Middle-East Journal of Scientific Research 13 (8): 972-982, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.13.8.3345

# Market and Welfare Economic Impacts of Sustainable Forest Management Policy on Timber Market in Sarawak, Malaysia

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**Abstract:** The main objective of this study is to analyse the impact of Sustainable Forest Management (SFM) practices on the timber market in Sarawak, Malaysia. A partial equilibrium model was applied in this study covering domestic and international timber market namely supply, domestic demand and export demand of timber. It was analysed by using a system of equations approach. All of the data are annual time series basis from 1970 to 2008. Based on the first three scenarios, the results show that changing from the conventional logging (CL) practices to SFM practices, reduce the equilibrium quantity of timber and increase the price level. The welfare economic impacts of SFM provide empirical evidence that there is a loss in welfare economic impacts on the timber industry in Sarawak, Malaysia. However, an increase in the domestic price of timber would help to compensate for the loss volume of timber. In addition, the scenarios of market access shows that Sarawak timber industry could benefit from this advantage.

**Key words:** Consumer surplus · Producer surplus · Equilibrium price · Equilibrium quantity

## INTRODUCTION

In Malaysia, [1] has conducted a study of total economics valuation (TEV) approach in the context of Conventional Logging (CL) and SFM practices. The TEV involves use value, non-use value, direct use value, indirect use value, option value, existence value and quasi-option value.

Table 1 indicates several goods and services with respect to the economic value estimated from the two types of forest management practices namely Conventional Logging (CL) and Reduced Impact Logging (RIL) practices where RIL is also represent the implementation of SFM practices. Both CL and RIL deal with the impacts of the forest management practices on the goods and services of the forest multiple functions through economic analysis. Economic analysis is referring to the social effects or externality effects that might occurred due to timber harvesting operations. For example, some of these include hydrological, rattan, bamboo, recreation, domestic water, fish, endanger species and carbon storage. The full valuation of forest goods and services would yield surpluses for countries to invest in and achieve SFM.

Owing to the externality effects, SFM policy is in favor to provide greater positive externality effects compared to CL practices. For example in Table 1, [1] found that at national benefit, the total social benefits under CL and SFM are RM627/ha and RM1,118/ha respectively. This has also increased the global benefits from RM8,389/ha to RM9,146/ha under CL and SFM respectively. In addition, [2] revealed that the cost of treating the water is lower under SFM practices with less externality effects.

This study will not only analyse the determinant of Sarawak timber market, but also internalise the externality effects in the systems analysis. For example, to minimising the externality effects from timber harvesting operations, the additional activities and procurement are really needed. This will lead to increase in the operational cost. A study by [5] revealed that the operational cost has increased by 47% due to additional activities that may

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Table 1: Forest of goods and services valuation under CL and SFM practices

| Goods/ Services | Method / variable analysis | Location | Value estimated CL | SFM | Source |
|---|---|---|---|---|---|
| Total social benefits[a] | TEV | Malaysia | RM627/ha | RM1,118/ ha | [1] |
| Total global benefits[b] | TEV | Peninsular Malaysia | RM8,389/ ha | RM9,146/ha | |
| Carbon Storage | TEV | Peninsular | | | |
| Malaysia | RM8,049/ha | RM8,677/ha | | | |
| Water | Cost of water treatment | Peninsular Malaysia. | RM704/ha | RM1,477/ha | [2] |
| Timber and non-timber | Cost-benefit (NPV) | Sarawak | RM9100/ha | RM9905/ha | [3] |
| Watershed protection | NPV | Peninsular Malaysia. | RM1,019/ha | RM1,060/ha | [4] |
| Forested catchment | NPV | Peninsular Malaysia. | RM1,006.1/ha | RM740.7/ha | [4] |

Notes: [a](Hydrological, rattan, bamboo, recreation, domestic water and fish). [B](Endanger species and carbon stock)

minimise the externality effects. In addition, the incremental cost of treating water due to timber harvesting will also incorporate in this analysis. This is because it could consider as externality effects as the third party namely water treatment plant has to bear higher cost in treating the water resulting from timber harvesting. One recent study by [6] showed that the cost of water treatment has increased by 49% due to timber harvesting activities. This is crucial issues need to analyse and discuss because if there is a significant distortion in the market, government intervention is one of the solution to easy the problem..

