

The Relationship among Petroleum Prices, Biodiesel Demand, and Malaysian Palm Oil Prices: Evidence from Simultaneous Equation Approach

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Abstract

The prices of petroleum and palm oil appear to be moving in tandem, a trend that has not been observed before. Oil prices are thought to have a direct effect on agricultural prices. This paper examines the relationship among world petroleum prices, biodiesel demand, and palm oil prices in Malaysia. To this end, a market model is formulated, representing palm oil supply, import, world excess demand, domestic consumption, export demand, rest-of-the-world excess supply, and palm oil prices. Using annual data for the period 1976–2010, a system of equations of eight structural equations and four identities is estimated through the two-stage least squares (2SLS) method. The simultaneous equation results suggest that world petroleum price significantly affects world palm oil price. Hence, our results support neutrality of palm oil commodity markets in Malaysia to direct effects of oil price changes. The elasticity of Malaysian palm oil domestic price with respect to biodiesel demand is then obtained. Results suggest that biodiesel demand has a positive impact on the Malaysian palm oil domestic price. Thus, significant growth in biodiesel demand is important in explaining Malaysian palm oil price determination.

Keywords: biodiesel demand; domestic price; simultaneous equations; world petroleum price; world price of palm oil

Acronyms:

2SLS	– two-stage least squares
ASEAN	– Association of Southeast Asian Nations
CBOT	– Chicago Board of Trade
EU	– European Union
GHG	– greenhouse gas
OPEC	– Organisation of Petroleum Exporting Countries
RM	– Malaysian ringgit
SEM	– structural econometric model
USD	– United States dollar

Introduction

Over a few decades of development, the Malaysian palm oil industry has succeeded in becoming 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. Malaysia now tops the list of the palm oil exporters, with the export figure of 16.7 million tonnes in 2010 (MPOB, 2011). Importers prefer Malaysian palm oil due to its competitive price, its superior attributes for various edible and nonedible applications, and its secure supply availability. The palm oil industry also plays a significant role in the Malaysian economy as it accounts for two-thirds of the country's agricultural export value and about one-third of its commodity export value (Bank Negara Malaysia, 2009). In 2009, exports rose to USD 10.1 billion, capturing about 7% of total exports.

Many energy-dependent economies, particularly those in developed countries, are seeking alternative energy sources due to recent price hikes and extreme volatility of crude oil prices and the rising concern for the environment. In mid-2008, the crude oil price volatility reached its peak at USD 133.00 per barrel. However, in March 2011, the price decreased to USD 108.65 per barrel (IMF, 2011). During these periods of high energy prices (1972–73 and 1980–81), oil shocks were triggered by supply disruptions in the Organisation of Petroleum Exporting Countries (OPEC) and by the revolution in Iran. Another factor that pushed biofuel demand is the environmental concerns that have risen in the past few years, which led to the establishment of the Kyoto Protocol, an international and legally binding treaty to reduce greenhouse gas (GHG) emissions worldwide. According to this treaty, industrialized countries agreed to reduce their collective GHG emissions by 5.2%.

The demand curve for biofuels was drawn through mandates and subsidies. Brazil and the United States succeeded in developing their biofuel industries, especially those for ethanol, through a variety of policy measures.

The United States is targeting 20% of fossil fuel to be replaced with ethanol by 2030. The targets set by the European Union (EU) Biofuels Directive for biodiesel production to replace fossil fuel increased from 2% in 2005 to 5.75% by 2010. The member countries of the Association of Southeast Asian Nations (ASEAN) have also pushed the demand for biofuels further through mandates and investments in the sector. For example, the Indonesian government set to replace 10% of its petroleum consumption with biofuel by 2020, with the transition starting in January 2009. Indonesia is expected to open up 2 to 3 million ha of oil palm by 2010 to achieve these plans (Mamat, 2008). In the case of Malaysia, although it started exporting biodiesel in 2006, it only started implementing the use of B5 blend (5% biodiesel, 95% petrodiesel) in all government vehicles 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. This is because as the price of crude oil increases, the demand for biofuel feedstocks will follow suit as consumers look for alternative energy. A number of factors have motivated the development of the biodiesel industry in Malaysia. First, introducing biodiesel as alternative fuel assists in reducing the country's imports of fossil fuels, which helps the government save hard currency spent on these imports and lessen spending on fuel subsidies. Second, it provides alternative energy source for the transportation and industrial sectors, and this reduces consumption of the country's oil reserves. Third, producing palm-based biodiesel for export will generate revenues and help ensure high prices for Malaysian palm oil by using palm oil stocks. Moreover, Malaysia is one of the signatory countries to the Kyoto Protocol and has ratified to reduce its greenhouse gas emissions from the use of fossil fuels.

