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# THE IMPACT OF BIODIESEL DEMAND ON THE MALAYSIAN PALM OIL MARKET

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*ABSTRACT*

In the last few years, the increase in fossil-based energy prices have resulted in some countries to look for bio-based alternative energies which lead to the increase in demand for bio-based feedstocks such as palm and rapeseed oil (for bio-diesel) and sugar cane and corn (for ethanol). This phenomenon has added a new dimension in the fats and oils market model particularly palm oil. This paper seeks to examine the impact of rising biodiesel demand on Malaysian palm oil industry. An estimated structural econometric model of the Malaysian palm oil industry using annual data for the period 1980-2007 was used to simulate the effect of increase in Malaysian biodiesel demand. The estimation method used is non linear Two Stage Least Squares (2SLS). A counterfactual analysis of a sustained 70 percent increase in Malaysian biodiesel demand predicts a direct effect of a 0.36 percent in Malaysian export demand of palm oil. The indirect effects via the export demand transmission channels are: 142.6 percent decrease in stock, 21.86 percent increase in supply, 109.74 percent increase in CPO price, 9.84 percent decrease in domestic consumption and there is also 0.04 percent increase in world price. The higher price would be disadvantage to biodiesel producers as CPO is the main feedstock for biodiesel. The higher cost passed on to downstream industry making Malaysia less competitive in export market.

*Keywords:* palm oil price; biodiesel; supply; demand; counterfactual analysis.

## 1. The Alternative Energy Market of Biodiesel: The Case of Malaysia

First triggered by the oil shocks of the 1970s, production of biofuels[1] mainly ethanol, grew rapidly for a while but then stood still during the 1990s. After 2000, however, it began to gain momentum driven by a number of interacting factors. The recent price hikes and extreme volatility crude oil prices have been a major driving force leading energy dependent economies, particularly in developed world, to seek alternative energy. The crude oil price volatility reached its peak in mid 2008 when it hit an all time high price at USD133 per barrel. However, by November 2008, the price has subsided to USD 54 per barrel (IMF, 2009).

The other factor is the disruption in oil supply. Previously, two periods of high energy prices; 1972-73 and 1980-81 were precipated by the supply disruptions. During these periods, oil shocks were triggered by supply disruptions in the Organisation of Petroleum Exporting Countries (OPEC), Iran revolution, the invasion of Kuwait by Iraq. This time, although supply threats remain persistent in the form of Russia’s pipeline, Iran’s impeding nuclear program, the high volatility of crude oil prices also caused by demand especially from China and India outstripping supply rather than production disruptions (Shane, 2007).

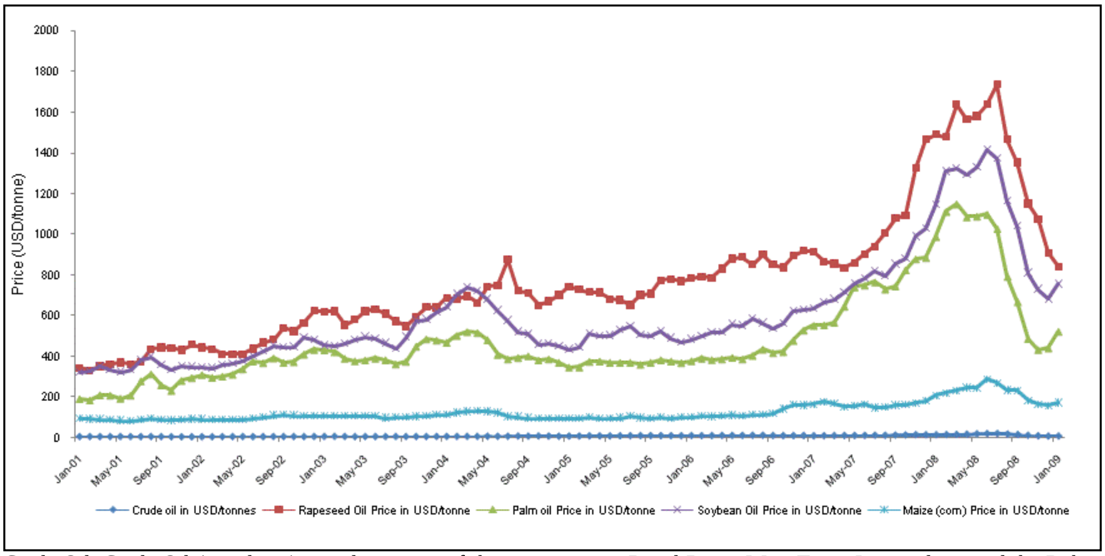
[1] There are two types of biofuels, bioethanol and biodiesel. Bioethanol is produced from carbohydrates such as sugarcane, corn, beet, wheat and sorghum while biodiesel is made from oils such as rapeseed, sunflower, soybean and palm oil (Kleffmann, 2007).

