The Link between Renewable Fuel Mandate and Natural Rubber Market in Malaysia: A Search for A Conceptual Framework

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Abstract— *Lately, fluctuation in world crude oil prices and increasing in biofuel demand have encourages the uses of biodiesel in worldwide. Malaysia is one of the countries that using renewable materials from crude palm oil. As the main feedstock for biodiesel, the implementation of biodiesel blend mandate in Malaysia is expected to interrupt the natural rubber industry due to the competition of land between oil palm and natural rubber. Previously, there was no any relationship between renewable energy particularly biodiesel to be linked with the natural rubber market. The implementation of B5 mandate in Malaysia will added a new dimension in the Malaysian natural rubber market. Therefore, the objective of this study is to develop the conceptual framework in examining the effect of biodiesel blend mandate on Malaysian natural rubber market. Malaysia natural rubber and palm oil market model been developed where consist of production, import, domestic consumption, export, domestic price and world price equations. The model was closed using domestic and world stock identity.*

Keywords— Conceptual framework, Renewable Fuel Mandate, Malaysian natural rubber market, Palm oil market.

I. INTRODUCTION

There are many countries that used biodiesel as an alternative for fossil fuels. The countries are European Union (EU), United State of America (USA) and Indonesia. It's been used primarily in transportation fuel.Beside, government policy such as mandate has increased the biodiesel demand in worldwide.

Germany is one of the leading in biofuel in EU's country (Thone and Rauch, 2012). The main source of biodiesel in Germany comes from rapeseed oil. Starting year 2004, the uses of B5 has been introduced in Germany while for B7, the consumption been encourage since year 2007. The mandate B5 means 5 percent of biodiesel need to be blend with diesel.

In USA, the Renewable Fuel Standard (RFS) had mentioned the minimum volume of biofuel that should be blend with biofuel. In Renewable Fuel Standard (RFS2), the goal is to achieve 36 billion gallons of biofuel uses by year 2022 (Schnepf and Yacobucci, 2013).

In the ASEAN countries, Indonesia target is to use 10 percent of biofuel on transportation in year 2010. However,as the largest producer for palm oil industry, in Indonesia National Energy Policy, it had increased the blending mandate to 20 percent by the year 2025 (Dillon, Laan and Dillon, 2008).

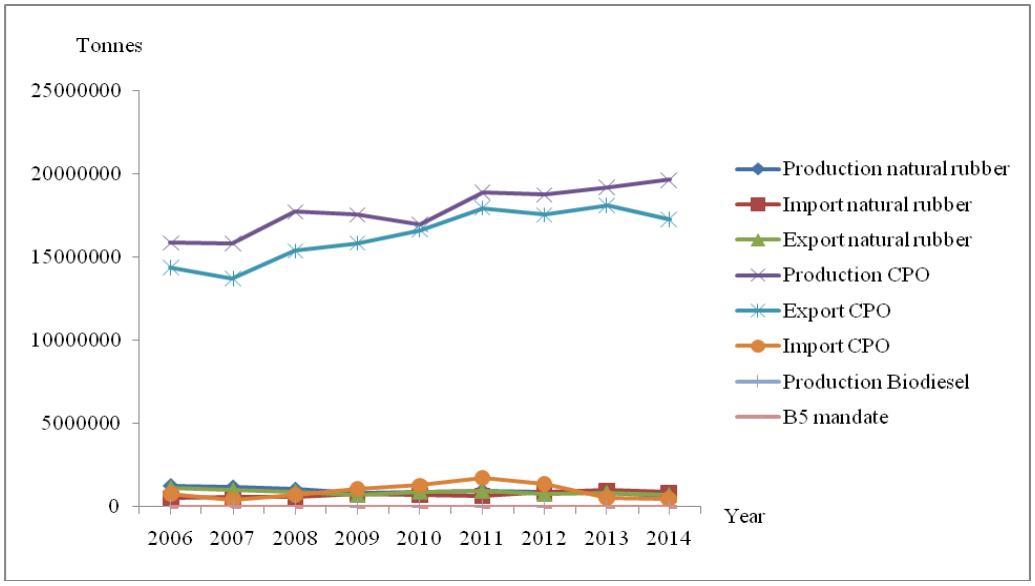
In Malaysia, only in year 2011 the uses of biodiesel in transportation had been commercialized. It had been` used at stage which involved 1,150 petrol stations started at Putrajaya on 1st June 2011 until at Selangor on November 2011. In year 2013, B5 had been mandate by Malaysia government.

Figure 1 show the production, import and export of natural rubber and CPO since year 2006. Production and export natural rubber decreased from year 2006 until 2009. While there is a fluctuated in production, export and import CPO.

After the launched of biodiesel mandate in year 2011, production of natural rubber decreased year by year. In year 2012, the natural rubber production was less than 1,000,000 tonnes(Malaysian Rubber Board, 2012). While import increased until year 2013. This trend will worsen when in year 2012 until 2014, the import of natural rubber exceed export.In year 2013, the contribution of natural rubber to export was only 0.98 percent (Malaysian Rubber Board, 2013).

