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Palm-Based Biodiesel Blend Mandate Increase on the Biodiesel Industry Growth in Malaysia: Evidence from Causal Loop Diagram

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Abstract

The government recent announcement to increase blend mandate of B10 for transportation sector and B7 for industrial sector has being deemed by expert as a huge turning point to Malaysia palm based biodiesel industry growth. However, this has attract several concerns on the viability of the industry especially during the low crude oil price period. To analyse this issue, the causal loop diagram of system dynamics method was built to explain the conceptual idea of developed model. The result found positive value from environmental and wide economic perspective despite negative value from cost-profit perspective. This study is important in changing current unfavourable perception towards government commitment in promoting the growth of biodiesel industry in Malaysia. Future works include thorough technical analysis using full stock and flow diagram as a continuum from this study.

Keywords: Palm-based biodiesel, conceptual model, system dynamics, causal loop diagram

1. INTRODUCTION

The world is craving for an alternative renewable fuel to reduce dependency on fossil fuel. Even though the plunging of crude oil price from economic perspective has discounted the feasibility of alternative fuel, in terms of environmental concern the search for renewable energy remain relevance. One of the widely developed renewable energy is biofuel. Biofuel are produced from vegetable oil and commonly blended with fossil fuel to be used in transportation and industrial sector. Some sector has even used one hundred percent biofuel without blending (e.g. B100 biodiesel) with no reported engine issues. These has given hope to the global community towards reducing the dependability on fossil fuel.

In Malaysia, government has launched biodiesel blend mandate to stimulate the growth of biodiesel industry. However, experts are questioning the government commitment in promoting biodiesel industry. The concerns include the significant influence on crude oil price (CPO) when biodiesel supply and demand enter the dynamic equation. When CPO become overly priced due to vibrant biodiesel demand, this will negatively affect downstream sector that use CPO as raw material particularly the food manufacturers. Ultimately, the production cost will be channelled to consumer. Another main concern is the cost that has to be borne by the government in order to retain biodiesel price competitiveness. This has been a major issue due to the low global crude oil price (Anonymous Biodiesel Producer, 2016). Despite the public concerns, government has recently announced the launching of new biodiesel mandate for transport sector from B7 to B10 and the use of B7 in industrial sector.

On that account, thorough investigation is needed to study the rationality of government commitment on biodiesel industry through pertinent policy implementation and its impact on palm oil industry. This study

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attempt to come up with an initial comprehensive preliminary analysis using conceptual model known as causal loop diagram (CLD) of system dynamics (SD). This diagram will be used for holistic causal and impact analysis of biodiesel blend mandate on Malaysia biodiesel industry. Furthermore, CLD also important for future development of full SD model. The outcome of this study is crucial as a preliminary effort in improving the perception towards the fully supported and high prospect but controversial biodiesel industry in Malaysia.

2. OVERVIEW OF MALAYSIA BIODIESEL INDUSTRY

As part of the government campaign to reduce dependability on fossil fuel, Malaysia has launched the National Biofuel Policy (NBP) in 2006 (MPIC, 2006). NBP aligned the government commitment to promote biodiesel usage domestically in all sectors. Further, Malaysia has launched the pilot B5 mandate programme in the federal administration of Putrajaya in 2011. This was then followed by four states: Malacca on July 11th, Negeri Sembilan on August 1st, Kuala Lumpur on September 1st, and Selangor on October 1st in the same year. B5 mandates programme requires the blending of five percent biodiesel with 95 percent petrodiesel targeted for the transportation sector. In 2014, the government increased the blend mandate from B5 to B7 for transportation sector. Recently, in 2016 the government announced B10 mandate programme for transportation sector and B7 for industrial sector. The implementation of B10 is deemed by expert to be a huge turning point for Malaysia biodiesel industry and put Malaysia on par with other biofuel countries like USA, Brazil, Indonesia Argentina and Colombia (Adnan, 2016).

Malaysia biodiesel mandate programme was launched for the purpose of stimulating domestic palm oil-based biodiesel (POB) demand. Furthermore, the programme was also meant to act as a CPO price stabilizing mechanism (Anonymous Biodiesel Producer, 2016). This is supported by finding from previous studies that found significant influence on CPO prices with the increase in POB demand (Ramli et al., 2007; Rahman et al. 2011; Shri-Dewi et al., 2011; Shri-Dewi et al., 2014). Furthermore, with high CPO stock reported each year, vibrant POB industry may help in utilizing the excess stock (Adnan, 2016). With the new implementation of B10 for transportation sector and B7 for industrial sector, the industry expected the combine POB consumption of approximately 750,000 tonne of CPO per annum (Adnan, 2016).