The environmental concerns that have risen in the past few years that led to the establishment of the Kyoto Protocol, an international and legally binding treaty to reduce greenhouse gas (GHG) emissions worldwide, is another factor pushing biofuel demand up. According to this treaty, industrialized countries agreed to reduce their collective GHG emissions by 5.2% compared to the year 1990 by the commitment period of 2008-2010.

The demand curve for biofuels was drawn through mandates and subsidies. Brazil and U.S succeeded in developing biofuel industries as they have supported their industries with a variety of policy measures especially for ethanol. In terms of ethanol, the U.S is targeting 20 percent by 2030. The targets set by the European Union (EU) Biofuels Direction increased from 2 percent in 2005 to 5.75 percent by 2010 for biodiesel. All these mandates were supported with massive subsidies and non-tariff protection by the U.S and EU. The U.S spent about USD 5.5 billion to USD 7.3 billion a year to support the biofuel production. The EU subsidies on biofuel production comes to the tune of USD 4.6 billion (Arshad, 2008). The ASEAN countries have also pushed the demand for biofuels further through mandates and investment into the sector. The Indonesian government set to replace 10 percent of its petroleum consumption with biofuel by 2020, starting from January 2009. Indonesia is expected to open up 2 to 3 million hectares of oil palm by 2010 to achieve these plans (Mamat, 2008). Although, Malaysia started to export biodiesel since year 2006, the policy mandate of B5 blend of palm oil based biodiesel into diesel in all government vehicles was only implemented in February 2009.

The prices of biofuels feedstock such as palm, soybean, rapeseed oils and maize are now moving in tandem with the crude oil prices (Figure 1). This is because as the price of crude oil increases, the demand for biofuel feedstocks will follow suit as consumers are looking for an alternative energy. The correlation coefficient also supports the presence of positive relationship between crude oil and the vegetable oils. The correlation coefficients for the period of January 2005 to January 2009 show a strong positive relationship between crude oil and the vegetable oils prices (crude oil and rapeseed oil, 0.92; crude oil and palm oil, 0.85; crude oil and soybean oil, 0.90; crude oil and maize, 0.83), compared to those in January 2000 to December 2004 (crude oil and rapeseed oil, 0.62; crude oil and palm oil, 0.41; crude oil and soybean oil, 0.50; crude oil and maize, 0.31).

The production of crude palm oil in Malaysia continued to increase for 10 consecutive years reaching 18 million tonnes in 2008, 190 percent higher than in 1990. This impressive production growth was mainly achieved through increasing matured areas, recovery in fresh fruit bunches yield to 20 tonnes per hectare from the biological stress last year and continued improvement in the national average oil extraction rate (OER) to 20 percent. The total oil palm planted area in the country increased 121 percent between 1990 and 2008. In the nearer term, there is an increase of 4.3 percent to 4.48 million hectares in 2008 compared to the previous year. The year end closing stock increased 19 percent in 2008, compared to the previous year because of the higher supply growth (MPOB, 2009).