Compare to CPO, the production decreased slightly in year 2012 and achieved 19,000,000 tonnes production in year 2013 and 2014. There is a fluctuated in total export CPO from year 2012 until 2014.It can be said that the B5 mandate decreased the natural rubber production and export but increased the import. Value -0.9957 show the strong negative coefficient between production natural rubber and biodiesel mandate. .While, mandate will increased the production CPO and decreased

the import CPO. However, the correlation showed that there is only a slightly decrease in import compare to slightly increased in export CPO.



Source: Malaysian Rubber Board (2015)and Malaysian Palm Oil Board (2015)

FIGURE 1: TREND NATURAL RUBBER, CPO AND BIODIESEL IN MALAYSIA (TONNES): 2006 - 2014

Therefore, it is important for Malaysia to sustain the local raw materials in develop the upstream and downstream activity in Malaysia. The local raw material is important in producing gloves, tires and other latex based product. This can reduced the volume of latex import from other countries. Therefore, it is important to build a conceptual analysis especially after the implementation of biodiesel mandate on natural rubber market in Malaysia based on the previous literature review. The link between renewable fuel mandate and natural rubber will be achieved in this article.

II. LITERATURE REVIEW

Majority of the authors used market model which has been introduced by Labys (1973). It have been used in natural rubber, palm oil and cocoa market. The authors are Mohammed (1988), Mohamed and Mad Nasir (1993), Amna et al,. (2010). In cocoa market, Amna et al,. (2010) also followed Labys (1973) and modified it into six behavioral equation called supply equation, import, consumption, export, domestic price and world price.

In palm oil market, ShriDewi et al., (2011) also used supply and import equation. But the author extended the model by including world import and rest of world export.The equation been using in ShriDewi et al., (2011) is same as previous study by ShriDewi et al., (2013).

In Malaysia's natural rubber market one previous research conducted on this topic is by Mohammed (1988). Based on Labys' (1973) equilibrium model, the author only used export and world price equation in his study and added two more equations called acreage and yield equation. Another study, Mohamed and Mad Nasir (1993) also examined natural rubber market and the authors used production, export, world price and stock equation in the model.

Another author, Romprasert (2009), examined the factors for monthly RSS3 future prices by including crude oil prices as one of the variables. The obtained result showed that crude oil price is a significant variable in determining future price. An increase of 1 percent petroleum prices will increase the RSS3 price to 0.0227 percent. Khin, Zainal and Amna (2012) also used crude oil prices as the variable in natural rubber price. They also used the substitute price, stock, production and consumption as the variables and all the variables are significant and played an important role in price equation.

Previous authors such as Acheampong et al,. (2010), Taheripouret al,. (2011) and Georges (2012) were examined the biofuel effect in feedstock price.Acheampong et al., (2010) examined the switchgrass production and ethanol impact on hay industry. The impact of ethanol mandate on cattle industry can be seen through the high price and low production of hay. Taheripour et al., (2011) examined the implication of EU and U.S. mandate in production and feedstock price. But, the different in Taheripour et al., (2011) study was they also investigated the competition between biofuel and livestock. Biofuel productions source such as corn also one of the animal feed. Both compete together in the source to get the feedstock.

Only Welch et al., (2008) had examined the ethanol effect on crops not directly tied to ethanol industry. In this study, the authors had examined the effect of ethanol on cotton industry. Result revealed that competition for planted area between corn and its competitor had effect the supply and demand for competing crops. The increasing in corn production return will reduced the quantity of cottonseed which next will increase the cottonseed price.

Besides, there is less research that examined the effect of mandate in ASEAN countries. Only ShriDewiet al,. (2013) investigated the blend mandate impact in Malaysia but they failed to link with crops which is not directly tied to biodiesel industry. Therefore, this study attempted to fill the gap in the literature. This study will extend Labys' (1973) market equilibrium by including more behavioral equations such as consumption and domestic price equation. It will clarify the factors for each new behavioral equation and examine it using the simultaneous equation. Although both of the studies above, Mohammed (1988) and Mohamed and Mad Nasir (1993), also used the simultaneous equation, more recent data are needed in determining the factors in natural rubber industry.