Even though biodiesel industry is driven by government mandate, the usage of biodiesel in transportation sector has few challenges. One of the major challenge is the engine compatibility issue. The auto manufacturer raises concern regarding the possible engine problem with the usage of biodiesel blended diesel including engine clogging and engine component damage (The Malaysian Reserve, 2016). To overcome this, government through its research bodies like Malaysia Palm Oil Board (MPOB) took initiative to run various on-field test using various blend of biodiesel including B5, B7, and B10 and produce technical report on the condition of the engine. The report found there is no significant issues with the usage of biodiesel blended diesel in their tested engine (Anonymous Biodiesel Producer, 2016).

Despite apparent government commitment in promoting biodiesel industry in Malaysia, experts has raised several issues on the economic viability of the industry even from the start of its launching (The Star, 2007). One of the important issues is regarding the high and uncertain prices of CPO (the main feedstock of biodiesel production). In the period of high CPO price, the production cost of biodiesel will increase subsequently deteriorating its price competitiveness as compared to petrol diesel price. Since biodiesel is mandate driven industry, government has to play its role by absorbing the price difference to retain biodiesel price competitiveness. This situation is exacerbate when global crude oil price is comparatively low like what is happening in the year 2016 which left the question whether it is an appropriate move for government to increase the blend mandate to B10. Theoretically, high blend mandates will increase biodiesel demand and further increase the existing high CPO prices. This in return may negatively impact the downstream sectors like food manufacturers that use CPO and PPO as its raw material. For this reason, current general perception on biodiesel industry can be concluded as not favourable (Anonymous Biodiesel Producer, 2016).

Hence, the use of appropriate method will help in evaluating the rationality of government commitment to uphold the biodiesel industry particularly in the current unfavourable economic period. Review of some of previous studies on Malaysia biodiesel industry is presented in the next section.

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3. REVIEW OF PAST STUDIES

Most of the previous studies on Malaysia biodiesel industry employed econometric time series analysis. Some of prominent studies include Ramli et al. (2007), Rahman et al. (2011), Shri-Dewi et al. (2011), and Shri-Dewi et al. (2014). These studies has shown a consistent finding on the significant impact of biodiesel industry on CPO prices.

Apart from econometrics, SD is a method from system thinking approach that has been proven to be useful in analysing the dynamic and complexity of problem including in biodiesel industry. Contrary to econometrics method, SD emphasize on the analysis of economic behaviour and underlying feedback process in a system. This section review the most recent studies which adopt SD method in analysing Malaysia biodiesel industry.

A study by Mohammadi et al. (2015) examined the impact of palm-based biodiesel on CPO production in Malaysia. The authors used SD to simulate scenario where B10 and B15 are implemented. The findings indicate the increase of fresh fruit bunch (FFB) yield and CPO production in Malaysia where additional demand are created with the implementation of higher blending mandate. The study on the other hand did not conclude the practicability of increasing blend mandate. This is important to verify government persistence in developing biodiesel industry relevancy particularly in the current period of low crude oil price.

Another study by Shri-Dewi et al. (2015) employed SD to investigate the suitable blend mandate for biodiesel industry in Malaysia. The study simulated the scenario of B5, B7 and B10 implementation and analyse their impact on Malaysia palm oil industry. The findings concluded that increasing blend mandate is not economically feasible because it will increase the need of biodiesel subsidies by government to ensure the biodiesel price competitive as compared to petrol diesel. However technically, the scope of the model was limited to the perspective of cost-profit of biodiesel production only which resulted into unfair analysis. On the contrary, the model should expand its scope by considering the impact from environmental or wide-economic perspective that will allow a multi-perspective analysis to avoid unwarranted conclusion on Malaysia biodiesel industry.