Crude Oil: Crude Oil (petroleum), simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai , USD per tonne; Rapeseed oil: Crude, fob Rotterdam; Palm oil: Malaysia Palm Oil Futures (first contract forward), 4-5 percent FFA, USD per metric tonne; Soybean Oil: Soybean Oil, Chicago Soybean Oil Futures (first contract forward) exchange approved grades, US$ per metric tonne;
Maize (Corn): U.S. No. 2 Yellow, FOB Gulf of Mexico, U.S price, USD per metric tonne
Source: ISTA Mielke GmbH, Oil World, various isues; International Monetary Fund, 2009.

Figure 1: Prices of Crude Oil, Maize, Palm Oil, Soybean Oil and Rapeseed Oil, January 2001 – January 2009 (USD per tonne)

While the supply shows a tremendous increase combined with escalating oil prices, the CPO prices declined. Even though the CPO prices increased in 2008 as compared to their 2007 level, they experienced an extreme price fluctuations over the year, with the highest month average in March 2008 (RM3,695 per tonne) and the lowest in November (RM 1,520.50 per tonne). During the first half of the year trading was above RM 3,500 per tonne where this level was supported by higher crude oil prices, demand for biodiesel, tight global vegetable oils situation and higher vegetable oil prices. However, towards the end of the year there was a sharp decline in CPO prices as well as other vegetables oil prices, high palm oil stocks, global financial crisis and fear of global recession results the price to fall below RM 2000 (MPOB, 2009).

Malaysia is the second world leading palm oil producer after Indonesia. The move to produce palm-diesel will expand the domestic (through mandatory target) and export market for palm oil. Recently, the Prime Minister of Malaysia announced a blend 5 percent biodiesel together with 95 percent diesel to be used by all the government vehicles by February 2009. Its use will be extended to industrial and transportation sectors with the full regulation by 2010. On this basis in Malaysia, biodiesel is considered as a price leverage mechanism by many stakeholders. This is to stabilize the palm oil prices and at the same time reduce the dependency on crude oil. The action to invest in biodiesel will help to achieve multi-prong objectives. In addition, the introduction of biodiesel as an alternative fuel for transportation will help economy in reducing diesel import. Malaysia consumes 500,000 barrels per day (bpd) of crude oil, blending 5 percent diesel at pumps will cut about 25,000 bpd of crude oil. Besides Malaysia, there are also other countries that implemented the similar legislation.

Palm oil has good potential as a feedstock for biodiesel production as it is a strong competitor with other biodiesel feedstock crops in terms of fuel yield per acre (4751 liter per hectare compared with 523 liter per hectare for soybean oil, and 954 liter per hectare for rapeseed oil). Malaysia has started to export biodiesel since 2006 to the major exporters (U.S and EU). The Malaysian biodiesel production has increased from 54,981 tonnes in 2006 to 171,554 tonnes in 2008, indicating an increase of 212 percent (MPOB, 2009).

The development of the palm based biodiesel industry in Malaysia and world-wide has added a new dimension in the Malaysian palm oil market model. Previously, crude oil entered the palm oil supply sector (particularly the aggregate production function) through the use of various energy-intensive inputs (such as fertilizer and fuel) and also transportation. The new relationship between crude oil and palm-based feedstock prices have to be embedded into the market equations of this commodity, an exercise where the previous studies have not examined thus far**.** Hence, the conventional market model for palm oil has to be adjusted. None of the previous studies tried to embede the biodiesel demand and the relationship with crude oil as one of the equation to absorb more of this oil as future fuel feedstock. The objective of the study is to investigate the effect of biodiesel demand on the Malaysian palm oil market.