III. METHODOLOGY

The basic market model by Labys (1973) was used to develop the framework of this study. The model can be divided into three sub model called supply (SS), demand (DD) and price (P). The condition for market equilibrium is supply is equal to denand. The sub model is as below:

$$SS_t = f(SS_{t-1}, P_{t-I}, RES_t, GOVP_t) \quad (1)$$

$$DD_t = f(DD_{t-1}, P_t, SUBP_t, INC_t, TECH_t) \quad (2)$$

$$P_t = f(P_{t-1}, \Delta I_t) \quad (3)$$

$$SS_t = DD_t \quad (4)$$

Where

SS_t = Supply at time t
SS_{t-1} = Supply with 1 lagged year
P_{t-1} = Price with 1 lagged year
RES_t = Resource
$GOVP_t$ = Government policy at time t
DD_t = Demand at time t
DD_{t-1} = Demand with 1 lagged year
P_t = Price at time t
$SUBP_t$ = Substitute price at time t
INC_t = Activity level or income
$TECH_t$ = Technology
ΔI_t = Changes in stock
I_t = Stock at time t
I_{t-1} = Stock with lagged 1 year

Based on Labys (1973), the factors of supply are supply and price with lagged, and policy variables. While, demand consists of demand with lagged, its own price, substitute price, economy activity and technology. Price is depending on price with lagged and changes in stock. The market model been closed by an identity which supply quantity minus quantity demanded.

IV. EMPIRICAL MODEL

4.1 Model Specification for Palm Oil

4.1.1 Palm Oil Supply

The palm oil supply is depends on domestic price of palm oil, domestic price of natural rubber and government expenditure with lagged. The equation is as shown in equation (5):

$$LNPRODPO_t = a_0 + a_1 LNPRICEPO_t + a_2 LNPRICENR_{t-i} + a_3 GOV_{t-i} + \mu_{1t} \quad (5)$$

Domestic palm oil price and government expenditure are expected to have a positive sign with production. Increasing in palm oil price is an encouragement for the producers to increase their own production while the shift in government

expenditure supply curve to the right will increase the producer's opportunity to expand their production in estates and smallholdings. Therefore, both variables are expected to have positive sign with production.

While as the competitor to palm oil, domestic price natural rubber is expected to has a negative sign with production because increasing in natural rubber price will reduce the producer encourage to plant oil palm. The producer will switch off from natural rubber plantation to oil palm plantation (Mastrianna, 2010).

4.1.2 Palm Oil Import Demand

Below is the equation for import palm oil:

$$LNIMPO_t = b_0 + b_1 LNDSPO_t + b_2 LNWPOP_t + \mu_{2t} \quad (6)$$

The variables for import demand are domestic stock and current world palm oil price.Both are expected to have a negative sign with import because, increasing in world palm oil will decrease the Malaysia initiative to import of palm oil from other countries due to high price in the world market.

4.1.3 Palm Oil Domestic Demand

The palm oil domestic demand variables are domestic price palm oil, biodiesel mandate and Malaysia population.

$$LNCPO_t = c_0 + c_1 LNPRICEPO_t + c_2 LNBD_t + c_3 LNPOPULATIONMSIA_{t-1} + \mu_{2t} \quad (7)$$

Only $c_1$is expected to havea negative sign. High palm oil price means consumer needs to spend more money in getting the palm oil feedstock in the economy. Therefore consumer prefers to consume other vegetable oil compare to palm oil. Besides, the biodiesel variable which representing of government mandate will increase the consumption palm oil because palm oil is the main source for biodiesel in Malaysia. Lastly, Malaysia population is also expected to increase the palm oil consumption because higher population means higher amount of palm oil needed in the economy.

4.1.4 Palm Oil Export Demand

In equation (8) the export demand is determined by world palm oil price, world industrial production index with lagged 1 year and exchange rate with lagged 1 year.

$$LNEXPO_t = d_0 + d_1 LNWPOP_t + d_2 LNIPIW_{t-1} + d_3 LNER_{t-1} + \mu_{3t} \quad (8)$$

All coefficients are expected to have negative sign except for d_2. High world palm oil price encourage decreasing in export natural rubber. While IPIW reflect the economy activity will increase the total export of palm oil. Lastly, exchange rate plays a negative relationship with export demand because depreciation in ringgit means Malaysia's export becomes cheaper.

4.1.5 Palm Oil Domestic Price

Refining sector capacity utilization, domestic stock, world palm oil price with lagged 1 year and time trend are 4 variables been investigate in domestic palm oil price. The equation shown as follows:

$$LNPRICEPO_t = e_0 + e_1 LNCU_t + e_2 LNDSPO_t + e_3 LNWPOP_{t-1} + e_4 T_t + \mu_{4t} \quad (9)$$

Less competition from refiners make the domestic price increase. Therefore, negative relationship is expected in refining sector capacity utilization. Less domestic stock of palm oil in the market means the price of palm oil will high. Therefore, negative relationship also is expected between domestic stock and domestic price. While, world palm oil price is expected to have a positive sign because the high world price will encourage trade in the international market. Therefore, the producer will increase the domestic price because of more opportunity to sell in the international market. Lastly, time trend showed that the preference plays negative relationship with domestic price which parallel with time, it can change consumer's preference to other competitor source. Next, reducing in demand will make the domestic price increase.