This study follow the establishment of SD method in an attempt to understand the dynamic of Malaysia biodiesel industry. Unlike the aforementioned previous study, we have incorporated additional variables so that multi-perspective analysis can be executed. The development of SD model involve several stages and this study on the other hand focuses on the initial stage of SD model development called conceptualization stage. In the conceptualization stage, conceptual model is built to describe the relationship between main variables and greatly facilitate the development of SD model. In this study, the analysis of biodiesel industry is done using conceptual model developed in the conceptual stage to obtain initial insights of the industry dynamic.

4. CONCEPTUAL STAGE IN SYSTEM DYNAMICS

SD rooted from the invention of industrial dynamics by Professor Jay W. Forrester in 1961 (Forrester, 1961). The concept evolve into SD and has been widely used in operation research field in various problem domain including agriculture (Shri Dewi et al., 2015), human diet management (Abidin et al., 2014), and healthcare (Halim et al., 2015). SD main attributes include its intensification on feedback process when modeling a system. SD also provide a platform for experimenting the impact of various scenarios and possible policy interventions in a system.

In conceptual stage, dynamic hypothesis is formulated before developing SD model. Dynamic hypothesis provides an explanation of the underlying feedback process in the system thus guiding the modeling efforts by focusing the modeler on certain structure (Sterman, 2000). The step for building dynamic hypothesis can be referred from Albin (1997). As shown in Fig. 1, there are four essential steps including defining model purpose, defining the factor that influence key variable, describing the reference mode, and constructing the initial model diagram.

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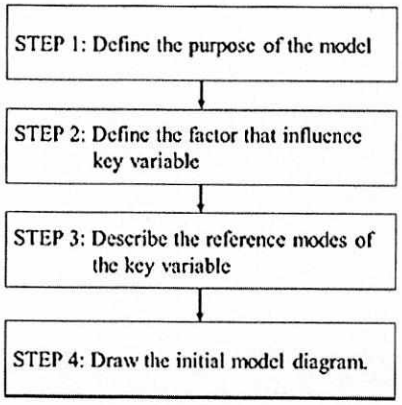

Fig. 1. Steps in formulating dynamic hypothesis.

In the final step of building dynamic hypothesis an initial model diagram will be produced. This initial model diagram is called as a conceptual model. In the standard SD modeling practice, conceptual model is usually built using CLD. Theoretically, CLD is drawn to capture the qualitative element of the studied system. CLD is very helpful in the early phases of model building especially in capturing the mental model of the problem in non-technical fashion (Sterman, 2000). CLD is built using variables and arrow which represent the relationship among variables.

CLD capture two types of feedbacks process in the studied system: positive and negative feedback. Positive feedback act as self-reinforcing force which amplifies effect brought by changes of variables in a loop. On the other hand, negative feedback poses a balancing loop where changes in a variable leads to a counteracting change of the total output in the loop (Morecroft, 2007). Positive and negative feedback are sometimes marked with 'R' and 'B' denoting 'reinforcing' and 'balancing' respectively. Albeit its usefulness, CLD only act as tool for preliminary analysis of studied system and can never be taken as complete imitation of real system. The limitation of CLD include non-distinguishable of stocks and flows and lack in details of feedback loops of the system (Sterman, 2000). The final SD model often include the quantifying process of variables' inter-relationship and translated into a stock and flow diagram (SFD) before full technical analysis can be done accordingly.

In this study, a comprehensive preliminary analysis of Malaysia biodiesel industry is done using CLD. A full model in a form of SFD will be developed as future works continuum from this study.

5. CONCEPTUAL MODEL OF THE MALAYSIA BIODIESEL INDUSTRY

Development process of conceptual model related to Malaysian biodiesel industry is closely referred to the dynamic hypothesis development step adopted from Albin (1997). Details of each step is successively explained in the next subsection.

The purpose of model development

The general purpose of the model is to study the effect of increasing biodiesel blend mandate on Malaysia palm oil industry and its biodiesel sector.

Key variables of the model

The key variables in biodiesel industry are identified through reviewed literature backed by data obtained from data collection process. In this study, collected data consist of primary and secondary data. Primary data are gathered through interview session from players in the industry. This include the producers and governing body which directly involved in designing policies in biodiesel industry. On the other hand, secondary data are

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collected from the literature review and Malaysia palm oil database available for public access compiled by Malaysian Palm Oil Board (MPOB) website (MPOB, 2016). Table 1 summarizes the data type and its sources.

Table 1. Type of data and its source.