Many studies were conducted to investigate the palm oil market, but since monitoring of any commodity market is an evolutionary procedure, especially the Malaysian palm oil market that has witnessed many recent developments, a timely study to investigate the changes in market variables and the impact of these changes on the industry is imperative. Thus, this paper attempts to estimate and analyze the relationship among world crude oil prices, biodiesel demand, and the Malaysian palm oil price.

Theoretical Models and Empirical Findings on Palm Oil and Other Resources

The relatively simple and generalized theoretical model has been widely applied to most agricultural commodities, such as palm oil, soybean oil, rubber, and cocoa. In Malaysia, it has been applied to analyze and model the palm oil, rubber, and cocoa markets. In palm oil, the structure is refined to

ease the penetration in the international market. There have been previous studies on the Malaysian palm oil market (Yusoff, 1988; Au and Boyd, 1992; Shamsudin and Arshad, 1993; Talib and Darawi, 2002). A few studies focused on the factors affecting palm oil prices and the forecasting palm oil prices using various techniques (Arshad and Ghaffar, 1987; Shamsudin et al., 1988; Shamsudin et al., 1994).

Yusoff (1988) incorporated export tax and exchange rate in his work. Later, Abdullah et al. (1993) simulated the Malaysian palm oil market using all the factors affecting palm oil in Malaysia. By differentiating supply response of estate and smallholder sectors and diversifying the nature of the export market, Shamsudin et al. (1994) expanded the earlier works on palm oil models. Alias et al. (1999) simulated the impact of liberalization on crude palm oil imports from Indonesia. Meanwhile, Talib and Darawi (2002) described the national model on Malaysian palm oil market between 1970 and 1999 by identifying 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. Using Engle and Granger (1987) cointegration and error correction approach, Alias and Tang (2005) have analyzed the supply response of the Malaysian palm oil market. The most recent study by Shri Dewi et al. (2011) analyzed the link between biodiesel demand and Malaysian palm oil market by using an econometric method that utilizes 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.

A simulation study on the impact of the exchange rate variation was done by Alias et al. (2006). There is also a study on the impact of structural change of the Indonesian production on the Malaysian palm oil market (Shri Dewi et al., 2007) between 1976 and 2005. The study of the impact of liberalizing trade on Malaysian palm oil was done by Talib et al. (2007). Later, Shri Dewi and Alias (2009) analyzed 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 to 2008.

Indeed, the link between energy and agriculture is not a new concern. Historically, agriculture has been an energy-intensive sector and, therefore, one can draw a direct linkage from oil prices to agricultural commodity prices. As discussed in Hanson et al. (1993), an increase in oil prices is followed by an increase in input costs, which in turn causes agricultural prices to rise. A study by Abdullah et al. (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 a time varying parameter. 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

Yahaya et al. (2006). Both these studies examine the biodiesel, crude palm oil, and petroleum price linkages.

Limitations of previous research are threefold. First, the previously noted studies ignored the importance of the price of petroleum in the Malaysian palm oil market model. Even though Shri Dewi et al. (2011) included biodiesel demand in their study, they ignored petroleum prices. Secondly, 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; Talib et al., 2007) ignored the role of stationarity and cointegration as a prerequisite test before proceeding to the simultaneous equation estimation procedure. Over time, most of the macroeconomic variables show a trending behavior. This phenomenon is known as nonstationary time series in econometrics. There might be spurious regression due to the presence of nonstationary variables (Granger and Newbold, 1974). It is inappropriate to make any valid statistical inference with the nonstationary data. Based on these current developments, there are few empirical studies that apply the simultaneous equation model using two-stage least squares (2SLS) method (Robledo, 2002; Sekhar, 2003a; 2003b; Song, 2006; Sekhar, 2008). As such, the Malaysian palm oil market model will be estimated using this procedure. Finally, we are unaware of any studies using the more recent data in a simultaneous equation models to examine the relationship of petroleum prices and biodiesel demand on the Malaysian palm oil market, especially the relationship with the palm oil prices.

Methods

The study uses a structural econometric model (SEM) of the Malaysian palm oil industry to estimate the relevant parameters, modifying for this purpose the structural models reported in various studies (cf. Shamsudin et al., 1988; Shamsudin and Arshad, 1993; Shamsudin et al., 1994; Alias et al., 1999; Talib and Darawi, 2002; Alias et al., 2006; Taylor et al., 2006; Park and Fortenberry, 2007; Talib et al., 2007; Shri Dewi et al., 2007). Petroleum price and biodiesel demand variables were added in the model. By doing so, a link is formed between energy and agriculture markets because of palm oil. The SEM of the Malaysian palm oil industry specified in this study consists of eight behavioral equations and four identities, which are discussed below.