## 2. 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 market. In terms of palm oil, the structure is refined to ease the penetration in the international market. Previous work of Malaysian palm oil market was done by Yusoff (1988), Au and Boyd (1992), Shamsudin and Arshad (1993) and Talib and Darawi (2002). There is also a study on factors affecting palm oil prices and forecasting palm oil prices using various techniques (Arshad and Ghaffar, 1987; Shamsudin, Mohamed and Arshad, 1988 and Shamsudin, Arshad, Mohamed and Lubis, 1994). Yusoff (1988) incorporated export tax and exchange rate in his work. Later a study by Abdullah, Amiruddin and Ibrahim (1993) simulate the Malaysian palm oil market using all the factors affecting palm oil in Malaysia. Shamsudin 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. Alias, Jani and Abdullah (1999) have done a simulation study of the impact of liberalization of crude palm oil imports from Indonesia. Description of the national model on Malaysian palm oil market between 1970 and 1999 by identifying the important factors that affecting the market was done by Talib and Darawi (2002). The domestic features as well as imports and exports are included to measure its performance in the international trade. Another simulation study on the impact of the exchange rate variation was done by Alias, Shri Dewi and Ali et al. (2006). Most of the previous Malaysian palm oil studies (Abdullah et al., 1993; Talib and Darawi, 2002; Alias et al. 2006; Shri Dewi et al., 2007 and Talib et al., 2007) ignored the importance of the phenomenon known as nonstationary time series in econometrics as a prerequisite test before proceeding to the simultaneous equation estimation procedure. Over the time, most of the macroeconomic variables show a trending behaviour. This phenomenon is known as nonstationary time series in econometrics. There might be spurious regression due to the presence of non-stationary variables (Granger and Newbold, 1974). A spurious regression is the results without any economic meaning which "look good" might have a high $R^2$, low Durbin Watson (DW) statistics and the t statistics appear to be misleading. It is inappropriate to make any valid statistical inference with the nonstationary data. The importance of this test was highlighted by Hsioa (1997a and 1997b), Robledo (2002) and Song (2006).

Many standard supply, demand, price and stock equations linking the production and biofuel demand to the agricultural commodity market have been estimated over the last one decade or so with conspicuous empirical success. In terms of biofuel impact studies, a number of different model specifications have appeared in the literature and some of these were reported by Taylor, Mattson, Andino and Koo (2006) and Park and Fortenbery (2007). Most of the studies linking biofuel demand using annual crops compared to perennial crops. Therefore, there are now an accepted part of most policy and applied academic work. Besides these study there are also other studies on biofuel impact studies (FAPRI, 2001 and 2005; Urbanchuk, 2001; Gustafson, 2002; Ferris and Joshi, 2004 and Abdullah, Abas and Ayatollah, 2007) that are relevant to this study.

Yahaya, Ahmad and Kennedy (2006) described the impact of biodiesel growth on the Malaysian palm oil industry using system dynamics model.

## 3. Model Specification

The structural econometric model of the Malaysian palm oil industry specified in this study consist of five behavioral equations and one identity (Table 1). A further explanation of the model are given in Shri Dewi et al. (2008), Shri Dewi et al. (2003) and Mohammad et al. (1999). The behavioural equations describe the determination of crude palm oil (CPO) supply, domestic consumption, CPO exports, CPO domestic prices and CPO world prices. This model is closed with an identity defining ending period stock level.