To make it clear, timber market in this study is also known as log market. Most of previous studies on timber market, the analysis typically deals with the prices, supply and demand in domestic and international market. However, to the best of authors knowledge, none of the study has analysed timber market by internalising the value of price and quantity as the value which incorporated the externality effects. For example, a current domestic timber prices in Sarawak is just determined by the market driven. It is expected that by internalising the externalities, the price would potentially higher than the current prices. Hence, government intervention is really needed to correct the distortion. In this context, this present study will provide some evidences that could be used by the government for decision making process. Therefore, the optimum level of output and price at externality level will be quantified because the net benefit is maximised when it takes into account the negative externality effects as well [7].

Most of the studies conducted either locally or abroad revealed that there is incremental cost in operating SFM other than the reduction in timber production [8,9]. All of these possible changes are directly related on harvesting regulations and additional guidelines on timber harvesting activities. This is because information about productivity, cost and applications of timber harvesting activities are important component for management plans [26]. Hence, this will reduce the volume of timber which can be extracted from forest as well as incurred higher cost. In other words, in the short run, it may reduce potential harvesting volumes and producers may have to bear higher cost in implementing SFM. However, in the long run, this may support a sustainable level of production that will exceed of what would be possible in later years if environmentally harvesting systems were to be continued [10]. Beside the issues of operation cost and timber production, several other elements in SFM that potentially give direct impact to timber market are also identified; such as price premium and market access. With regard to the economic reasons, timber producers must acknowledge that there are some economic advantages to participate in SFM.

With the above issues raised relating to the Malaysian timber industry, it is paramount that the market to be understood in term of the relationship of its major parameters. It has become essential to know the various impacts of SFM practices on timber market in Sarawak, Malaysia. This is where we have to come out with several scenarios of SFM practices and carry out simulations analysis for examining the market and welfare economic impacts.

**Methodology and Data:** While there are different issues in forest sector policies analysis, the analytical framework is quite similar. The common approach is to develop a forest sector model and to simulate the impacts of the policy on timber and product markets for domestic or international markets. A typical model building involves the estimation of output consumption, price and trade of the timber products. The impacts of the policies were evaluated by comparing the simulated results for with and without policy scenarios.

Studies on forest related policies such as [8,11,12] have used such framework. However, this paper differs as it takes into account the SFM policy by incorporating with several scenarios of SFM practices namely (1)

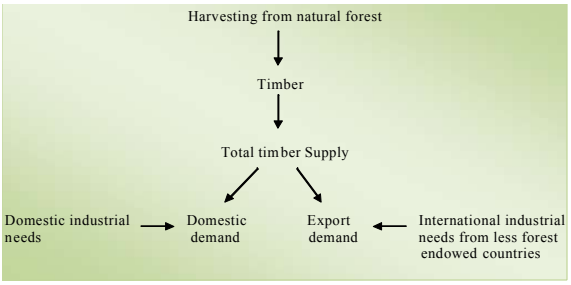


Fig. 1: Schematic diagram of timber supply

reduced by 24-percent in harvested area, (2) increased by 49-percent in external cost of timber harvesting, (3) increased by 47-percent in the cost of internalisation the externalities and (4) 20-percent gain in market access. In other words, the current input cost of timber harvesting operations has to be incorporated together with the cost related to the externalities. This is where most of the prior studies have ignored the externality effects in their econometric modeling.

**Malaysian Timber Market Model:** This study adopted and modified the model developed by [11,12, 9]. Timber that comes from natural forests will be analysed in this study.

The schematic diagram (Figure 1) not only shows the flow of production of timber but also insist on developing the model. There are timber supply, domestic demand and export demand in the diagram. Import demand is not considered in this study. This is because Malaysia is not fully relying on imported timber particularly for Sarawak. The detailed justifications will be explained in the next section.

**Supply of Timber from Natural Forest:** The timber supply from natural forest is given by the equation:

$$\ln TS_t = \alpha_0 + \alpha_1 \ln P_t + \alpha_2 \ln AH_t + \alpha_3 \ln IC_t + \alpha_4 \ln TS_t + \varepsilon_t \quad (1)$$

Where:

$\ln TS_t$ = Supply of natural forest timber
$\ln P_t$ = Price of timber
$\ln AH_t$ = Harvested area in natural forest
$\ln IC_t$ = Total salaries and wages paid in logging industry
$\ln TS_{t-1}$ = Lag supply of timber supply by one year
$t$ = Years
$\varepsilon_t$ = Error term
ln = Natural logarithm

Equation (1) estimates the total supply of timber from natural forest, which should be positively related to the natural forest timber prices and harvested area in natural forest. $TS_t$ is the supply of natural forest timber as endogenous or dependent variable. $P_t$ is the price of natural forest timber, which is an important variable in determining the quantity of natural forest timber supply. $AH_t$ is the natural forested area open for harvesting. $IC_t$ is total salaries and wages paid in logging industry represents to the production cost. $TS_{t-1}$ is previous year natural forest timber supply, which have influenced the natural forest timber supply.