Data type	Description	Source	Year
Primary data	Overview on the past and current situation of Malaysia palm oil industry.	• Meeting with industry players	2015
Secondary data	Historical time series and latest data on palm oil market (e.g. production, prices, export, and consumption)	• MPOB website • Newsletter from MPOB • Annual report from MPOB	2000 - 2015

There are several key variables identified in the biodiesel industry. Table 2 listed the key variables classified based on exogenous or endogenous type. The list is an initial compilation of important variables to kick start the development of SD model. In the later stage, more variables maybe added as understanding of the model increase and also to add further precision in depicting real system.

Table 2. List of key variables included in the model.

Type	Variables	Description
Endogenous	Biodiesel supply	Biodiesel supply represent the production and stock of biodiesel.
	Biodiesel demand	Domestic and export demand.
	CPO supply	The feedstock for biodiesel is CPO so it is important to include CPO supply which include CPO production, import and stock.
	CPO demand	Apart of biodiesel feedstock, CPO is mainly used to process PPO which become the main ingredient in food and non-food industry.
	CPO prices	The ratio between CPO supply and demand determine the CPO prices. With an increase in CPO demand to cater biodiesel sector, CPO prices will show significant effect.
	Overall revenue from palm oil sector	Palm oil and its products is one of the major contributor to Malaysia Gross National Income (GNI). The fluctuation of CPO prices thus exhibit significant influence to the nation income.
	Livelihood quality of smallholder	As compared to major oil palm plantation estates, oil palm smallholder is the most affected by CPO prices.
Exogenous	Biodiesel mandate	The main policy in biodiesel industry is biodiesel blend mandate.
	Petrol diesel prices	Petrodiesel price influence the competitiveness of biodiesel prices.

The hypothesized reference mode

For comparison, reference mode is established from historical data or hypothesized mental model built with plot of the behavior of key variables of a system over time. Reference mode is essential both as a guide and a test throughout the model building process (Albin, 1997). One of the important policy in biodiesel industry is biodiesel blend mandate. Based on the reviewed literature and interview with industry players, the increase of blend mandate is hypothesized to increase biodiesel demand, CPO prices, overall revenue from palm oil industry and the livelihood quality of oil palm smallholder. On the other hand, with increase CPO prices the demand for it will increase in diminishing rate until the CPO prices reach the highest tolerable level and eventually tumble demand. However this process involve time delay particularly in the case where price of commodity were based on future price contract. In terms of the model time horizon, the period from year 2000 until 2030 is chosen. The time horizon is assumed sufficient in depicting the pre- and post-implementation of biodiesel blend mandate in year 2011. Fig. 2 shows the hypothesized mental model used as references mode in this study.

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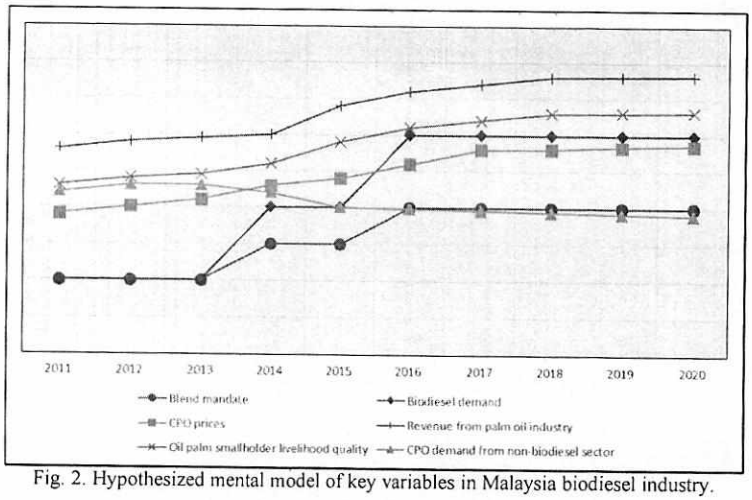

Fig. 2. Hypothesized mental model of key variables in Malaysia biodiesel industry.

Causal loop diagram for biodiesel industry

CLD is drawn as an initial model diagram to determine the basic mechanism of Malaysia biodiesel industry. Fig. 3 shows the CLD for this study with two positive and negative feedback loops. The impact of biodiesel industry will be measured based on three values namely environmental, cost-profit, and wide economic values. Note that these variables are put in hexagon box.