Palm Oil Supply

The model specification used to estimate the supply response for Malaysian palm oil supply is based on a previously developed model (cf. Alias and Tang, 2005; Alias et al., 2006; Shri Dewi et al., 2007; Shri Dewi et al., 2011). The supply of crude palm oil is assumed to depend on the ratio of the palm oil

current price and natural rubber, ratio price of palm oil and natural rubber lagged three years, government development expenditure on agriculture, interest rate, and time trend. A three-year lag was used due to the gestation period in the palm oil market (cf. Alias et al., 2006; Shri Dewi et al., 2007; Shri Dewi et al., 2011).

Supply of crude palm oil, an unknown quantity, is assumed to follow the stock adjustment process, and we have another variable of palm oil supply lagged one year. Palm oil supply can be specified as follows:

$$POQ_t = \alpha_0 + \alpha_1 CPOPNR_t + \alpha_2 CPOPNR_{t-3} + \alpha_3 IR_{t-3} + \alpha_4 GOVDE_{t-3} + \alpha_5 T + \alpha_6 POQ_{t-1} + \mu_{1t} \quad (1)$$

where:

POQ	= palm oil supply (tonnes)
CPOPNR _t	= relative price of palm oil to rubber
CPOPNR _{t-3}	= relative price of palm oil to rubber lagged three years
IR _{t-3}	= interest rate lagged three years
GOVDE _{t-3}	= government development expenditure on agriculture lagged three years
T	= time trend variable

Equation (1) suggests that the crude palm oil supply is expected to be positively related to the relative price of palm oil to rubber, relative price of palm oil to rubber lagged three years, government development expenditure on agriculture lagged three years, time trend variable, and palm oil supply lagged one year and negatively related to interest rate lagged three years.

Malaysian Import

According to Labys (1973), a country model should include exports as well as imports in order to reflect trading in the international market. Adapting import equation from previous studies (cf. Abdullah et al., 1993; Alias et al., 1999; Talib and Darawi, 2002; Alias et al., 2006; Taylor et al., 2006; Talib et al., 2007; Shri Dewi et al., 2007; Shri Dewi et al., 2011), the desired Malaysian import equation of palm oil can be postulated as follows:

$$CPOM_t = \beta_0 + \beta_1 POWP_t + \beta_2 PSB_t + \beta_3 GDP_t + \beta_4 STOCK_t + \beta_5 CPOM_{t-1} + \mu_{2t} \quad (2)$$

where:

CPOM _t	= Malaysian import demand of palm oil (tonnes)
POWP _t	= real world price of palm oil (USD/tonne)

$$\begin{aligned} \text{PSB}_t &= \text{real world price of soybean oil (USD/tonne)} \\ \text{GDP}_t &= \text{Malaysian GDP at 2000 prices (RM million)} \\ \text{STOCK}_t &= \text{beginning stock (tonnes)} \end{aligned}$$

The signs of the coefficients for palm oil world price, price of soybean, Malaysian gross domestic product (GDP), and palm oil import lagged one year are expected to be positive. But the signs for stock of palm oil are expected to be negative. This is because as Malaysian stock levels of palm oil become lower, the imports of palm oil tend to go higher.

World Import

The world import or world excess demand is determined by world price, soybean price, world income, world stock, and world palm oil import lagged one year. This is shown as follows:

$$\begin{aligned} \text{WEXCDD}_t = & \omega_0 + \omega_1 \text{POWP}_t + \omega_2 \text{PSB}_t + \omega_3 \text{WGDPN}_t + \\ & \omega_4 \text{WSTOCK}_t + \omega_5 \text{WEXCDD}_{t-1} + \mu_{3t} \end{aligned} \quad (3)$$

where:

$$\begin{aligned} \text{WEXCDD}_t &= \text{world excess demand (tonnes)} \\ \text{WGDPN}_t &= \text{world GDP at 2000 prices (USD billion)} \end{aligned}$$

Domestic Demand

Domestic demand is assumed to depend on the real domestic price of palm oil, domestic economy activity (represented by real GDP), real domestic price of soybean oil, and Malaysian population. The domestic consumption equation is renamed as follows:

$$\begin{aligned} \text{DCCPO}_t = & \gamma_0 + \gamma_1 \text{CPOP}_t + \gamma_2 \text{GDP}_t + \gamma_3 \text{PSB}_t + \gamma_4 \text{MPOP}_t + \\ & \gamma_5 \text{DCCPO}_{t-1} + \mu_{4t} \end{aligned} \quad (4)$$

where:

$$\begin{aligned} \text{DCCPO}_t &= \text{domestic palm oil consumption (tonnes)} \\ \text{CPOP}_t &= \text{real Malaysian price of palm oil (RM/tonne)} \\ \text{MPOP}_t &= \text{Malaysian population (million people)} \end{aligned}$$