Incorporation the cost of internalisation the externalities and external cost
Input cost under the scenario of SFM = input cost + cost of internalisation the externalities (2)

Input cost under the scenario of SFM = input cost + external cost of timber harvesting (3)

Equations (2) and (3) explain the situation where the timber market model is incorporated with the cost of internalisation the externalities and external cost. Incorporation those elements are crucial, otherwise it can lead to the market failure. Market failure associated with the externality effects resulting from timber harvesting activities in forest. Without taking into account the externality effects, the timber production from natural forest could be considered as being managed without sustainably produced. In other words, it cannot achieve the optimum level of quantity and price of timber. Most of previous studies especially studies using econometric modeling had ignored the monetary value of externalities and external cost of timber harvesting in their research. Therefore, this study tries to incorporate those elements so that the research outcome could represent the optimal level estimation of quantity and price in timber market.

**Demand of Timber from Timber Processing Mills:**

$$\ln DD_t = \alpha_0 + \alpha_1 \ln P_t + \alpha_2 \ln IPI_t + \alpha_3 \ln WMP_t + \alpha_4 \ln DD_{t-1} + \varepsilon_t \quad (4)$$

Where:

$Dd_t^*$ = Domestic demand for timber
$P_t$ = Domestic price for timber
$IPI_t$ = Industrial production index
$WMP_t$ = World import price of timber

$DD_{t-1}$ = Lag of domestic demand for timber for by one year
$_t$ = Years
$\varepsilon_t$ = Error term
ln = natural logarithm

Equation (4) describes the estimated total domestic demand for timber from natural forests. It suggests that the lower the price offer, the higher the volume of forest timber demanded domestically. On the other hand, the higher world import price of timbers would encourage further consumption of domestic timbers. Similarly, the higher industrial production index (IPI) would promote timber processing mills (i.e. sawmills, plywood and veneer mills) to demand more domestic timbers. Instead of using Malaysian income, IPI will be used in this study because timber demand is considered as intermediate goods. IPI is also used to measure the economic growth of timber-based manufacturing industries and it should therefore be positively related to the timber demand. When there is a growth in timber processing mills, demand for timbers would rise but domestic demand would have to compete with other substitute such import of timber. Hence, we used world import price of timber (WMP) which represents substitute good. It suggests that the higher the WMP, the higher the volume of domestic demand of timbers. $\ln DD_t^*$ is the dependent variable for domestic demand for timber, which is influenced by the domestic price of timber ($P_t$), Industrial production index ($IPI_t$), world import price of timber ($WMP_t$) and the previous year's domestic demand of timber ($DD_{t-1}$).

**Export Demand of Timber from less Forest Endowed Countries:**

$$\ln XD_t = \alpha_0 + \alpha_1 \ln XP_t + \alpha_2 \ln MKA_t + \alpha_3 \ln ER_t + \alpha_4 \ln SWP_t + \alpha_5 \ln XD_{t-1} + \varepsilon_t \quad (5)$$

Where:
$Xd_t$ = Export demand for timber
$Xp_t$ = Export price for timber
$Er_t$ = Exchange rate
$MKA_t$ = Market access
$SWP_t$ = World average price of softwood timber
$Xd_{t-1}$ = Lag of timber export for by one year
$_t$ = Years
$\varepsilon_t$ = Error term
ln = Natural logarithm

Equation (5) is expected to estimate the total export demand for timber from natural forests. It is expected to show a negative relationship with the export price for timber export. Whereas, positive relationship with the exchange rate, market access and its substitutes good which refers to world average price of softwood timber. *MKA* measures the ratio of market access. For example the ratio total timber exports of Sarawak with total timber import by the importing countries that imported timber from Sarawak. There is a positive relationship between exported demands of timber with *MKA*. This is because the higher the ratio, this shows timber from Sarawak is the main favorite from timber importing countries as a result of SFM practices. $XD_t$ is an endogenous or dependent variable for export demand equation. Timber export demand is influenced by the export price of timber ($XP_t$), exchange rate ($ER_t$), market access ($MKA_t$), world average price of softwood timber ($SWP_t$) and the previous year's timber export ($XD_t$).