4.1.6 Palm Oil World Price

The variables for world palm oil price are world soybean oil price, world stock and time trend. The equation can be writing as follows:

$$LNWPOP_t = f_0 + f_1 LNWSOYAP_t + f_2 LNWSPO_t + f_3 T_t + \mu_{5t} \quad (10)$$

f_2 and f_3 are expected to have a negative sign. Only world soybean oil price is expected to have a positive effect with world palm oil price. As the competitor for palm oil, high in world soybean oil price next will increase the world palm oil price.

World stock palm oil will increase the world price if the stock in consuming countries is low compare to stock in producing countries. The world price will increase because consumer country will buy the palm oil from another country in replenish its own stock Mohammed (1988).

While, time trend which represent the preference showed that consumer would consume other commodity which increase the world palm oil price in the market.

4.1.7 Palm Oil Domestic Stock

The model been closed by the using the stock equation in equation (11). The formula of domestic stock is production plus import and domestic stock with lagged 1 year minus local consumption and export.

$$LNDSPO_t=LNDSPO_{t-1} + LNIMPO_t + LNPRODPO_t - LNCPO_t - LNEXPO_t \quad (11)$$

4.1.8 Palm Oil World Stock

For world stock equation, the model been closed by domestic stock plus rest of world stock.

$$LNWSPO_t= LNDSPO_t + LNRESTWSPO_t \quad (12)$$

4.2 Model Specification for Natural Rubber

This section elaborates the model specification for natural rubber market:

4.2.1 Natural Rubber Supply

The factors for natural rubber supply are current domestic price of palm oil, domestic natural rubber price with lagged 1 year and time trend. The equation can be writing as follows:

$$LNPRODNR_t= g_0 + g_1LNPRICEPO_t + g_2LNPRICENR_{t-1} + g_3T_t + \mu_{1t} \quad (13)$$

All the variables are expected to have a positive sign except for g_1. Increasing palm oil price will decrease the total production of natural rubber in Malaysia. It is contrast with the domestic natural rubber price with lagged 1 year which any increase in the natural rubber prices will increase the total of natural rubber production in the industry. This is because high price is an encouragement to producers to plant and produce more natural rubber in the future. Time trend which represent the level of technology in the agricultural production is expected to have a positive sign with the total of palm oil production. More time been used, the level of agricultural productivity will increase parallel with the growth in the technology.

4.2.2 Natural Rubber Import Demand

Malaysia's GDP, exchange rate, time trend and world natural rubber price with lagged 3 years are 4 variables in import demand equation. The equation is as follows:

$$LNIMNR_t= h_0 + h_1LNMGDP_t + h_2LNER_t + h_3T_t + h_4LNWNRP_{t-3} + \mu_{2t} \quad (14)$$

Two variables h_1 and h_3 are expected to have a positive sign compare to h_2 and h_4.Increasing in Malaysia's GDP will increase the import natural rubber. Therefore, the positive sign is expected. While, depreciation in ringgit means increasing cost in importing product based on natural rubber. The sources become expensive. Therefore, it will discourage import in the future. Next, time trend is referred to technology. Parallel with the time, increasing in new technology will increase the natural rubber import in Malaysia. Therefore, time trend is also expected to have a positive sign with import. The world natural rubber price at with lagged 3 years is expected to have a negative relationship with the import demand of natural rubber because the higher the world natural rubber price, less amount of natural rubber would be import from other countries.

4.2.3 Natural Rubber Domestic Demand

$$LNCNR_t= i_0 + i_1LNPRICENR_t + i_2LNPOPULATIONMSIA_t + i_3LNMGDP_{t-1} + \mu_{3t} \quad (15)$$

In the consumption equation, the variables are domestic price of natural rubber, Malaysian population and GDP with lagged 1 year. Only i_1 is expected to have a negative sign. The negative relationship in domestic natural rubber price with domestic demand is because reducing in domestic price means the consumers need to spend less money in getting the natural rubber

source in the economy. Therefore, this situation will increase natural rubber consumption. Next, the higher population means higher amount of palm oil needed in the economy. So, consumption will increase. Lastly, Malaysia's GDP as the proxy for income means the higher the income, more palm oil can be consumed.

4.2.4 Natural Rubber Export Demand

The equation for natural rubber export demand is as follows:

$$LNEXNR_t = j_0 + j_1 LNIPIW_t + j_2 LNPSBR_t + j_3 T_t + j_4 LNWNRP_{t-1} + \mu_{4t} \quad (16)$$

The variables are world industrial production index, world synthetic rubber price, time trend and world price of natural rubber with lagged 1 year. j_1 and j_2 are expected to have positive sign whilej_3 and j_4 are expected to have a negative sign with export demand. IPIW is reflecting the level of economy activity in the world. Malaysia will increase the number of export if the level of economy activity in the world will also increase.

While, world synthetic rubber price is expected to has a positive sign because of substitution effect. Country will export more natural rubber to other country because of increasing in demand due to cheaper price in natural rubber price.

