiliser and services. As Malaysia has opted to invest offshores, in a bid to reduce cost of production in ASEAN countries such as Indonesia, Papua New Guinea and lately in selected African countries.

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TABLE 1: Model Listing

Supply

[1] $POQ_t = f_1 (CPOPNRP_t, CPOPNRP_{t-3}, GOVDE_{t-3}, IR_{t-3}, T, POQ_{t-1})$

Malaysian Crude Palm Oil Import

[2] $CPOM_t = f_2 (POWP_t, PSB_t, GDP_t, STOCK_t, CPOM_{t-1})$

World Excess Demand (World Import)

[3] $WEXCDD_t = f_3 (POWP_t, PSB_t, WGDP_t, WSTOCK_t, WEXCDD_{t-1})$

Domestic Consumption

[4] $DCCPO_t = f_4 (CPOP_t, GDP_t, PSB_t, MPOP_t, BDDMAND_t, DCCPO_{t-1})$

Palm Oil Exports

[5] $EXDD_t = f_5 (POWP_t, PSB_t, PRSOt, WGDP_t, ER_t, WPOPt, EXDD_{t-1})$

Rest of the World Excess Supply (Rest of the world Export)

[6] $ROWEXCSS_t = f_6(POWP_t, ROWPOQ_t, ROWEXCSS_{t-1})$

CPO Domestic Prices

[7] $CPOP_t = f_7 (STOCK_t , POWP_t, CPOP_{t-1})$

CPO World Prices

[8] $POWP_t = f_8 (PSB_t, WGDP_t, WSTOCK_t, PCO_t, POWP_{t-1})$

Identities

Malaysian Palm Oil Ending Stock

[9] $STOCKPO_t = STOCKPO_{t-1} + POQ_t + CPOM_t - DCCPO_t - EXDD_t$

Malaysian Excess Supply

[10] $MEXCSS_t = POQ_t - DCCPO_t$

World Excess Supply

[11] $WEXCSS_t = MEXCSS_t + ROWEXCSS_t$

World Stock

[12] $WSTOCK_t = STOCKPO_t + ROWSTOCK_t$

Note: Definition and classification of variables are given in TABLE 2.

TABLE 2: Definition and Classification of Variables

Definition of Variables			
a.	**Endogenous Variables**		
1.	POQ_t	=	Palm oil production (tonnes)
2.	$CPOM_t$	=	Palm oil import (tonnes)
3.	$WEXCDD_t$	=	World excess demand (tonnes)
4.	$DCCPO_t$	=	Domestic consumption of palm oil (tonnes)
5.	$EXDD_t$	=	Export demand of palm oil (tonnes)
6.	$ROWEXCSS_t$	=	Rest of the world excess supply (tonnes)
7.	$CPOP_t$	=	Real domestic price of CPO (RM/tonne)
8.	$POWP_t$	=	Real world price of CPO (USD/tonne)
9.	$STOCK_t$	=	Malaysian ending stock (tonnes)
10.	$MEXCSS_t$	=	Malaysian excess supply (tonnes)
11.	$WEXCSS_t$	=	World excess supply (tonnes)
12.	$WSTOCK_t$	=	World stock (tonnes)
b.	**Exogenous Variables**		
1.	$CPOPNRP_t$	=	Relative price of CPO and natural rubber
2.	$CPOPNRP_{t-3}$	=	Relative price of CPO and natural rubber lag three years
3.	$GOVDE_{t-3}$	=	Government agricultural and rural development expenditure lag 3 years (RM million)
4.	IR_{t-3}	=	Interest rate lag three years (%)
5.	T_t	=	Time trend
6.	PSB_t	=	World price of soybean oil (USD/tonne)
7.	GDP_t	=	Malaysia GDP (RM million)
8.	$WGDP_t$	=	World income (USD million)
9.	$WSTOCK_t$	=	World stock of palm oil (tonnes)
10.	$MPOP_t$	=	Malaysian population (million people)
11.	$PRSO_t$	=	Real price of rapeseed oil (USD/tonnel)
12.	$GDPBD_t$	=	Biodiesel importing countries GDP (USD billion)
13.	ER_t	=	Exchange rate (RM/USD)
14.	PCO_t	=	Price of crude oil (USD/barrel)
15.	$WPOP_t$	=	World population (million people)
16.	$ROWPOQ_t$	=	Rest of the world production (tonnes)
17.	BDDMANDt	=	Biodiesel blend mandate (B5) (tonnes)
18.	$ROWSTOCK_t$	=	Rest of the world stock of palm oil (tonnes)
c.	**Predetermined Variables**		
1.	POQ_{t-1}	=	Malaysian production of CPO lag one year (tonnes)
2.	$CPOM_{t-1}$	=	Palm oil import lag one year (tonnes)
3.	$WEXCDD_{t-1}$	=	World excess demand lag one year (tonnes)
4.	$DCCPO_{t-1}$	=	Domestic Consumption lag 1 year (tonnes)
5.	$EXDD_{t-1}$	=	Export demand of palm oil lag 1 year (tonnes)
6.	$ROWEXCSS_{t-1}$	=	Rest of the world excess supply lag 1 year (tonnes)
7.	$CPOP_{t-1}$	=	Domestic price of CPO lag one year (RM/tonne)
8.	$POWP_{t-1}$	=	World price of palm oil lag 1 year (USD/tonne)
9.	$STOCK_{t-1}$	=	Stock one period lag (tonnes)