*Closing Identities (Total Supply of Timber)*

The above timber market model has three main equations. To close the system, an identity equating timber availability with summation of domestic and export demands of forest timbers is postulated as equation below:

$$Ts_t = DD_t + XD_t \quad (6)$$

To analyse the timber market model, this study estimates timber supply and demand for domestic and export market. Then, re-estimate the supply and demand simultaneously followed by simulation analysis of several scenarios under the SFM practices. The export demand equation will be estimated by Ordinary Least Square (OLS) while the domestic supply and domestic demand equations will be estimated by system of equations approach. From Equation (6), a partial equilibrium of quantity and price of timber can be generated. In addition, the producer and consumer's surplus that represents welfare economic impacts are also being quantified.

**Data Description:** Data used in this analysis is time series data. With regards to the time series data analysis, this study intends to evaluate the empirical performance of SFM practices in Sarawak timber market using annual data

from 1970 to 2008. Published and unpublished data on all variables in this study were gathered from the Forestry Department of Sarawak, Malaysia, Department of Statistics, Malaysia and Ministry of Plantation Industries and Commodities, Malaysia.

## RESULTS AND DISCUSSION

Econometric analysis is capable of providing a quantitative analysis of the actual economic phenomenon based on the concurrent development of theory and observation, related by an appropriate method of inference [13]. Since this analysis uses time series data, it is necessary to find out whether the data are stationary or otherwise. For this reason, unit root test has been conducted using the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root test.

**Unit Root Test on Time Series Data:** Since the unit root test results are sensitive to different values of the autoregressive lag lengths, the selection rule of the truncation lag parameter is crucial in determining the order of integration of the data. In this study, the optimal lag length of the ADF test is chosen based on automatic selection by Schwartz Information Criterion (SIC), while Newey-West Bandwidth criterion is used for the optimal lag length selection in the PP test to ensure the errors are white noise. All the unit root tests are carried out using E-views 6.0 software. In order to conserve the space in this paper, we decided not to present the results of unit root test.

All variables are non-stationary in levels. Thus, we cannot reject the null hypotheses of a unit root in both the ADF and PP tests. On the other hand, all series appear to be stationary after first differencing, that is I(1). This result is consistent for both ADF and PP tests used in this study. Therefore, higher order of differencing is not required to make the data into stationary process. The results imply that there is I(1) variables in the Sarawak data and no existence of I(2) variable.

There is a concrete support for the existence of a unit root stationary at I(1) by ADF and PP unit root tests in Sarawak. The result of I(2) is automatically do not need to carried out because all the variables are integrated at I(1). If, there are not integrated at I(0) and I(1), then it is necessary to analyse the unit root test at I(2) level.

**Estimated Coefficients of Timber Market:** Sarawak timber market model comprised of supply function, domestic and export demand functions of timber and as a whole appeared to fit the data well (` 2). Sarawak is still exporting its timber, unlike Peninsular Malaysia has banned its timber exports. Table 2 showed the empirical results of the estimated supply, domestic and export demand equations in Sarawak.

The supply and domestic demand equations were estimated using the system of equations approach as endogenous variable exists in each of the equation. The remaining equation was estimated using OLS. All of the variables coefficients in the model produced an expected sign consistent with the theory and similar with previous studies.

For timber supply function, the policy variables (i.e. *IC* and *AH*) estimated coefficients are statistically significant at the level of 5-percent and 1-percent respectively. This means that, they are the significant determinants of timber supply. For *IC*, the result suggests that for every 10-percent increase in average *IC*, *ceteris paribus*, timber supply would decreased by 0.9-percent. The significant coefficient of *IC* verified the *priori* assumption that cost is a burden for timber producers. In other words, larger value in *IC*, will in turn reduced the volume of timber produced. On the other hand, *AH* has a positive coefficient. Based on the estimation, an increase of 10-percent in *AH*, *ceteris paribus,* timber supply would increased by 8-percent. *AH* appeared to be highly significant at the level of 1-percent and almost elastic. This was believed to be due to the direct relationship between timber harvesting activities and timber supply. Therefore, the State Government of Sarawak has adopted one of the forest-related policies related to *AH* which is the rate of Annual Allowable Cutting (AAC). This is the reason of declining in AAC since early 1990s. This to a certain extent would increase pressure to timber producers in producing timber. Furthermore, timber producers would experience diminishing timber supply aroused from the increasing important demand for Non-timber Forest Products (NFTPs) and environmental protection [1]. Results from the present study confirmed some of the general themes and conclusions in previous studies[5].

For the case of Sarawak, there is an export market for timber since early 1960s until today. Like Sabah, Sarawak supplied timber to Peninsular Malaysia as well. In fact, the export of timber in Sarawak rose 50-percent in year 2010 compared to the same period in 2009 [14]. This is a

reasonable explanation for the exclusion of import demand function for timber in the Sarawak timber market model.