The time trend is expected to have a negative sign because the other countries have a choice to import natural rubber from other countries due to the changes in preference (Mohammed (1988). They can switch off to the other alternative commodity such as synthetic rubber. Therefore, more years give more time for the countries to seek for the good commodity or product that they want.

Vice-versa, the situation is different in world natural rubber price variable. It is assume to have a negative effect because increasing in the price of natural rubber means the price of natural rubber in the industry relatively is more expensive compare to its substitute price. Therefore, foreign country will switch off from export more natural rubber to export synthetic rubber.

4.2.5 Natural Rubber Domestic Price

$$LNPRICENR_t = k_0 + k_1 LNWNRP_t + k_2 LNDSNR_t + k_3 LNPSBR_t + \mu_{5t} \quad (17)$$

In the domestic price equation, it depends on current world natural rubber price, its current domestic stock and current world synthetic rubber price. $k_1$is assumed to have positive sign while k_2 and k_3 are assumed to have a negative sign with domestic price. The world natural rubber price is expected to have a positive relationship because the high world price will encourage trade in the international market which producer will increase the domestic price because of more opportunity to sell in the international market.

Stock natural rubber has negative expectation because the reducing in the total of Malaysia stock showed that the reducing in the availability of stock in the market. In theory economic, decreasing in the number of product will increase the price. Therefore, as the availability of stock is decrease, the producers will increase the domestic price.

For world substitute price, it is assume to have a negative relationship because decreasing in synthetic rubber price will make the natural rubber price increase.

4.2.6 Natural Rubber World Price

The variables for world natural rubber price are world synthetic rubber price, world stock and oil price.

$$LNWNRP_t = l_0 + l_1 LNPSBR_t + l_2 LNWSNR_t + l_3 LNOILP_t + \mu_{6t} \quad (18)$$

Positive sign are expected in coefficients l_1 and l_2. While l_3 is expected to has a negative sign. In world price equation, the world synthetic rubber price at time t is expected to have a positive relationship because of the substitution effect. Consumer will change its preference to the natural rubber source since the substitute price is high. This situation leads to a higher world natural rubber price. Next, stock is expected to have a negative sign because if stock in the world market is less, the world price will increase. The consuming country would buy natural rubber in replenish the consuming country stock in the market.

While, when crude oil price increase, substitution effect make positive relationship between both variable. Sources from crude oil will also have high price. Therefore, it assume will affect the natural rubber price in the positive relationship.

4.2.7 Natural Rubber Domestic Stock

Lastly, the natural rubber market model can be closed by using the stock equation. The formula of stock is production of natural plus import and domestic stock with lagged 1 year minus consumption and export of natural rubber.

$$LNDSNR_t = DLNDSNR_{t-1} + LNIMNR_t + LNPRODNR_t - LNCNR_t - LNEXNR_t \quad (19)$$

4.2.8 Natural Rubber World Stock

$$LNWSNR_t = LNDSNR_t + LNRESTWSNR_t \quad (20)$$

For world stock equation, the model been closed by domestic stock plus rest of world stock. The summary of system equation for Malaysia palm oil and natural rubber market model can be seen in Appendix 1.

V. CONCEPTUAL FRAMEWORK

Figure 2 which is the conceptual framework will explain the link of biodiesel mandate on Malaysian natural rubber market. It begins with the increase in the world crude oil prices and this increase will encourage the government to implement B5 mandate in the country. The implementation of mandate will increase the domestic demand for palm oil since palm oil is a feedstock for biodiesel. Next, it will reduce the stock of palm oil in the market. This will increase the domestic price of palm oil. The domestic price will affect the supply for natural rubber. The effect of biodiesel mandate in natural rubber industry can be seen through the palm oil price in the natural rubber supply equation. In this context, the high price of palm oil will decrease the production of natural rubber. Palm oil is the competing crop with natural rubber in terms of land allocation. Next, the decrease in natural rubber production will decrease the Malaysian natural rubber stock. The decrease in natural rubber stock will increase the price of natural rubber. Eventually the increasing in natural rubber price will decrease the consumption of natural rubber in Malaysia.