TABLE 3: Estimated Structural Equations

Supply

POQ$_t$ = -67.1519 + 194.5692CPOPNRP$_{t-3}$ + 0.2179GOVDE$_{t-3}$ – 46.7472IR$_{t-3}$ + 153.8780T +0.6939POQ$_{t-1}$
(-0.10) (2.16)** (1.75)* (-1.52) (2.15)** (4.22)***
$\bar{R}^2$ = 0.9644 F stat=360.33

Malaysian Import

CPOM$_t$ = -1486.62 – 465.508LPOWP$_t$ + 238.0557 LGDPM$_t$ + 825.7864LPSB$_t$ + 1.1868LCPOM$_{t-1}$
(-1.52) (-1.50) (2.15)** (2.45)** (1.086)
$\bar{R}^2$ = 0.5989 F stat=12.94

World Excess Demand (World Import)

WEXCDD$_t$ = -7663.75 – 2.9258POWP $_t$+ 308.7357+ 5.0244PSB$_t$ + 0.7374WEXCDD$_{t-1}$
(-2.27)** (-0.57) (2.52)** (1.97)* (5.64)***
$\bar{R}^2$ = 0.9824 F stat= 391.10

Domestic Consumption

LDCCPO$_t$ = 7.5929 - 0.0002CPOP$_t$ +7.1723GDPM$_t$ + 1.0771BDDMAND$_t$
(54.17) (-2.11)** (2.11)** (2.65)**
$\bar{R}^2$ =0.9316 F stat= 131.73

Export Demand

LEXDD$_t$ = 5.4138 – 1.2227LPOWP$_t$ + 1.4056LPRSO$_t$ + 1.8667LER$_t$
(4.34)*** (-2.50)** (2.88)** (4.49)***
$\bar{R}^2$ =0.6876 F stat= 21.27

Rest of the World Excess Supply (Rest of the world Export)

LROWEXCSS = -2.3088 - 0.0131LPOWP$_t$ + 0.6596LROWPOQ$_t$+ 0.6733LROWEXCSS$_{t-1}$
(-1.50) (-1.09) (2.26)** (5.11)
$\bar{R}^2$ =0.9435 F stat=161.28

Domestic Price

CPOP = -359.639 – 0.3773STOCKPO$_t$ +2.102POWP$_t$ + 0.1820CPOP$_{t-1}$
(-2.90)** (2.98)*** (7.48)*** (1.35)
$\bar{R}^2$ =0.8735 F stat=74.67

World Price

POWP = 232.531+0.9166PSB$_t$+10.5853WGDP$_t$ - 0.0752WSTOCK$_t$ + 0.1911POWP $_{t-1}$
(-1.76) (13.03)*** (1.91)* (-2.59)** (2.21)**
$\bar{R}^2$ =0.9327 F stat=111.92

Identities

STOCKPO$_t$ = STOCKPO$_{t-1}$ + POQ$_t$ + CPOM$_t$ –DCCPO$_t$ –EXDD$_t$
MEXCSS$_t$ = POQ$_t$ - DCCPO$_t$
WEXCSS$_t$ = MEXCSS$_t$ + ROWEXCSS$_t$
WSTOCK = STOCKPO$_t$ + ROWSTOCK$_t$

Note: Number in parentheses are t-values.
*** Significant at 1 percent level
** Significant at 5 percent level
* Significant at 10 percent level

TABLE 4: Impact of Increase in Biodiesel Blend Mandate from B5 to B10 (Counterfactual Analysis)

Variables	**The effects of increase in biodiesel blend mandate from B5 to B10**
Domestic Consumption	12.05
Malaysian Palm Stock	-76.36
Domestic Price	156
Palm oil Production	1.48
World Stock	-37.75
Palm Oil World Price	78.95
Export of Palm Oil	-5.02