In the domestic demand equation, the coefficient estimates signs of *P, IPI* and *WMP* were as expected. The insignificant result of *P* and *WMP* were similar to the study conducted by [11]. Unlike timber supply function, *P* is not an important determinant of the domestic demand for timber in the domestic market. Perhaps, this could be due to local timber processing mills having higher willingness to pay in getting their raw material. Timber market is a supplier's market. *IPI* is an important variable influencing the demand for timber in Sarawak. *IPI* is significant at the level of 10-percent. An increase of 10-percent in the *IPI* was associated with a 2.7-percent increase in the demand for timber. This implied that the growth in economic activities in Sarawak would influence the domestic demand for timber. In contrary, [11] found that *IPI* is not a significant variable influencing timber demand in Peninsular Malaysia.

The estimates obtained for the export demand equation was inconsistent with the *prior* theory. The result indicated that the own prices and exchange rate were not important determinants of the export demand for timber in the international market. However, the export demand function was significant dependent on the *MKA* and $XD_{t-1}$. An increase of 10-percent in *MKA* increases the quantity export demanded by 5.9-percent.

The positive cross-price elasticity with respect to the export price of timber is 0.014, indicating that softwood timber is a substitute for timber. However, the result obtained is not statistically significant. This result is similar with the findings by [11].

**Validation of Timber Market Model in Sarawak:** The overall fit of the equation between the explanatory variables and dependent variable can be explained by the value of *R*-square. This is an important criterion for evaluating the quality of regression. For example, the value of *R*-square obtained from the estimated supply equation is 0.92. This implied that 92 percent of the variation in timber supply could be explained by the explanatory variables in the model.

Other diagnostic tests that have been carried out for timber supply, domestic and export demand equations were serial correlation, heteroscedasticity, Ramsey RESET test and Wald test (Table 2). The results of Durbin-Watson (DW) and Heteroscedasticity tests have shown no evidence of serial correlation and heteroscedasticity problems. The Ramsey RESET test has proven that the equation is stable and has no functional misspecification. The Wald test revealed that there is a significant long run cointegration at 1-percent level.

The root mean square error and Theil inequality test demonstrated that the deviation of simulated variables is quite close to the average size of the variable in the equation. A historical simulation has been carried out throughout the sample period of study. This is where the adequacy of the model in forecasting and policy analysis. The detailed tests and results were depicted in Table 3. The Root Mean Square Error (RMSE) and Theil's inequality coefficient were found to be relatively small for the timber supply (TS), domestic demand (DD) and export demand (XD). This suggests that the forecasting and policy analyses can be considered accurate.

The value of bias proportion is equal to zero, indicating the non-existence of a systematic bias for *TS, DD* and *XD*. Figure 2 (a), Figure 2 (b) and Figure 2 (c) showed the actual, fitted and residual graphs of the timber supply, domestic and export demand equations respectively. This result provides strong evidence that the equation is stable between the dependent and all independent variables.

**Results of Price and Quantity Equilibrium:** Table 4 presents the empirical results of the average simulated value calculated from the timber partial market equilibrium model for the period of 1995 to 2008. The impact analysis comprises of four scenarios; (1) reduced by 24-percent in harvested area, (2) increased by 49-percent in external cost of timber harvesting, (3) increased by 47-percent in the cost of internalisation the externalities and (4) 20-percent gain in market access. As mentioned before, the percentage of the reduction in harvested area and percentage gain in market access was adopted from the study conducted by [15] and [16] respectively. Whereas, the remaining two scenarios (i.e. incremental cost of internalisation the externalities and incremental external cost of timber harvesting activities) were borrowed from the study conducted by [5] and [6] respectively.

In this impact analysis, the equilibrium price has been calculated from the estimation of the timber market model at the market equilibrium was set-up. (Eq.6). After substituting the equilibrium price into the supply or demand model, the equilibrium quantity was obtained. In other words, the equilibrium price and quantity of

Table 2: Results of Timber Market for Sarawak

Supply Function

$\ln TS = 1.8206 + 0.1532\ln P - 0.089\ln IC + 0.8047\ln AH + 0.2663\ln TS_{t-1}$

(0.00)*** (0.02)** (0.00) *** (0.00)***

$R^2 = 0.98$; Adj. $R^2 = 0.98$; DW = 1.96; Ramsey RESET Test = (0.41);

Heteroskedasticity Test = (0.38); Wald Test = (0.00)***

Domestic Demand Function

$\ln DD = 4.2196 - 0.2237\ln P + 0.2709\ln IPI + 0.0332\ln WMP + 0.7273\ln DD_{t-1}$

(0.37) (0.05)* (0.86) (0.00)***

Export Demand Function

$\ln XD = 4.1937 - 0.0818\ln XP + 0.5941\ln MKA + 0.0143\ln SWP + 0.8837\ln REER$

(0.19) (0.02)** (0.89) (0.69)

$+ 0.7488\ln XD_{t-1} - 0.3794AR(1)$

(0.00)*** (0.00)***

$R2 = 0.94$; Adj. $R2 = 0.93$; DW = 1.82; Ramsey RESET Test = (0.22);

Heteroskedasticity Test = (0.43); Wald Test = (0.00)***

Notes: ***Significant at 1 percent, **Significant at 5 percent, *Significant at 10 percent.
The values in the parentheses ( ) contain the *p*-value.