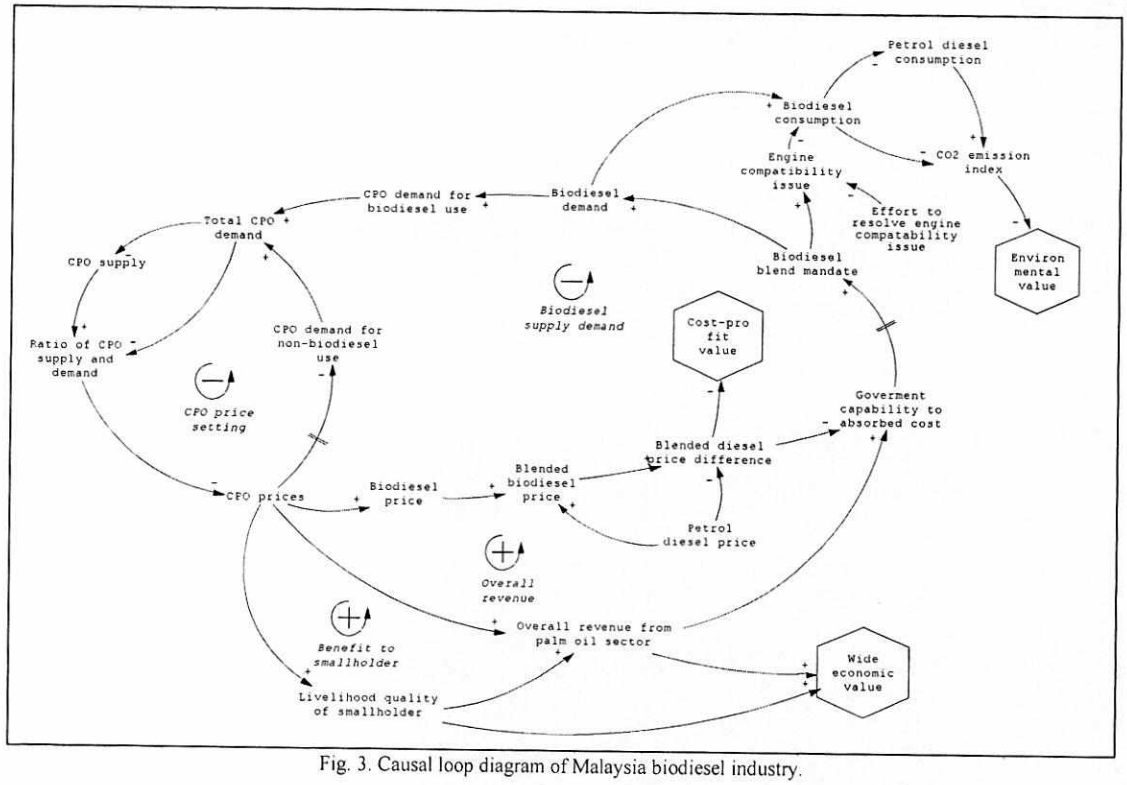

Fig. 3. Causal loop diagram of Malaysia biodiesel industry.

The first negative loop is CPO price setting loop. CPO supply and demand made up a ratio of CPO supply and demand. The ratio determine the CPO prices. When CPO demand exceeds its supply, CPO prices will increase

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and vice-versa. High CPO price discourage the purchase of CPO for non-biodiesel production like food industry. However, the CPO price effect on demand may involve some delay because the commodity trade normally depend on future contract prices. High CPO price eventually will lower CPO demand for non-biodiesel use and decrease total CPO demand. Low CPO demand increase the ratio as CPO demand exceed its supply and increase CPO prices again.

The second negative loop is biodiesel supply demand loop. With the addition of biodiesel supply demand loop, it will further helps in increasing CPO price and act as stabilizing mechanism. When CPO price is low due to excess in CPO supply, additional CPO demand from biodiesel sector helps in boosting CPO price. CPO price unfortunately contribute to the increase of biodiesel price due to the fact that major portion of biodiesel production cost is coming from its feedstock price (Yahaya et al., 2006). The blended diesel price then is generated based on biodiesel price and petrol diesel price using Automatic Price Mechanism (APM) under strict government supervision (Anonymous Biodiesel Producer, 2016). Biodiesel industry in Malaysia is currently a mandate driven industry. Thus, the difference in blended biodiesel price will be absorbed by government to retain its competitiveness compare to petrol diesel price. On that account, this raise the question regarding how far the government will continue to absorb the cost in price difference. The higher the difference between blended diesel price and petrol diesel price, the lower cost-profit value will be.