Domestic consumption of palm oil suggests that the higher the price received, the lesser the amount of palm oil consumed in Malaysia. This is also based of the law of demand where the consumers will act negatively to increase in the palm oil price. The real price of Malaysian palm oil was calculated by deflating the nominal prices by the consumer price index (CPI): 2000 = 100. The real GDP variable is the proxy of Malaysian economic activity

and should therefore be positive. This function also suggests that domestic consumption is positively related to prices of soybean, which is assumed to be a substitute commodity for palm oil. However, Talib and Darawi (2002) used real domestic price of coconut oil as a substitute to palm oil. In this study, only the real price of soybean oil is used since it is the closest feedstock competitor of palm oil. The world CPI is used as the deflator for the world prices of soybean oil. Population is expected to have a positive relationship with domestic demand. This is because as population increase, the demand for palm oil also will increase. Finally, domestic demand lagged one period is used as a variable to add dynamism to the model.

Export Demand of Palm Oil

The export demand for palm oil shown in equation (5) as follows:

$$XPO_t = \chi_0 + \chi_1 POWP_t + \chi_2 PSB_t + \chi_3 WGDPN_t + \chi_4 ER_t + \chi_5 XPO_{t-1} + \mu_{5t} \quad (5)$$

where:

XPO_t = export demand of palm oil (tonnes)

ER_t = exchange rate (RM/USD)

Equation (5) indicates that palm oil export demand is modelled as a function of real world price of palm oil, price of other substitutes (i.e., soybean oil price), real world GDP, exchange rate, and the endogenous variable lagged one year. Export of palm oil is postulated to depend on prices. In terms of real world price of palm oil, it is expected to be negatively related to export demand of palm oil. This suggests that the higher the price received, the lesser the amount of palm oil exported. The substitute for palm oil plays an important role in determining export demand of palm oil (cf. Alias, 1988; Shamsudin et al., 1994; Alias et al., 1999; Alias et al., 2006; Shri Dewi et al., 2007; Shri Dewi et al., 2011). If the soybean price falls, the demand for soybean will increase and demand for palm oil will decrease. A world economic activity is represented by real world GDP. The impact of exchange rates is measured by the Malaysia ringgit (RM) over U.S. dollar (USD). It is expected to have a positive relationship. This variable has also been included in other studies (cf. Alias, 1988; Yusoff, 1988; Alias et al., 1999; Shri Dewi et al., 2007; Talib et al., 2007; Park and Fortenberry, 2007; Shri Dewi et al., 2011). Finally, the lagged dependent variable is used as an independent variable to capture dynamics in the use of palm oil export.

Rest-of-the-World Excess Supply

The rest-of-the-world excess supply is affected by palm oil world price, rest-of-the-world palm oil supply, and the lagged one year of the rest-of-the-

world excess supply (cf. Shamsudin et al., 1997). All these factors have positive impact on the world excess supply. The rest-of-the-world excess supply can be specified as follows:

$$\text{ROWEXCSS}_t = \varphi_0 + \varphi_1 \text{POWP}_t + \varphi_2 \text{ROWPOQ}_t + \varphi_3 \text{ROWEXCSS}_{t-1} + \mu_{7t} \tag{6}$$

where:

- ROWEXCSS_t = rest-of-the-world excess supply (tonnes)
- ROWPOQ_t = rest-of-the-world production (tonnes)

Domestic Price

The domestic price equation can be specified as follows:

$$\text{CPOP}_t = \varsigma_0 + \varsigma_1 \text{STOCK}_t + \varsigma_2 \text{PSB}_t + \varsigma_3 \text{POWP}_t + \varsigma_4 \text{BDDD}_t + \varsigma_5 \text{CPOP}_{t-1} + \mu_{8t} \tag{7}$$

where:

- CPOP_t = domestic price of palm oil
- STOCK_t = ending stock of crude palm oil (tonnes)
- BDDD_t = biodiesel demand (export volume of biodiesel in tonnes)

The inclusion of a stock variable indicates that the presence of stock together with time may influence the local price of palm oil (Abdullah et al., 1993). A negative relationship is expected between stock and the price of palm oil. Another affecting variable could be the soybean oil price (cf. Alias, 1988; Yusoff, 1988; Abdullah et al., 1993; Alias et al., 1999; Alias et al. 2006; Abdullah et al., 2007; Shri Dewi et al., 2007; Talib et al., 2007). Soybean and palm oils are the two examples of agricultural commodities that have similar characteristics and can be substituted in many applications. According to Abdullah et al. (2007), the prices are highly correlated with the highest correlation index of 0.82, compared with any other oils and fats, except palm kernel oil. Another reason is that their relationship is very close; whenever there is an increase in soybean oil price, the palm oil price follows. Furthermore, soybean oil price is also quoted in the Chicago Board of Trade (CBOT) futures market and used as a reference or benchmark for these oils and fats. As such, this is the reason soybean oil price is selected over other substitutes. A positive relationship between palm oil price and soybean oil price is expected. Biodiesel demand has been included, following Abdullah et al. (2007), in a time-varying parameter model in an attempt to include it in the Malaysian palm oil market model. A positive relationship is expected.