Table 3: Historical Simulation of Timber model for Sarawak

| | TS | DD | XD |
|---|---|---|---|
| Root Mean Square Error | 0.06 | 0.18 | 0.25 |
| Theil's inequality coefficient | 0.001 | 0.006 | 0.008 |
| Bias proportion | 0.000 | 0.000 | 0.005 |
| Variance proportion | 0.003 | 0.021 | 0.014 |
| Covariance proportion | 0.99 | 0.97 | 0.79 |

Table 4: Average Simulated Values due to SFM Practices for Sarawak

| Variable | | Equilibrium Quantity | Equilibrium Price |
|---|---|---|---|
| Unit | | $m^3$ | $RM/m^3$ |
| Baseline scenario | | 2,596,681 | 470 |
| Scenarios % changes due to SFM practices | Reduced by 24% in harvested area | 2,152,674 | |
| | 1050 | | |
| | Rise by 49% in external cost of timber harvesting | 1,697,884 | 3,546 |
| | Rise by 47% in cost of internalisation the externalities | 1,992,579 | 1344 |
| | Rise 20% in market access | 2,616,273 | 507 |

Table 5: Average Welfare Impacts due to SFM Practices for Sarawak

| Item | | Producer surplus | Consumer surplus | Total Social benefits |
|---|---|---|---|---|
| Baseline scenario | | 27,014,313 | 637,932,059 | 664,964,372 |
| Scenarios % changes | Reduced by 24% in harvested area | 22,100,885 | 637,752,042 | 659,852,927 |
| under SFM practices | Rise by 49% in external cost of timber harvesting | 16,973,385 | 636,814,728 | 653,788,113 |
| | Rise by 47% in cost of internalisation the externalities | 18,553,630 | 637,498,806 | 656,052,436 |
| | Rise 20% in market access | 28,433,145 | 762,030,132 | 790,463,277 |

timber could be further quantified from the estimated coefficients. Therefore, the average timber market equilibrium point for price and quantity was $RM470/m^3$ and 2.60 millions $m^3$ respectively. This point corresponds with the baseline scenario.

After incorporating the SFM practices scenarios through simulation analysis, the equilibrium quantity showed a negative effect. This is due to several changes such as reduction in harvested area, incremental external cost of timber harvesting activities and incremental cost of internalisation the externalities from timber harvesting activities. However, the price of timber has shown a positive effect as it increases under the SFM practices scenarios. As shown in Table 4, the price of timber has increased by 123-percent, 505-percent, 185-percent and 8-percent to $RM1,050/m^3$, $RM2,846/m^3$, $RM1,344/m^3$ and $RM507/m^3$ respectively under the four scenarios of SFM practices. This result reflected the domestic and export timber market in Sarawak and could be considered as price premium averaging from 8- to 507-percent. This is because