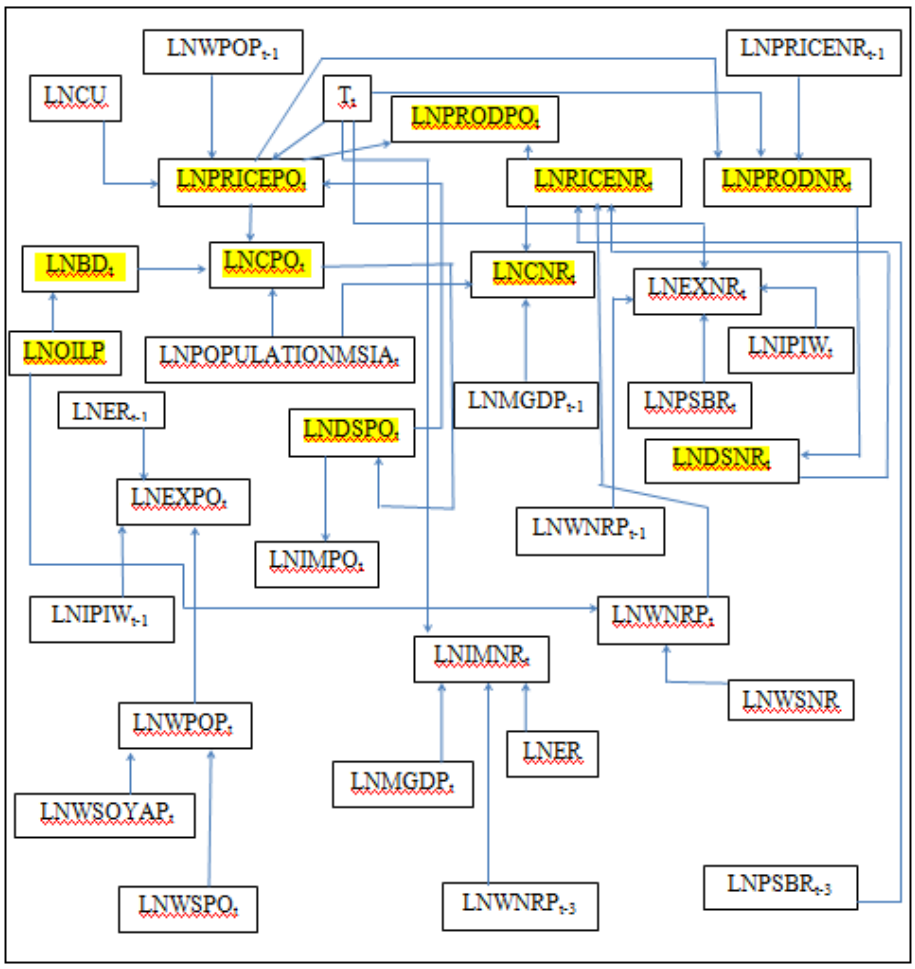


FIGURE 2: FLOW CHART THE EFFECT OF BIODIESEL MANDATE ON MALAYSIAN NATURAL RUBBER MARKET

TABLE 3
DEFINITION AND CLASSIFICATION OF VARIABLES

Variable		Definition
$OILP_t$	=	Crude oil price at time t (USD/barrel)
BD_t	=	Biodiesel mandate (tonnes)
CPO_t	=	Consumption palm oil at time t (tonnes)
$DSPO_t$	=	Domestic stock palm oil at time t (tonnes)
$PRICEPO_t$	=	Domestic price palm oil at time t (RM/tonne)
$PRODPO_t$	=	Production palm oil at time t (tonnes)
$WORLDNRP_t$	=	World price of natural rubber at time t (USD/tonne)
$PRODNR_{t-1}$	=	Production natural rubber with lagged 1 year (tonnes)
Variable		**Definition**
$DSNR_t$	=	Domestic stock natural rubber at time t (tonnes)
$PRICENR_t$	=	Domestic price natural rubber at time t (RM/tonne)
CNR_t	=	Consumption natural rubber at time t (tonnes)
$WSNR_t$	=	World stock natural rubber at time t (tonnes)
$PRODNR_t$	=	Production natural rubber with lagged 1 year (tonnes)

VI. CONCLUSION

Based on the previous literature review, this paper develops the conceptual framework in examining the effect of biodiesel blend mandate on Malaysian natural rubber market. Due to the competition of land between these two commodities, the implementation of biodiesel blend mandate in Malaysia is expected to interrupt the natural rubber industry. Decreasing production of natural rubber lately will worsen the situation. This trend worsen when in year 2012 and 2013, the import of natural rubber exceed export. Therefore, it is important for Malaysia to sustain the local raw materials and reduced the volume of latex import from other countries. Therefore, it is important to build a conceptual analysis especially after the implementation of biodiesel mandate on natural rubber market in Malaysia.

REFERENCES

[1] Acheampong, K., Dicks, M. R., & Adam, B.D. (2010). The impact of the biofuel mandates and switchgrass production on hay markets.Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management. St. Louis, MO. Retrieved from http://www.farmdoc.illinois.edu/nccc134

[2] Amna A. A. H., Shri, D. A., Fatimah, M. A. & Mad N. S. (2010). An econometric model of the Malaysian cocoa market. Retrieved at www.internationalconference.com.my/.../PAPER_232_MalaysianCocoaMarket.pdf

[3] Department of Statistics, Malaysia, (2013).Selected agricultural indicators Malaysia 2013.Retrieved from http://www.statistics.gov.my/portal/download_Agriculture/files/Selected_Agricultural_Indicators_Malaysia_2013.pdf

[4] Georges, J. (2012, August). Energizing livelihoods: The impact of the biofuel act in the Phillippines. Paper presented at the Agricultural and Applied Economics Association's 2012 AAEA Annual Meeting, Seattle, Washington. Retrieved from http://ageconsearch.umn.edu/bitstream/124952/2/Georges2.pdf

[5] Labys, W. C. (1973). Dynamic commodity models specification, estimation and simulation. Lexington, D. C. Health and Company.