The government capability to absorb price difference will influence, albeit after some delay, the decision to increase blend mandate. In other words, it may take some time before new blend mandate is announced because the increase of blend mandate will stimulate more demand for biodiesel, disrupting CPO supply-demand ratio and ultimately increase biodiesel price. Wider price gap require government to absorb more cost to ensure the competitiveness of blended diesel price.

The increasing of blend mandate also solicit issue such as engine compatibility. This is currently happening with the recent launching of B10 diesel. Automaker raise concerns of possible engine damage with the usage of B10 diesel (The Malaysian Reserve, 2016). It will take some delay to resolve the engine compatibility issues before B10 can be fully accepted by automaker. In the same loop, the increasing of biodiesel consumption offset the usage of petrol diesel particularly in the transportation sector. The use of biodiesel reportedly emit 40 to 50 percent less CO^2 as compared to petrol diesel (Pehnelt & Vietze, 2013). Hence, higher biodiesel consumption will result in higher environmental value.

Final loop is the two positive loop: overall revenue loop and benefit to smallholder loop. Higher CPO prices add more contribution in terms of national revenue from palm oil sector. In simple term, every increment of RM100 in CPO price per tonne contribute to RM2 billions of national revenue from palm oil industry (Adnan, 2016). More revenue will strengthen the government capability to absorb the cost difference between blended diesel price and petrol diesel price. Subsequently, biodiesel will continue to grow vigorously under this loop as long as CPO price keep increasing. Nevertheless, the balancing price setting loop will balance out the outcome and keep CPO price from becoming extremely high. Stable CPO price keeps all affiliate industry like food industry as well as biodiesel industry from severe consequences. Moreover, stable CPO price will also ensure the livelihood quality of oil palm smallholder at satisfying level. Oil palm smallholder is the most affected party during the low CPO price period due to their small scale economic activity as compared to estate owners (The Malaysian Reserve, 2016). Both overall revenue from palm oil industry and livelihood quality of smallholder variables determine the wide economic value of biodiesel industry in this study.

6. SCENARIO EVALUATION USING CONCEPTUAL MODEL

Although CLD is limited of its function in imitating the real system for full analysis, it is always provisional in capturing the important feedback process in a complex system (Sterman, 2000). Thus, initial analysis based on CLD can be done for brief understanding of the basic mechanism and component's impact on the system behaviour. We start the analysis with brief explanation on current Malaysia economic situation. We then incorporate the information gather from current economic situation in Malaysia into the conceptual model for analysis. The elaboration of the analysis is presented following each loop in the conceptual model.

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In 2016, global crude oil price is currently at the average lowest record in the history at approximately USD47 per barrel (NASDAQ, 2016). Further, in the same year government has announced the launching of B10 for transportation sector and B7 in industrial sector. On that reason, the concern arise whether it is a right move by government given that average CPO price is currently high at average RM2700 per tonne making biodiesel price less competitive as compared to petrol diesel (MPOB, 2016).

The implementation of new blend mandate stimulate CPO demand for biodiesel. In biodiesel supply demand loop, the ratio of CPO supply over demand will drop and further increase CPO prices. Increase CPO prices means extra cost for biodiesel production thus increasing biodiesel prices and widening the price gap with petrol diesel. The current low petrol diesel price exacerbate the biodiesel price competitiveness. This means more cost has to be borne by government to sustain the production of biodiesel. Cost-profit value thus mark a negative value. Nevertheless, increased biodiesel mandate spark more biodiesel demand which increase biodiesel consumption. High biodiesel consumption offset petrol diesel consumption. Industry experts expected the implementation of B10 and B7 in transportation and industrial sector respectively will consume up to approximately 750,000 tonne of biodiesel. That is equivalent 750,000 tonne petrol diesel consumption offset and about 40 to 50 percent or 375,000 tonne equivalent less CO^2 emission. The impact on environment is significant thus environmental value mark a positive value. Fig. 4 illustrate the feedback process in biodiesel supply demand loop.