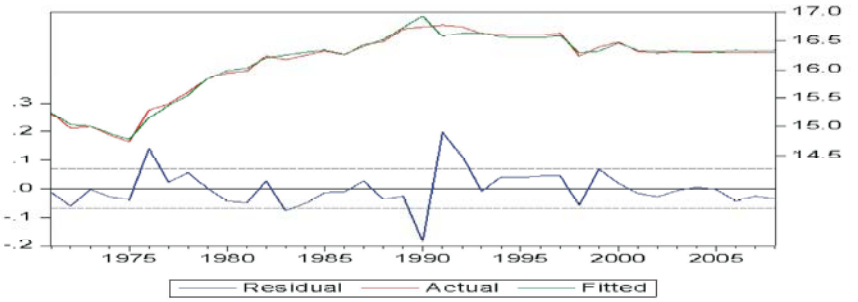


Fig. 2(a): Simulation of Timber Supply Model for Sarawak

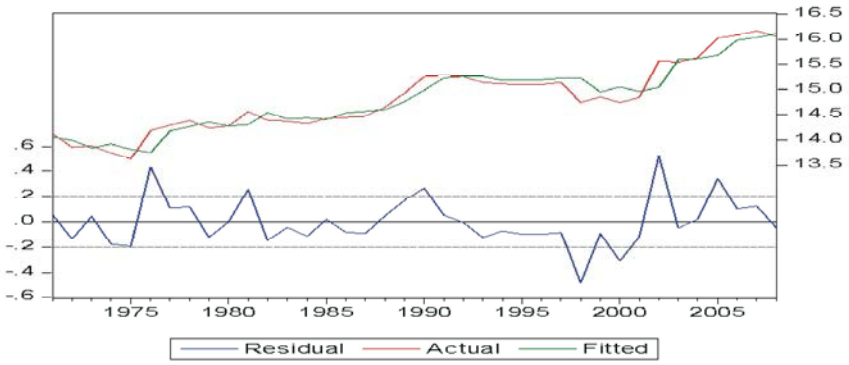


Fig. 2(b): Simulation of timber demand model for Sarawak

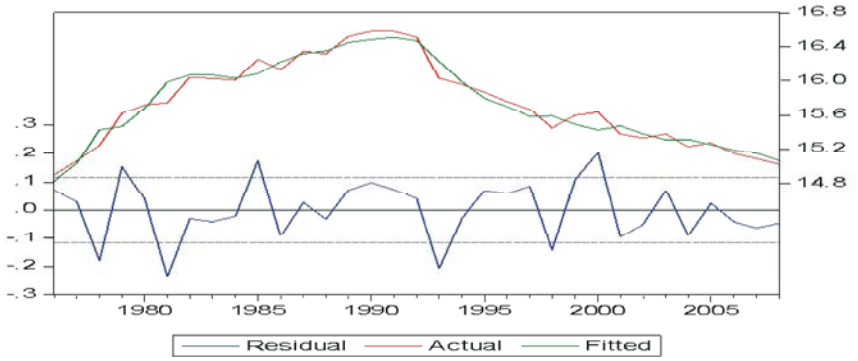


Fig. 2(c): Simulation of Timber Export Demand Model for Sarawak

the incremental price of timber is due to the four scenarios under SFM practices. In this context, the government could use this finding to formulate the price premium mechanisms such as conducting programme to educate consumers and to promote the timber produced from forest that practiced SFM.

This may suggest that the price increased reflects the value of price premium for timber produced from SFM practices or certified forests in Sarawak. Similar with the results of previous studies [17], the price for timber produced from SFM practices or certified forest would potentially fetch price premium ranging from 2- to 56-percent.

As seen in Table 4, the simulation results of the first three scenarios revealed that the equilibrium quantity of timber has decreased to 2.15 million $m^3$, 1.70 million $m^3$ and 1.99 million $m^3$ which is 17-percent, 34-percent and 23-percent decrease from 2.60 million $m^3$. This finding is consistent with the study conducted by [18] who found that the reduction of timber supply in the long run was due to SFM practices. This implied that the domestic timber processing mills might cut down their consumption of timber as raw material from the natural forest in the long run. In addition, [19] revealed that the total number of timber processing mills (i.e. sawmills, plywood and veneer mills) were expected to be drastically reduced due to SFM

practices. On the other hand, when the market access scenario under SFM was simulated, the equilibrium quantity of timber increased by 0.8-percent to 2.62 million $m^3$.

Based on these scenarios, the reduction in harvested area provides tremendous impact on equilibrium quantity and price of timber. This is due to the elasticity of this variable is almost elastic (0.8). The result of this study provides an empirical evidence of the implication of SFM practices on the timber market in Sarawak. As price, harvested area and input cost were policy variables and revealed significant determinant on the quantity of supply for timber, Sarawak's State Government and Forestry Department could use some mechanisms related to these variables to enhance the SFM practices. Furthermore, effort should be made to convince tropical timber consumers that timber produced from SFM practices should be accorded premium prices in view of high cost of timber harvesting operations due to internalisation of externalities. In other words, the extra value of timber prices could reflect the price for environmental resources.

The percentage of decreases in equilibrium quantity of timber under SFM scenarios would give an explanation for timber to be extracted to meet the needs of the present generation without compromising the ability of the future generations to fulfill their needs. However, with the use of appropriate technology in the timber harvesting operations, the recovery rate for volume of timber to be extracted could be enhanced.

**Results of Welfare Economic Impacts:** Based on the simulated value calculated earlier as given in Table 4, the average annual estimated values of welfare economic impacts were further calculated (Table 5). The similar scenarios as what in the market impact analysis were adopted and simulated in this welfare economic impacts analysis. The simulation results showed that the calculated value of producer surplus and consumer surplus changes when incorporating the four scenarios under SFM practices.