It is useful to check the order and rank conditions of a model. Once the order and rank condition is fulfilled, then the cointegrating test will be carried out. Exogenous variables are generated by an integrated process. In the case of nonstationary exogenous variables, this will result to nonstationarity in endogenous variables too. Also endogenous variables are generated by autoregression linear or nonlinear function of lags of endogenous variables and levels of exogenous variables whom there have cointegration relations in a simultaneous equation models (Hsiao, 1997b). Hsioa's study also showed that, the least square estimator for the long run reduced form are consistent in the 2SLS and 3SLS estimators. It is optimal to estimate the long run simultaneous equation by 2SLS if there are G (endogenous variables) cointegrating relations and integrated variables. 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, 1997b). 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 in biodiesel demand on the Malaysian industry is through the CPO exports (equation 3). We postulate a positive relationship between biodiesel demand (BDDD) and CPO exports (XPO). This relationship assumes other factors remaining constant. It is acknowledged that there are other factors such as the link between biodiesel demand and crude petroleum prices and the shortage of corn oil for food and etc. With an increase in BDDD, indirect effects on the Malaysia palm oil industry are through the price transmission channel of CPO exports (equation 3). The increase in CPO exports in turn decreases the stock of CPO. A decrease in CPO stock increases the CPO prices. An increase in CPOP can be viewed as a effect on two parties that is from the perspective of producers of CPO and also from the perspective of biodiesel producers.

From the CPO producers' perspective, a higher domestic price of CPO would lead to a higher income, *ceteris paribus*. The higher price would however be loss to biodiesel producers as CPO is the main feedstock to produce biodiesel. An increase in the CPOP would lead to a higher cost of biodiesel production. The higher cost if passed on to downstream industries making Malaysia less competitive in the export market (equation 3). The price for CPO is determined in the world market and the inclusion of BDDD is to test the significance of increasing Malaysian biodiesel demand in price determination. Dynamic responses are modelled using partial adjustment mechanisms. The interrelationships among the variables of the model are depicted in Figure 2.

Table 1: Model Listing

**1.1. Supply**

[1] $lnCPOQ_t = f_1 (lnCPOP_t, lnCPOP_{t-3}, lnGOVDE_{t-4}, T, lnIR_{t-3}, lnCPOQ_{t-1},)$

**1.2. Domestic Consumption**

[2] $DCOP_t = f_2 (CPOP_t, GDP, T, PSB_t, MPOP_t, DCPOP_{t-1})$

**CPO Exports**

[3] $lnXPO_t = f_3 (lnPOWP_t, lnPSB_t, lnGDPPK_t, lne, T, DUM, lnPCO_{t-1}, lnBDDD, lnXPO_{t-1})$