[6] Malaysian Rubber Board, (2013). Natural rubber statistics 2011. Upstream: Malaysian's NR production. Retrieved from http://www.lgm.gov.my/nrstat/nrstats.pdf

[7] Mohamed, Y. & Mad Nasir, S. (1993). Production and trade model of the Malaysian natural rubber industry. Retrieved from http://www.ikdpm.upm.edu.my/forecasting/content/2-production.and.trade.model.of.the.malaysia.natural.rubber.industry.pdf

[8] Mohammed, Y. (1988). Malaysian natural rubber market model.Pertanika 11(3): 441-449. Retrieved from http://psasir.upm.edu.my/2629/1/Malaysian_Natural_Rubber_Market_Model.pdf

[9] Organization for Economic Co-operation and Development. (2013). OECD-FAO Agricultural Outlook 2011-2020. Retrieved from http://stats.oecd.org

[10] ShriDewi, A., Anizah, M. A., & Mohammad, A. (2013).Impact of biodiesel blend mandate (B10) on the Malaysian palm oil industry.In the Proceedings PERKEM VIII (2).766-777. Retrieved from http://www.ukm.my/fep/perkem/pdf/perkemVIII/PKEM2013_3D3.pdf

[11] Suwanakul, S., &Walies, E. J.(1987). Estimates of structural relationships for the world's rubber market with the particular emphasis on Thailand's natural rubber market.Kasetsari Journal (Social Science 8:173-188. Retrieved from http://kasetsartjournal.ku.ac.th/kuj_files/2010/A1009011508402812.pdf

[12] Taheripour, F., Hertel, T. W. & Tyner, W. E. (2011). Implications of biofuels mandates for the global livestock industry: a computable general equilibrium analysis. Agricultural Economics, 42, 325-342. Retrieved from http://web.ics.purdue.edu/~hertel/data/uploads/publications/biofuels-and-livestock-taheripour-hertel-tyner-agricultural-economics.pdf

[13] Welch. M., Pan, S., Mohanty, P. &Fadiga, M. (2008). Ethanol's effect on the U.S cotton industry. The Journal of Cotton Science 12, 99-108. Retrieved from http://www.cotton.org/journal/2008-12/2/upload/JCS12-99.pdf

APPENDIX 1

Table 1: Summary of the System Equation for Malaysia Palm Oil and Natural Rubber Market Model

Palm Oil Equation

i. Palm Oil Supply Equation

$$LNPRODPO_t = a_0 + a_1LNPRICEPO_t + a_2LNPRICENR_t + a_3LNGOV_{t-i} + \mu_{1t} \quad (5)$$

ii. Palm Oil Import Demand Equation

$$LNIMPO_t = b_0 + b_1LNDSPO_t + b_2LNWPOP_t + \mu_{2t} \quad (6)$$

iii. Palm Oil Domestic Demand Equation

$$LNCPO_t = c_1LNPRICEPO_t + c_2LNBD_t + c_3LNPOPULATIONMSIA_t + \mu_3 \quad (7)$$

iv. Palm Oil Export Demand Equation

$$LNEXPO_t = d_0 + d_1LNWPOP_t + d_2LNIPIW_{t-1} + d_3LNER_{t-1} + \mu_4 \quad (8)$$

v. Palm Oil Domestic Price Equation

$$LNPRICEPO_t = e_0 + e_1LNCU_t + e_2LNDSPO_t + e_3LNWPOP_{t-1} + e_4T_t + \mu_{5t} \quad (9)$$

vi. Palm Oil World Price Equation

$$LNWPOP_t = f_0 + f_1LNWSOYAP_t + f_2LNWSPO_t + f_3T_t + \mu_{6t} \quad (10)$$

vii. Palm Oil Domestic Stock Equation

$$LNDSPO_t = LNDSPO_{t-1} + LNIMPO_t + LNPRODPO_t - LNCPO_t - LNEXPO_t \quad (11)$$

viii. Palm Oil World Stock Equation

$$LNWSPO_t = LNDSPO_t + LNRESTWSPO_t \quad (12)$$

Natural Rubber Equation

ix. Natural Rubber Supply Equation

$$LNPRODNR_t = g_0 + g_1LNPRICEPO_t + g_2LNPRICENR_{t-1} + g_3T_t + \mu_{7t} \quad (13)$$

x. Natural Rubber Import Demand Equation

$$LNIMNR_t = h_0 + h_1LNMGDP_t + h_2LNER_t + h_3LNWNRP_{t-3} + h_4T_t + \mu_{8t} \quad (14)$$