Finally, the palm oil price lagged of one period is added due to the market price as a result of partial adjustment process.

World Price

The world price of palm oil is determined by the world supply and demand. The world price equation can be specified as follows:

$$\text{POWP}_t = \Pi_0 + \Pi_1 \text{PSB}_t + \Pi_2 \text{WGDPN}_t + \Pi_3 \text{WSTOCK}_t + \Pi_4 \text{PCO}_t + \Pi_5 \text{POWP}_{t-1} + \mu_{9t} \quad (8)$$

where:

WSTOCK_t = world stock of palm oil (tonnes)

PCO_t = petroleum price (USD)

Equation (8) suggests that real world price of palm oil would have a positive relationship with the price of its substitute soybean, world GDP, petroleum price, real world price of palm oil lagged one year, and a negative relationship with world stock of palm oil. As soybean oil is a competitor to palm oil, soybean price would have a positive relationship with real world price of palm oil. An increase in world supply indirectly affects domestic price through the real world price of palm oil.

Closing Identities

The introduction of four identities (i.e., Malaysian stock, Malaysian excess supply, world excess supply, and world stock) will complete the system. The four identities are as follows:

$$\text{STOCK}_t = \text{STOCK}_{t-1} + \text{POQ}_t + \text{CPOM}_t - \text{DCCPO}_t - \text{XPO}_t \quad (9)$$

$$\text{MEXCSS}_t = \text{POQ}_t - \text{DCCPO}_t \quad (10)$$

$$\text{WEXCSS}_t = \text{MEXCSS}_t + \text{ROWEXCSS}_t \quad (11)$$

$$\text{WSTOCK}_t = \text{STOCK}_t + \text{ROWSTOCK}_t \quad (12)$$

where:

MEXCSS_t = Malaysian excess supply (tonnes)

WEXCSS_t = world excess supply (tonnes)

ROWEXCSS_t = rest-of-the-world export (tonnes)

WSTOCK_t = world stock (tonnes)

The total Malaysian ending stock of palm oil is defined as the sum of beginning stocks, production, and imports minus domestic consumption and

export demand. The Malaysian excess supply is of Malaysian supply minus the domestic consumption. The world excess supply or world export is composed of the sum of Malaysian palm oil and the rest-of-the-world export. Finally, world stock is the sum of Malaysian stock and rest-of-the-world stock. The variables of the model are interrelated (Figure 1).

Before carrying out the cointegrating test and estimation, order and rank conditions were confirmed. Since the model meets these conditions, it can be solved with a unique solution; then the cointegrating test will be carried out. The sample period for this study was from 1976 to 2010. The data were extracted from publications of the Department of Statistics of Malaysia, Malaysian Palm Oil Board, and International Financial Statistics of the International Monetary Fund. The 2SLS estimation was applied to the specified model.

Results and Discussion

The nonlinear 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 (Table 1). The relevant Durbin-Watson (DW) statistics and h-statistics show that the autocorrelation is not serious. Cointegration test and the order and rank conditions are fulfilled before proceeding to 2SLS estimation. 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 when they have cointegration relations in a simultaneous equation model. The endogenous variables are nonstationary if exogenous variables are nonstationary (Hsiao, 1997). This study also shows that the least square estimator for the long run reduced form is consistent in the two- and three-stages least squares 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, 1997).

The results suggest that the supply of crude palm oil in Malaysia is determined by the ratio of its price with that of rubber, interest rate, government development expenditure on agriculture, and time trend. All of the estimated coefficients in the supply equation of palm oil have the expected signs. This finding is consistent with that of Alias and Tang (2005), who studied supply response of Malaysian palm oil producers, and Remali et al. (1998), who studied Malaysian cocoa supply response. This reflects the importance of