**1.3. CPO Domestic Prices**

[4] $CPOP_t = f_4 (STOCK_t, T, PSB_t, CPOQ_{t-1}, POWP_t, CU_t, CPOPt_{-1})$

**1.4. CPO World Prices**

[5] $lnPOWP_t = f_5 (lnPSB_t, lnWGDP_t, T, lnWSTOCK_t, lnPOWP_{t-1})$

**Identity**

**Stock**

[6] $STOCK_t = STOCK_{t-1} + CPOQ_t + CPOM_t – DCOP_t – XPO_t$

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

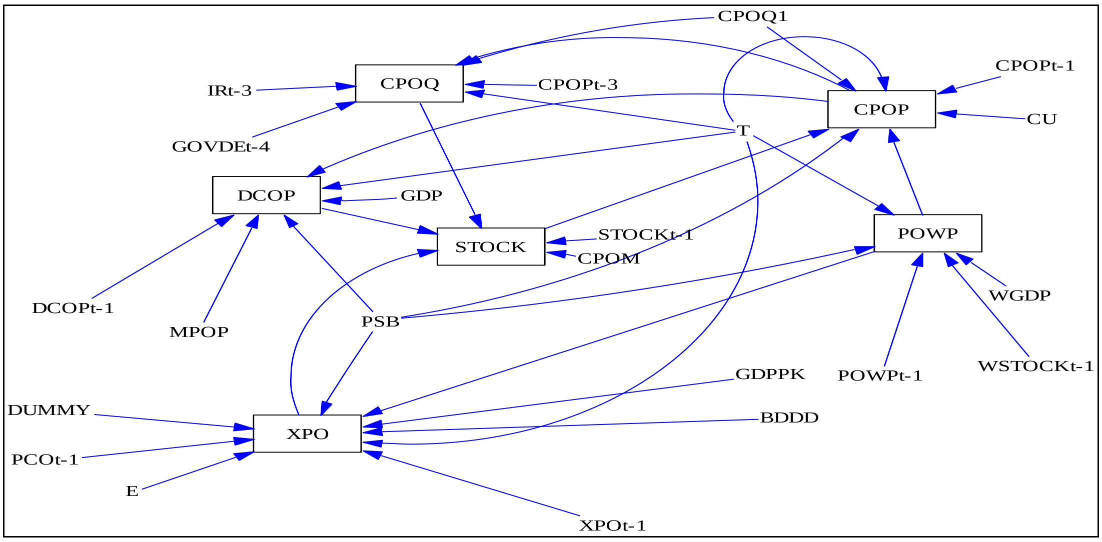



Figure 2: Full Causal Loop Diagram for the Malaysian Palm Oil Market

Table 2: Definition and Classification of Variables

| | |
|---|---|
| **a. Endogenous Variables** | |
| 1. CPOQ | = Malaysian production of CPO (′000 metric tons) |
| 2. DCOP | = Domestic consumption of palm oil (′000 metric tons) |
| 3. XPO | = Malaysian exports of palm oil (′000 metric tons) |
| 4. CPOP | = Domestic price of CPO (RM $t^{-1}$) |
| 5. POWP | = World price of CPO (US$ $t^{-1}$ ) |
| 7. STOCK | = Ending stock for the current year (′000 metric tons) |
| **b. Exogenous Variables** | |
| 1. $GOVDE_{t-4}$ | = Government agricultural and rural development expenditure (RM million) |
| 2. T | = Time trend variable (year) |
| 3. GDP | = Gross Domestic Product (base year 2000) |
| 4. PSB | = World price of soybean (US$) |
| 5. GDPPK | = GDPPK income for palm oil importing countries from Malaysia (USD) |
| 6. e | = Exchange rate (RM/US$) |
| 7. CPOM | = Malaysian imports of CPO (′000 metric tons) |
| 8. CU | = Refining sector capacity utilization (percent) |
| 9. MPOP | = Malaysian population (Millions) |
| 10. DUM | = Dummy variable representing export of biodiesel from Malaysia |
| 11. BDDD | = Biodiesel demand from Malaysia (tonnes) |
| 12. WGDP | = World Gross Domestic Product (USD billion) |
| **c. Predetermined Variables** | |
| 1. $CPOP_{t-1}$ | = Domestic Price of CPO lag one year (RM $t^{-1}$) |
| 2. $CPOP_{t-3}$ | = DOMESTIC Price of CPO lag three years (RM $t^{-1}$) |
| 3. $CPOQ_{t-1}$ | = Malaysian production of CPO lag one year (′000 metric tons) |
| 4. $XPO_{t-1}$ | = Malaysian exports of processed palm oil lag 1 year (′000 metric tons) |
| 5. $WSTOCK_{t-1}$ | = World stock of CPO lag one year (′000 metric tons) |
| 6. $DCOP_{t-1}$ | = Domestic consumption of palm oil lag one year (′000 metric tons) |
| 7. $POWP_{t-1}$ | = World price of CPO lag one year (US$ $t^{-1}$) |
| 8. $STOCK_{t-1}$ | = Domestic stock lag one year (′000 metric tons) |

The primary sources of data used to estimate the econometric model are obtained from Malaysian Palm Oil Board (MPOB) and International Financial Statistics of the International Monetary Fund. Annual data for the period 1980 to 2007 are used. Based on the rules for identification, the structural equations satisfy both the order and rank condition. The six endogeneous variables, eleven exogenous variables and eight predetermined variables are represented in Table 2 respectively.

## 4. Findings

The estimates of the structural model are given in Table 3**.** The non linear Two Stage Least Squares (2SLS) results obtained are quite satisfactory in terms of high $R^2$, significance of the coefficients of the variables and that the signs of the coefficients are consistent with *a priori* expectations.