xi. Natural Rubber Domestic Demand Equation

$$LNCNR_t = i_0 + i_1LNPRICENR_t + i_2LNPOPULATIONMSIA_t + i_3LNMGDP_{t-1} + \mu_{9t} \quad (15)$$

xii. Natural Rubber Export Demand Equation

$$LNEXNR_t = j_0 + j_1LNIPIW_t + j_2LNPSBR_t + j_3LNWNRP_{t-1} + j_4T_t + \mu_{10t} \quad (16)$$

xiii. Natural Rubber Domestic Price Equation

$$LNPRICENR_t = k_0 + k_1LNWNRP_t + k_2LNDSNR_t + k_4LNPSBR_t + \mu_{11t} \quad (17)$$

xiv. Natural Rubber World Price Equation

$$LNWNRP_t = l_0 + l_1LNPSBR_t + l_2LNWSNR_t + l_3LNOILP_t + \mu_{12t} \quad (18)$$

xv. Natural Rubber Domestic Stock Equatio

$$LNDSNR_t = LNDSNR_{t-1} + LNIMNR_t + LNPRODNR_t - LNCNR_t - LNEXNR_t \quad (19)$$

xvi. Natural Rubber World Stock Equation

$$LNWSNR_t = LNDSNR_t + LNRESTWSNR_t \quad (20)$$

TABLE 2
DEFINITION AND CLASSIFICATION OF VARIABLES FOR SYSTEM EQUATION FOR MALAYSIA PALM OIL AND NATURAL RUBBER MARKET MODEL

Type of Variables		Definition of the Variables
$LNPRODPO_t$	=	Production palm oil at time t (tonnes)
$LNPRICENR_t$	=	Domestic price of natural rubber at time t (RM/tonne)
$LNPRICEPO_{t-3}$	=	Palm oil price with lagged 3 years (RM/tonne)
$LNGOV_{t-3}$	=	Government expenditure with lagged 3 years (RM million)
μ_t	=	Error term at time t
$LNIMPO_t$	=	Import palm oil at current price (tonnes)
$LNDSPO_t$	=	Domestic stock palm oil at time t (tonnes)
$LNCPO_t$	=	Domestic consumptionat time t (tonnes)
$LNPRICEPO_t$	=	Domestic price of palm oil at current year (RM/tonne)
$LNBD_t$	=	Biodiesel mandate at time t (tonnes)
$LNPOPULATIONMSIA_t$	=	Population at time t (million)
$LNEXPO_t$	=	Export palm oil at time t (tonnes)
$LNWPOP_t$	=	World palm oil price at current year (USD/tonne)
$LNIPIW_{t-1}$	=	Index of industrial production with lagged 1 year (2005=100)
$LNER_{t-1}$	=	Exchange rate with lagged 1 year (RM/USD)
$LNCU_t$	=	Refining sector capacity utilization at time t (percent)
$LNWPOP_{t-1}$	=	World palm oil price with lagged 1 year (USD/tonne)
T_t	=	Time trend at time t
$LNWSOYAP_t$	=	World soybean oil price at time t (USD/tonne)
$LNWSPO_t$	=	World stock palm oil at time t (tonnes)
$LNRESTWSPO_t$	=	Rest world stock palm oil at current price (tonnes)
$LNPRODNR_t$	=	Production natural rubber at time t (tonnes)
$LNPRICEPO_{t-1}$		Domestic palm oil price with lagged 1 year (RM/tonne)
$LNIMNR_t$	=	Import natural rubber at time t (tonnes)
$LNMGDP_t$	=	Malaysia Gross Domestic Product at time t (RM million)
$LNER_t$	=	Exchange rate at current price (RM/USD)
$LNWNRP_{t-3}$	=	World natural rubber price with lagged 3 years (USD/tonne)
$LNCNR_t$	=	Consumption natural rubber at time t (tonnes)
$LNMGDP_{t-1}$	=	Malaysia Gross Domestic Product with lagged 1 year (RM million)
$LNEXNR_t$	=	Export natural rubber at time t (tonnes)
$LNIPIW_t$	=	Index of industrial production at current price (2005=100)
$LNPSBR_t$	=	World synthetic rubber price at time t (USD/tonne)
$LNWNRP_{t-1}$	=	World natural rubber price with lagged 1 year (USD/tonne)
$LNWNRP_t$	=	World natural rubber price at time t (USD/tonne)
$LNWSNR_t$	=	World stock natural rubber at current price (tonnes)
$LNOILP_t$	=	Crude oil price at time t (USD/barrel)
$LNDSNR_t$	=	Domestic stock natural rubber at time t (tonnes)
$LNDSNR_{t-1}$	=	Domestic stock natural rubber with lagged 1 year (tonnes)
$LNRESTWSNR_t$	=	Rest world stock natural rubber at time t (tonnes)