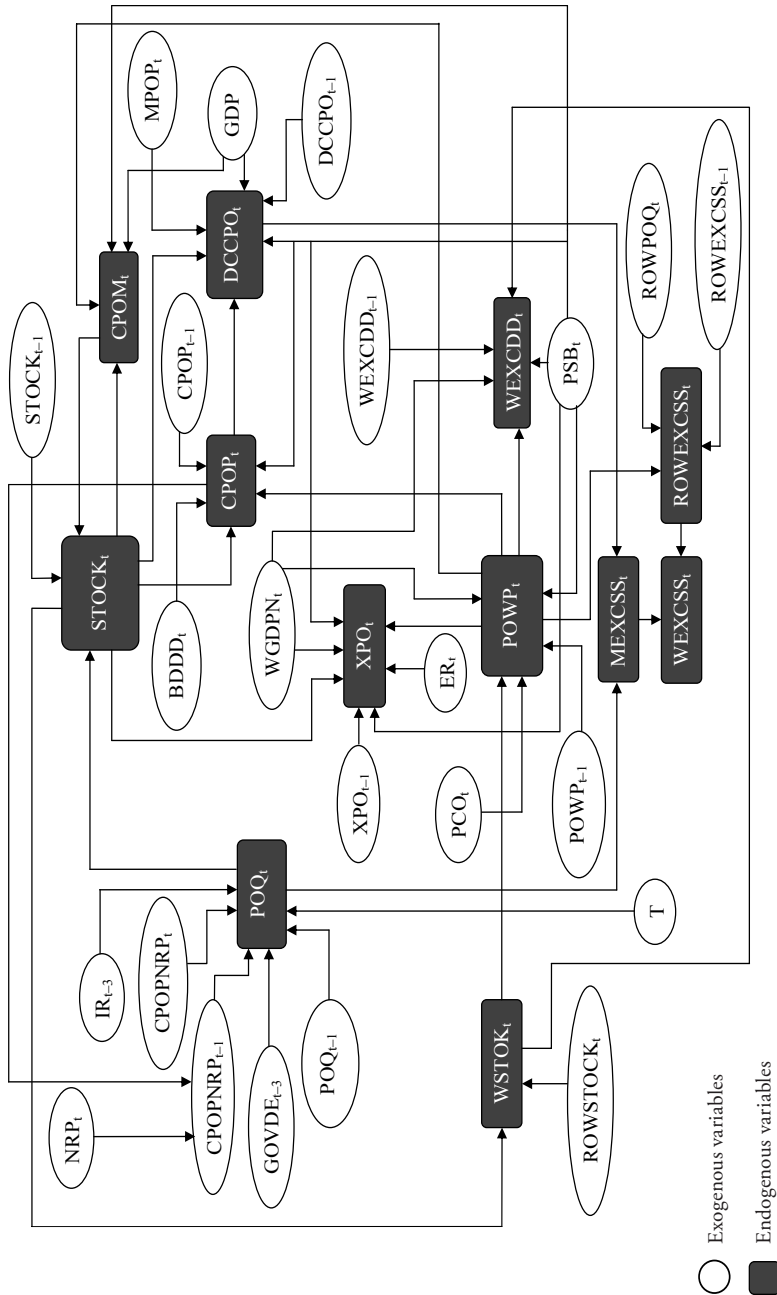


Figure 1. Flow chart of the Malaysian palm oil market model

Table 1. Estimated structural equations

Supply (Malaysian Palm Oil Production)

$$\begin{aligned} \text{POQ}_t &= -663.35 + 96.55\text{CPOP}_{t-1} + 277.81\text{CPOP}_{t-3}^* - 314.43\text{IR}_{t-3}^{***} + \\ &\quad 1.12\text{GOVDE}_{t-3}^{**} + 419.23\text{T}^{***} \\ R^2 &= 0.98 \quad F \text{ stat} = 184.16 \quad DW = 1.94 \end{aligned}$$

Malaysian Import

$$\begin{aligned} \text{LCPOP}_t &= -12.43 - 8.22\text{LPOWP}_t^{**} + 5.05\text{LPSB}_t + 3.77\text{LGDP}_t^{***} - 0.81\text{LSTOCK}_t \\ R^2 &= 0.57 \quad F \text{ stat} = 11.15 \quad DW = 1.84 \end{aligned}$$

World Excess Demand (World Import)

$$\begin{aligned} \text{LWEXCDD}_t &= 17.36^{***} - 0.36\text{LPOWP}_t^{***} + 0.10\text{LPSB}_t + 0.50\text{LWEXCDD}_{t-1}^{***} \\ R^2 &= 0.99 \quad F \text{ stat} = 1183.83 \quad h = -0.78 \end{aligned}$$

Demand (Domestic Consumption)

$$\begin{aligned} \text{LDCCPO}_t &= 0.88 - 0.16\text{LCPOP}_t^{**} + 0.63\text{LGDP}_t^{***} + 0.04\text{LPSB}_t + 0.51\text{LDCCPO}_{t-1}^{***} \\ R^2 &= 0.99 \quad F \text{ stat} = 642.67 \quad h = -0.51 \end{aligned}$$

Export Demand

$$\begin{aligned} \text{LXPO}_t &= 2.96 - 0.32\text{LPOWP}_t + 0.31\text{LER}_t + 0.31\text{LPSB}_t + 0.28\text{LWGDP}_t + 0.61\text{LXPO}_{t-1} \\ R^2 &= 0.99 \quad F \text{ stat} = 501.95 \quad DW = 2.09 \end{aligned}$$