The results suggest that supply of CPO (CPOQ) are determined by price of CPO lag three years ($CPOP_{t-3}$) and time trend (T). All of the estimated coefficients in the supply equation of palm oil have the expected signs. Price of CPO lag three years is negatively associated with the supply of palm oil. It is significant at the five percent level. A one percent increase in the CPO price lag three periods ago leads to a 0.10 percent increase in the current supply. The time trend (T) is significant at the one percent level, suggesting CPO production is trending upward due to three plausible factors. First, the producers' preference for oil palm relative to natural rubber and cocoa in terms of land use. Secondly, it is due to the biodiesel demand an d finally technology innovation in cultivation, management and development of high yeilding also contributed to the increase in palm oil production.

The domestic demand equation in this research is based on Marshallian demand function. The domestic demand empirically affected by domestic palm oil price, time trend and lagged one period of domestic demand. All of the variables are significant at least at the 10 percent level. This equation indicates that a low price of palm oil would encourage domestic consumption. The positive coefficient of the time trend shows that the domestic demand is trending upward. The coefficient of lagged domestic demand also significant indicating that lagged adjustment model is appropriate. The adjustment coefficient 0.5402 suggesting that adjustment to the desired level of domestic consumption is rapid at about 54 percent per year. The results are consistent with the earlier studies such as that by Mohammed (1988), Mohammad et al., (1999), Mad Nasir et al., (1988) and Shri Dewi et al., (2007).

The export demand function are determined by palm oil world price (POWP), price of soybean (PSB), biodiesel demand (BDDD) and also price of crude oil lag one year (PCO1). All the coefficients are significant at the one percent level. For the export demand, the elasticities with respect to the POWP, PSB, BDDD and PO1 are -0.4689, 0.3911, 0.1277 and -0.0646 respectively. The BDDD variable is included as aproxy to model the effect of rising importance of BDDD in Malaysia on Malaysian palm oil industry. The effect is modelled indirectly in export demand and CPO nexus.

The estimated CPO domestic price equation (CPOP) suggests that it is significantly influenced by the Malaysian palm oil stock (STOCK), world price (POWP) and capacity utilization (CU). There is negative relationship between STOCK and CPO domestic price while POWP has a positive sign and significant at 1 percent level. There is a negative relationship between CU and CPOP eventhough it is not significant. An increase in CU as a results of a fall in refining capacity will result in a drop in CPOP. The underlying theory is that with a fall in refining capacity, there is less competition for crude palm oil from the refiners. The estimation results for POWP indicate that price of soybean has a dominant effect on palm oil world price. This is because soybean oil is palm oil's main substitute. The soybean oil coefficient is significant at the one percent level. We have retained explanatory variables that are found to be insignificant in the estimated model. We retained them on a priori ground, i.e we believe that the variables are relevant, but because of possible data and econometric problem, accurate estimates are not possible. The model also able to simulate better the historical values of the endogenous variable, that is also the purpose we retained them (Pyndyck and Rubinfeld, 1998).

Table 3: Non Linear 2SLS Estimation Results

**Supply**

$\widehat{\ln CPOQ_t} = 8.3476 + 0.1006\ln CPOP_{t-3} + 0.0633T$

(28.23)*** (2.24)** (34.88)***

$R^2 = 0.9866$ DW = 1.5389

**Domestic Consumption**

$\widehat{DCOP_t} = -107.662 - 0.3610CPOP_t + 181.0055T + 0.6358DCOP_{t-1}$

(-0.34) (-1.97)** (3.24)*** (3.38) ***

$R^2 = 0.9895$ h=2.0822

**Export Demand**

$\widehat{\ln XPO_t} = 8.8016 - 0.4689\ln POWP_t + 0.39111\ln PSB_t + 0.1277\ln BDDD - 0.0646\ln PCO_{t-1}$