The simulation result showed that the calculated value of producer surplus changed when the four scenarios under SFM practices were incorporated. Under scenario one where *HA* was reduced by 24-percent, the producer surplus reduced from RM27.01 million under the baseline scenario to RM22.10 million. Similarly, the consumer surplus also decreases from RM637.93 million under the baseline scenario to RM637.75 million. Under scenario two where the external cost of timber harvesting rose by 49-percent, the producer surplus reduced from RM27.01 million under the baseline scenario to RM16.97 million. Similarly, the consumer surplus also decreased from RM637.93 million under the baseline scenario to RM636.81 million. Under scenario three where the cost of internalisation the externalities went up by 47-percent, the producer surplus reduced from RM27.01 million under the baseline scenario to RM18.55 million. Similarly, the consumer surplus also decreased from RM637.93 million under the baseline scenario to RM637.49 million. On the other hand, under scenario four where the export market gained 20-percent of market access, the producer surplus increased from RM27.01 million under the baseline scenario to RM28.43 million. Similarly, the consumer surplus also increased from RM637.93 million under the baseline scenario to RM762.03 million.

This result indicates that the variations in *HA* and *IC* were the causes of reduction in the calculated value of the producer and consumer surplus. This situation would bring towards a loss in economic welfare on the timber market in Sarawak. The economic welfare in this study referred to the calculated value of total social benefit. Hence, this finding implied that when timber industry complied with SFM practices, it will decline stakeholders' economic welfare in the timber sector.

As noted by [20], there is an element of trade-offs between environmental protection and timber production from the forest. SFM practices could ensure the source of timber supply from natural forest is sustainable and to minimise the externality effects from timber harvesting activities. Otherwise, the regeneration of timber from the natural forests would be affected and the nation would lose the valuable NFTPs and environmental services [21]. claimed that SFM practices could enhance growing stock of timber and forest productivity of timber and non-timber forest produce.

The simulation result showed that the calculated value of consumer and producer surplus increases when the scenario of market access (20-percent gained in market access) was incorporated. The consumer surplus increased to RM762.03 million which is 20-percent increase from RM637.93. The producer surplus increased by 5-percent to RM28.43 million. This would bring economic welfare gain to the stakeholders in the timber industry. This is because the timber produced from sustainably managed forest could give consumers a credible guarantee that the timber is coming from environmentally responsible and social beneficial forest [22]. According to [23], Malaysia will continue to support the international efforts to ensure sustainability in forest management and market access of Malaysian timber products, especially for the environmentally sensitive markets. Hence, the loss in value of economic welfare

under the first three scenarios of SFM practices could be offset by the market access that could potentially be realised in the Sarawak timber market.

## CONCLUSIONS

The results of timber market in Sarawak have shown that harvested area, market access and input cost were the variables that gave significant impacts on the equilibrium price and quantity process, which in turn affects the producer's profits under SFM practices. Moreover, SFM practices would certainly affect the stakeholders in timber-based industry as their interests normally require trade-offs from the environmental and natural resource concerns. The interests of different stakeholders were rarely fully mutually reinforcing [24]. SFM deals with various stakeholders that were related to the natural forests. In this study, stakeholders in the timber sector were evaluated.

For a partial equilibrium timber market analysis, the result showed that compliance with SFM practices reduced the supply of timber. However, in the equilibrium process, compliance with SFM practices pushed up the level of price. Hence, the equilibrium price and quantity of timber has increased and decreased respectively as a result of internalising the externalities from timber harvesting activities. For the case of Sarawak, the scenario analysis showed that the market and welfare economic impacts due to SFM practices were modest. Based on those scenarios, decreased harvested levels in connection with SFM practices were likely to affect the market and economic welfare more than increased input costs. Similarly, [8] found that decreased in harvested levels gave an immense impact on forest products market than increased in the operational costs due to SFM practices.

On the other hand, the existence of market access from consumers that consume only timber produced from SFM practices, would give timber producers some advantages on their economic welfare. For example, export of Sarawak timber has rose up to 50-percent in the first 4 months in 2010 compared with the same period in 2009 [14]. In addition, Sarawak timber industry has received recognition from the Japan Lumber Importers' Association (JLIA) for the sustainably managed forests in Sarawak [25]. This would give a good indicator to the Sarawak timber industry. At the same time, "green" or price premium and several incentives from the Sarawak State Government would offset the reduction in economic welfare and could promote the implementation of SFM in Sarawak. Therefore, stakeholders from the timber and other sectors which represent the society as a whole could at least have some mutual benefits.

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