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

$$\begin{aligned} \text{LROWEXCSS} &= -6.03^{***} + 0.06\text{LPOWP}_t + 1.12\text{LROWPOQ}_t^{***} + 0.15\text{LROWEXCSS}_{t-1} \\ R^2 &= 0.96 \quad F \text{ stat} = 265.55 \quad h = 1.18 \end{aligned}$$

Price (Domestic Price)

$$\begin{aligned} \text{LCPOP} &= 4.01 - 0.12\text{LSTOCK}_t + 0.34\text{LPOWP}_t + 0.23\text{LBDDD}_t + 0.09\text{LCPOP}_{t-1} \\ R^2 &= 0.79 \quad F \text{ stat} = 26.92 \quad h = 1.15 \end{aligned}$$

World Price

$$\begin{aligned} \text{LPOWP} &= 4.99 + 0.02\text{LPSB}_t^{**} + 0.17\text{LPCO}_t^* + 0.001\text{LPOWP}_{t-1}^{***} \\ R^2 &= 0.56 \quad F \text{ stat} = 10.17 \quad h = 1.44 \end{aligned}$$

Identities

$$\begin{aligned} \text{STOCK}_t &= \text{STOCK}_{t-1} + \text{POQ}_t + \text{CPOM}_t - \text{DCCPO}_t - \text{XPO}_t \\ \text{MEXCSS}_t &= \text{POQ}_t - \text{DCCPO}_t \\ \text{WEXCSS}_t &= \text{MEXCSS}_t + \text{ROWEXCSS}_t \\ \text{WSTOCK} &= \text{STOCK}_t + \text{ROWSTOCK}_t \end{aligned}$$

Note:

*** Significant at 1% level

** Significant at 5% level

* Significant at 10% level

this variable at the time the investment is made. Oil palm, rubber, and cocoa are competitors in terms of land use in the Malaysian context. In this study, the relative price of palm oil with respect to the price of rubber was chosen because rubber is the main substitute crop. The increase in this relative price will increase the palm oil production due to higher price of palm oil.

The interest rate variable is included to account for the cost of borrowing, and it is negative according to the theory. Planting is discouraged with the negative effect on working capital due to increase in interest rate. According to Alias and Tang (2005), there are two major findings: First, monetary policy has an impact on the planting (investment) decisions. The planters are encouraged to replace old rubber trees either with new ones or with oil palm, especially if there is a lower cost of borrowing, which is relevant in the current context. Second, there is a need to narrow the gap between potential yield and realized yield. Increasing the rate of replanting is a more effective strategy in the long run, considering that a large proportion of trees planted 25 to 30 years ago are yet to be replanted. This indicates that monetary policy has an impact on investment decisions. A lower cost of borrowing would encourage planters to replant old trees or to replace rubber trees with oil palm.

Government expenditure, a proxy for government support, is positively associated with the supply of palm oil, which mainly benefits the smallholding sector. Government expenditure acts as a shifter variable in the supply function of crude palm oil. It is significant at the 5% level and gives empirical support for government intervention. The time trend (T) is significant at the 1% level, suggesting palm oil production is trending upward due to technology innovation in cultivation and management.

The estimates obtained for the import demand are consistent with a priori expectations. Malaysian imports of crude palm oil was negatively related to the price of world palm oil but positively related to price of soybean. An increase of 1% in palm oil world price will decrease 8.2% in the palm oil import, which is supported by Talib and Darawi (2002). The coefficient of the price of soybean is found to be negative even though statistically insignificant. The coefficient of the Malaysian GDP is found to be positive. Its elasticity indicates that a 1% increases in GDP would increase imports of palm oil by 3.77%. As expected, the coefficient of beginning stocks has a negative sign even though it is statistically insignificant. A 1% increase in beginning stocks could decrease Malaysian imports of palm oil by 0.81%. Therefore, imports provide substitutes for decreasing stocks.

The empirical estimates of world excess demand suggests that the primary factors affecting changes in world excess demand are world price, world price of soybean, and world import lagged one year. The own price elasticity is 0.36, which is different from the finding of Shamsudin et al. (1997) at 0.28. The world income was significant at 1% level and had the expected sign. The

coefficient on lagged world import demand is significant at 1% level with the adjustment coefficient being approximately 0.5 indicates a relatively moderate adjustment to the equilibrium level.