(43.46)*** (-7.21)*** (4.56)*** (58.22) *** (-2.63)***

$R^2 = 0.9951$ DW = 1.8320

**Domestic Price**

$\widehat{CPOP_t} = -275.012 - 0.8037STOCK_t + 2.9805POWP_t - 424.036CU_t$

(-0.74) (-2.73)** (6.60)*** (-0.58)

$R^2 = 0.7800$ DW = 1.2729

**World Price**

$\widehat{POWP_t} = -19.1818 + 1.0225PSB_t - 0.0172WSTOCK_t$

(-0.41) (11.73)*** (-1.92)*

$R^2 = 0.8639$ DW = 0.9274

**Identities**

**Stock:** $STOCK_t = STOCK_{t-1} + CPOQ_t + CPOM_t - DCOP_t - XCPO_t$

t ratio in bracket, ( )
*** Significant at 1 percent level
** Significant at 5 percent level
* Significant at 10 percent level

## 4.1 *Simulation on a Sustained 70% increase in Biodiesel Demand*

Baseline simulation values were developed from the model based on the historical data for the period 1980-2007. To gauge the impact of increasing trend in Malaysian biodiesel demand, a counterfactual 70 percent increase in Malaysian biodiesel demand from year 2000 to 2007 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.

Table 4: Simulation Average Value (1980-2007) for all the Endogenous Variables and Baseline Compared to 70% Increase in Indonesian Production

| Variables | Baseline | Increase in Biodiesel Demand | Percentage Change |
|---|---|---|---|
| XPO | 7,699.0 | 7,727 | 0.36 |
| STOCK | 575.0 | -244.8 | -142.6 |
| CPOP | 590.6 | 1,238.7 | 109.74 |
| CPOQ | 8,677.9 | 10,574.7 | 21.86 |
| DCOP | 9,149 | 8,329.2 | -9.84 |
| POWP | 457.4 | 457.6 | 0.04 |

The model is able to simulate the impact of 70 percent increase in Malaysian biodiesel demand. The directions of response are in general, consistent with the predictions of the theory. The increase of 70 percent in biodiesel demand leads to an increase in XPO. The XPO increase is expected is expected to be about 0.36 percent. The relatively low response is beacause of the inelastic response of export demand due to an increase in BDDD (see estimated structural equation for export demand). The elasticity of 0.1277 indicates that the one percent increase in BDDD leads to 0.1277 percent increase in XPO.

The increase in export demand leads to a 142.6 percent decrease in STOCK. This in turn leads to an increase in CPOP. The increase in CPOP is a loss to biodiesel producers but a boon to CPO producers. CPOP is expected to rise by 21.86 percent. This is due to the government plan to increase the palntation of oil palm as a move to provide more feedstock for biodiesel. The increase in CPO decreases the DCOP. DCOP is expected to decrase by 9.84 percent. The decrease in STOCK by 142.6 percent leads to an indirect effect from the increase in XPO. As shown by the STOCK identity a current increase in XPO will lead to contraction in ending STOCK. XPO is treated as a disappearence in stocks. As there is no domestic price effect on world price so ther is no indirect effect from the increase in biodiesel production on the world price.

## 5. Conclusion

A counterfactual analysis of a sustained 70 percent increase in Malaysian biodiesel demand predicts a direct effect of a 0.36 percent in Malaysian export demand of palm oil. The indirect effects via the export demand transmission channels are: 142.6 percent decrease in stock, 21.86 percent increase in supply, 109.74 percent increase in CPO price, 9.84 percent decrease in domestic consumption and there is also 0.04 percent increase in world price. The higher price would be disadvantage to biodiesel producers as CPO is the main feedstock for biodiesel. The higher cost passed on to downstream industry making Malaysia less competitive in export market. To more fully understand the overall impact of biodiesel demand on supply, demand, price and stock of Malaysian palm oil market, future research includes measuring the impact of this demand by combining the econometric and system dynamics modeling approach as it is seen as the best way to deal with multiple feedback loops.

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