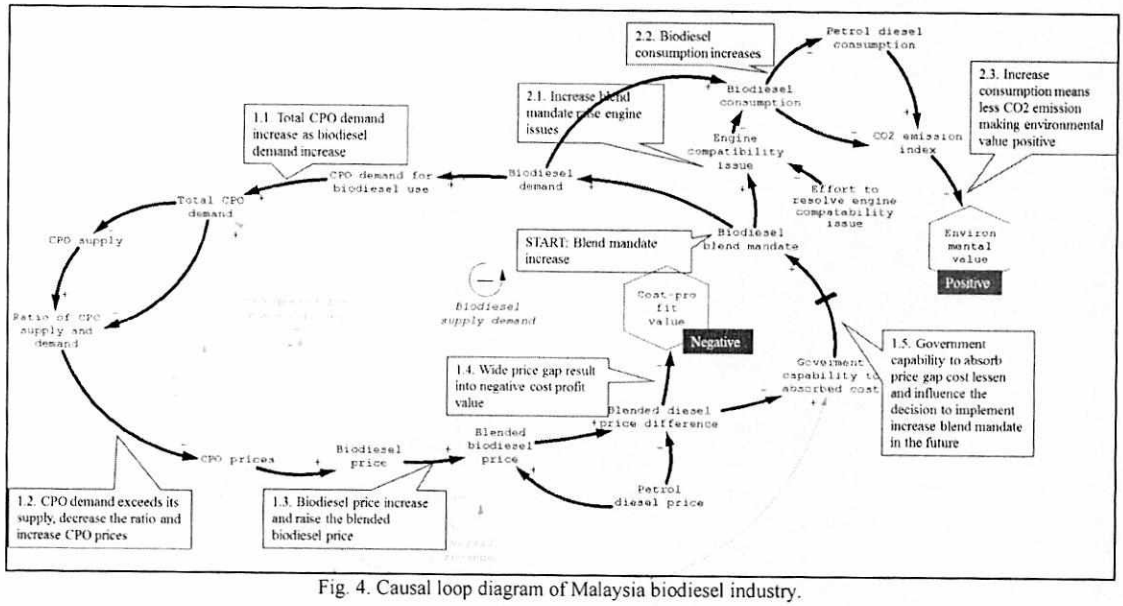

Fig. 4. Causal loop diagram of Malaysia biodiesel industry.

With high CPO prices, the overall revenue from palm oil sector increases and contribute to the capability of government to absorb cost differences between blended diesel and petrol diesel prices. Simultaneously, high CPO prices benefits the livelihood quality of oil palm smallholder which also add up the contribution to the increase of overall revenue in palm oil sector. This is because with good income, there will be less allocation channelled to help smallholder in terms of their daily expenses as well as plantation activities. Moreover, good income stimulate the domestic economic activities in non-direct fashion because it increase the purchasing power of oil palm smallholder. Hence, wide economic value mark a positive value. Fig. 5 illustrate the feedback process in overall revenue loop and benefit to smallholder loop.

In long term, high CPO prices bring negative impact on non-biodiesel industry and after some delay the demand will be slowed due to capacity planning to accommodate high raw material price. Slow demand increase CPO supply vis-à-vis its demand and eventually return CPO price back to its equilibrium. Note that the process involves delay because CPO price purchase is normally based on future contract prices, where short term CPO

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price fluctuation has little impact on production. In this scenario, price setting loop act as price stabilizing mechanism due to perturbation from biodiesel supply demand loop. Fig. 6 illustrate the feedback process in price setting loop.