The domestic demand equation in this study is based on Marshallian demand function. The domestic demand empirically affected by own price, Malaysian GDP, price of soybean, and lagged domestic demand. All of the variables are significant at least at the 5% level, except price of the substitute (i.e., soybean). The adjustment coefficient at 0.50 indicates a moderate adjustment to the equilibrium level. An increase in own price by 1% would decrease domestic use by 0.16%. These results show that own price is inelastic. The inelastic in own price has also been obtained by Talib and Darawi (2002) with 0.39. In Shamsudin et al. (1997), the elasticity is 0.24. In the short run, given a 1% increase in Malaysian GDP, the domestic consumption would only increase by 0.63%. The coefficient of the current price of soybean oil is positive, following the expected sign. However, this coefficient is not statistically significant, implying that the consumption level of palm oil does not merely depend on the soybean price. The current level of consumption also relies on one year lagged consumption. The coefficient of lagged domestic demand is also significant, indicating that the lagged adjustment model is appropriate. The adjustment coefficient is 0.50, suggesting that adjustment to the desired level of domestic consumption is rapid at about 50% per year. The results are consistent with earlier studies (cf. Yusoff, 1988; Alias et al., 1999; Shamsudin et al., 1988; Alias et al., 2006; Shri Dewi et al., 2007).

A perusal of these results indicates 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, exchange rate, world income, and lagged endogenous variable are significant at least at the 5% level. The own price elasticity is -0.32 . The results confirm earlier findings (Shamsudin and Arshad, 1993; Shamsudin et al., 1988) that the export demand for agricultural demand is inelastic. The Malaysian financial exchange rate is also important as a determinant of the palm oil export. Malaysian palm oil export can be increased by about 0.31% for every 1% increase in the Malaysian ringgit–U.S. dollar exchange rate. The coefficient of palm oil export lagged one year is statistically significant and also shows that the adjustment to the desired level of exports is small (0.39) due to the large amount of Malaysian palm oil exports, i.e., on average, more than 90% of total production is exported every year, which also confirms previous findings (Yusoff, 1988; Talib et al., 2007).

The rest-of-the-world export is mainly determined by production in the rest of the world. The production variable is significant at the 1% level. However, despite having the expected sign, the world price variable is not statistically significant. The same is true for the coefficient of the rest-of-the-

world export lagged one year, which has the expected sign but is not statistically significant. The speed of adjustment shows that the adjustment to the desired level of rest-of-the-world exports is very big at 0.85.

All the estimated coefficients in the domestic price equation have the expected signs. The price flexibilities with respect to stock and world price are -0.12 and 0.34 , respectively. The biodiesel demand variable is included as a proxy to model the effect of rising importance of biodiesel demand on Malaysian palm oil industry (Abdullah et al., 2007). The coefficient of this variable is 0.28 , which is statistically significant at 1% level and follows the correct sign. The coefficients on lagged prices indicate that the adjustment price to the equilibrium is relatively fast (0.91). Stock disequilibrium determines the changes in primary commodity prices, and also the speed of adjustment is generally faster for agricultural commodities (Shamsudin et al., 1993; Hwa, 1979). The speed of adjustment in this study is also found to be consistent with that of Abdullah and Lazim (2006) at 0.66 .

In the case of the equation for the palm oil world price, all the variables could explain the variation; and these are price of soybean, world petroleum price, world stock, and the lagged dependent variable. Price of soybean is found to be significant at 5% level where this confirms the belief that soybean oil is palm oil's main substitute and both oils compete in the international fats and oils market (cf. Yusoff, 1988; Talib et al., 2007). Thus, a 1% increase in the price of soybean would result to a 0.02% increase in the palm oil world price. The other variable, the price of petroleum, is significant at 10% level, and this shows the relationship between energy and agricultural prices.

Overall, the estimation results of the Malaysian palm oil market model are statistically acceptable and have identified many important factors related to supply, domestic demand, export demand, and prices (domestic and world), specifically the relationship among world petroleum prices, biodiesel, and palm oil prices. Some of the coefficients are found to be insignificant, but we retained them on a priori ground, i.e., we believe that the variables are relevant, but because of possible data and econometric problems, accurate estimates are not possible.

Conclusions

The central theme of this paper is to examine the relationship among world petroleum prices, biodiesel demand, and palm oil prices. The results indicate that the Malaysian palm oil price function has a reasonably good fit and all the variables have expected signs and significant coefficients, except stock of palm oil with correct sign but insignificant value. Price of petroleum is significant at 10% level, and this shows the relationship between energy and

agricultural prices. Besides that, all the estimated coefficients in the domestic price equation have the expected signs. The biodiesel demand variable was included as a proxy to model the effect of the rising importance of biodiesel demand on the Malaysian palm oil industry. The coefficient of this variable was statistically significant and followed the correct sign. The coefficients on lagged prices indicate that the adjustment price to the equilibrium was relatively fast. Palm oil world price and lagged domestic price were also found to be significant.

This study also shows how the energy and agricultural markets, especially for palm oil, are intertwined because of biodiesel demand. To fully understand the overall impact of world petroleum price on the Malaysian palm oil market, future research should include the conduct of counterfactual analysis of the change of the policy variable on the main endogenous variables.

Acknowledgment

We would like to thank the many individuals and organizations who assisted us during the study. Special thanks to Universiti Utara Malaysia, Research Management Centre, and Universiti Putra Malaysia through the Research University Grant Scheme.

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