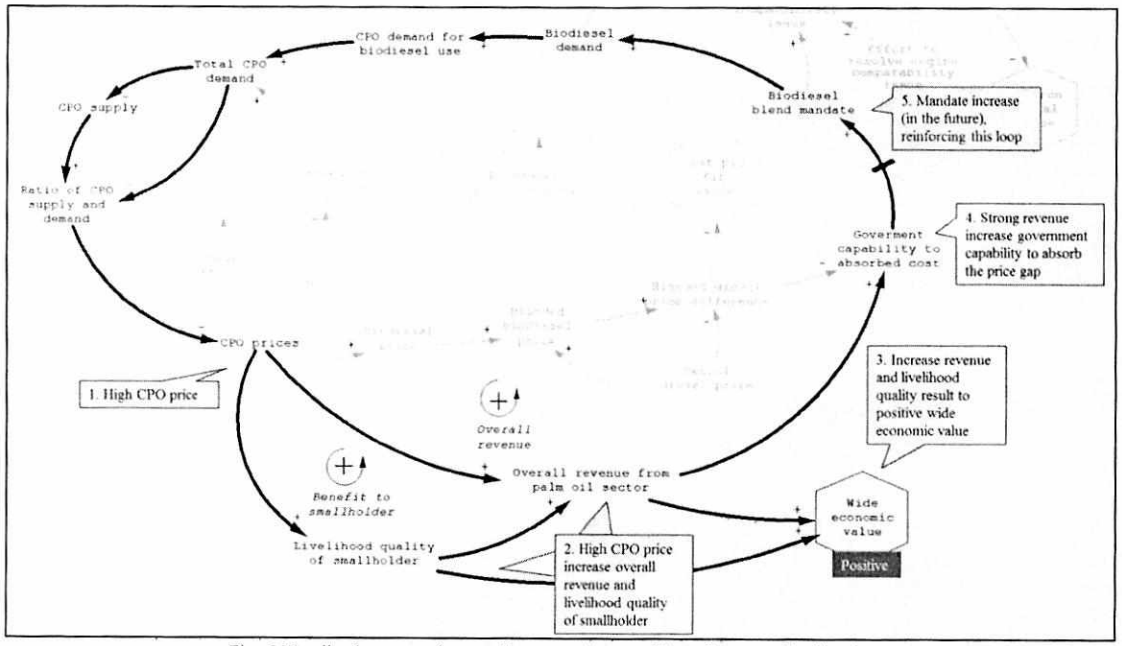

Fig. 5. Feedback process in overall revenue loop and benefit to smallholder loop.

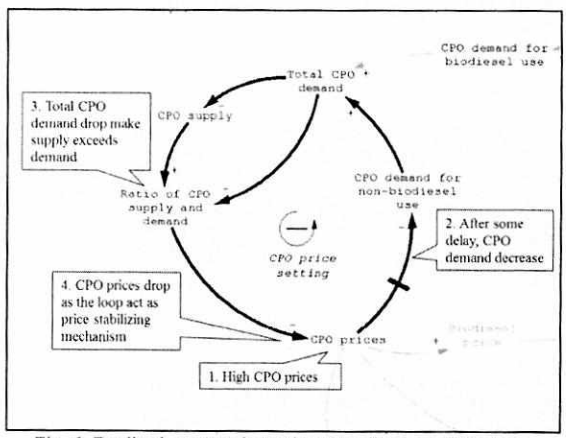

Fig. 6. Feedback process in crude palm oil price setting loop.

As a conclusion, environmental and economic values both mark positive while cost-profit value mark negative. Based on this result, it is proven that government commitment in developing biodiesel is rational even though the current economic condition is unfavourable.

7. CONCLUSIONS AND FUTURE WORKS

In this study, we assess the impact of various blend mandates towards Malaysia biodiesel industry based on three values namely cost-profit, environmental, and wide economic values. Analysis using conceptual model based on current economic situation produced positive environmental and wide economic value but negative

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cost-profit value. These suggest the rationale behind government persistence in promoting and developing biodiesel industry despite the unfavourable economic condition.

Another important finding from the analysis is that palm oil industry has effective price stabilizing mechanism with the addition of biodiesel supply demand loop. In the period of low CPO price, biodiesel can help in boosting CPO price by utilizing excess CPO stock and depress CPO supply. Biodiesel production does not significantly affected by high CPO prices because it is mandate driven industry. However, extremely high CPO prices may negatively affect CPO demand for non-biodiesel sector in the long term. When this happen, negative price setting loop, after some delay, will act as stabilizer and return CPO price to optimal level. In other words, the presence of two negative loops complement each other as CPO price stabilizing mechanism. Stable CPO price embolden vigorous growth both palm oil industry and biodiesel sector.

The use of conceptual model for analysis has produced comprehensive preliminary insight on Malaysia biodiesel industry. However, the analysis outcome is subject to technical limitation of CLD. Thorough analysis is plausible through the quantification of component relationships and addition of necessary details by developing SFD. In addition, counter-intuitive behaviour may also be revealed during the analysis of SFD. Next step will be the development of quantitative model in the form of SFD followed by various validation test of its structure and behaviour. SFD will permeate more thorough and technical analysis of Malaysia biodiesel industry.

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