

MARKET AND WELFARE ECONOMIC IMPACTS OF SUSTAINABLE FOREST MANAGEMENT PRACTICES—AN EMPIRICAL ANALYSIS OF TIMBER MARKET IN SABAH, MALAYSIA

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ABDUL RAHIM AS, MOHD SHAHWAHID HO, MAD NASIR S & AWANG NOOR AG. 2012. Market and welfare economic impacts of sustainable forest management practices—an empirical analysis of timber market in Sabah, Malaysia. The Sabah State Government has given its priority to Sustainable Forest Management (SFM) practices. The widely known tool, reduced impact logging option has been adopted in order to achieve SFM practices. Hence the main objective of this study was to analyse the impact of SFM practices on the timber market in Sabah, Malaysia. Impact analysis was conducted based on four scenarios arising from SFM practices, i.e. reduction by 24% in harvested area, increase by 49% in external cost of timber harvesting, increase by 47% in the cost of internalisation of the externalities and 20% gain in market access. Based on the first three scenarios, the results showed that the equilibrium quantity and price of timber had decreased and increased respectively after converting conventional logging (CL) practices to SFM practices. The economic impact of SFM provided empirical evidence that loss was incurred in the welfare of timber industry in Sabah. However, there was also an increase in the domestic price of timber, which would then help to compensate for the loss of timber volume. In addition, the scenario of 20% gain in the market access showed that Sabah's timber industry could benefit from this advantage. The State Government and other related agencies should be able to use these results as a reference in designing good mechanisms to strengthen the effectiveness of SFM practices.

Keywords: Consumer surplus, producer surplus, equilibrium price, equilibrium quantity

ABDUL RAHIM AS, MOHD SHAHWAHID HO, MAD NASIR S & AWANG NOOR AG. 2012. Impak pengurusan hutan secara mampan terhadap ekonomi pasaran dan kebajikan—analisis empirikal bagi pasaran kayu balak di Sabah, Malaysia. Kerajaan negeri Sabah memberi keutamaan kepada amalan pengurusan hutan secara mampan (SFM). Akibatnya, pembalakan berimpak rendah diterima pakai dengan meluasnya. Justeru, objektif utama kajian ini adalah untuk menyelidik impak SFM terhadap pasaran kayu balak di Sabah. Analisis impak dijalankan berdasarkan empat senario yang timbul daripada amalan SFM iaitu pengurangan sebanyak 24% kawasan tebang, peningkatan sebanyak 49% kos luaran untuk tebang pokok, peningkatan sebanyak 47% kos internalisasi faktor luaran dan 20% peningkatan dalam pasaran. Berdasarkan tiga senario yang pertama, keputusan menunjukkan yang pertukaran daripada pembalakan secara konvensional kepada SFM mengurangkan keseimbangan kuantiti dan meningkatkan harga kayu balak. Impak ekonomi daripada pelaksanaan SFM menunjukkan kerugian dalam industri kayu balak di Sabah. Bagaimanapun, peningkatan dalam harga tempatan kayu balak akan membantu meringankan bebanan industri kayu balak. Selain itu, 20% peningkatan dalam pasaran menunjukkan yang industri kayu balak di Sabah boleh mendapat faedah daripada pelaksanaan SFM. Kerajaan negeri dan agensi yang berkaitan boleh menggunakan hasil kajian ini untuk merangka pelan tindakan bagi memperkukuh keberkesanan amalan SFM.

INTRODUCTION

Sustainable Forest Management (SFM) should cover all mechanisms of allocation and not solely focus on the market itself (Kumari 1995). However, there are many situations and resources which are not and cannot be allocated by the market mechanism.

Table 1 indicates several goods and services with respect to the economic values estimated

from the two types of forest management practices, namely, conventional logging (CL) and reduced impact logging (RIL). Reduced impact logging is also considered a tool to accomplish the goal towards SFM practices.

Both CL and RIL deal with the impact of forest management practices upon various goods and services through economic analysis.

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Table 1 Valuations of forest goods and services under CL and SFM practices

Goods/ services	Method / variable analysis	Location	Value estimated (RM ha ⁻¹)		Source
			CL	SFM	
Total social benefits ^a	Total economic valuation	Malaysia	627	1118	Kumari (1996)
Total global benefits ^b	Total economic valuation	Peninsular Malaysia	8389	9146	
Carbon storage	Total economic valuation	Peninsular Malaysia	8049	8677	
Water	Cost of water treatment	Peninsular Malaysia	704	1477	Mohd Shahwahid et al. (1999)
Water	Cost of water treatment	Peninsular Malaysia	188	126	Abdul Rahim & Mohd Shahwahid (2011)
Timber and non-timber production	Cost-benefit net present value	Sarawak	9100	9905	Dagang et al. (2001)
Watershed protection	Net present value	Peninsular Malaysia	1019	1060	Mohd Rusli (2002)
Forested catchment	Net present value	Peninsular Malaysia	1006.1	740.7	Mohd Rusli (2002)

^a Hydrological properties, rattan, bamboo, recreation, domestic water and fish; ^b endangered species and carbon stock; CL = conventional logging, SFM = sustainable forest management; USD1 = RM3.4

Economic analysis is a systematic approach for determining the optimum use of scarce resources. It takes into account the opportunity costs of resources employed and the attempts to measure the explicit and implicit costs in monetary terms. In this study, the economic analysis refers to the externality effects that could potentially occur due to timber harvesting operations or better known as implicit costs to the timber producers. For example, with timber harvesting operations, hydrological properties, rattan, bamboo, recreation, domestic water, fish, endangered species and carbon storage would be affected. These externality effects will then be translated into monetary values, representing losses as being incurred by the society. In this paper, the term timber that we use refers to log. For example, the timber harvesting operations that we mentioned earlier refer to the log harvesting operations in the forest.

In minimising the externality effects, SFM is a preferred policy compared with CL as SFM provides greater benefits. For example, in Table 1, at national level, the total social benefits under CL and SFM practices are RM627 and RM1118 ha⁻¹ respectively (Kumari 1996). In

addition, global benefits have also increased from RM8389 to RM9146 ha⁻¹ under CL and SFM practices respectively. Furthermore, a study revealed a lower cost in treating water under SFM practices compared with CL practices (Mohd Shahwahid et al. 1999). This indicates that as a result of SFM practices, the quality of river water has improved considerably.

Apart from the reviewed benefits and costs at the social level, this study also includes some important elements relating to benefits and costs at the private level. Table 2 shows the results of previous studies related to SFM practices. Timber producers have incurred higher costs in practising SFM. For example, Ahmad Fauzi et al. (2002) showed that there was an incremental cost of SFM from RM117.05 to RM198.54 m⁻³. Similarly, Abdul Rahim et al. (2009) also observed that the cost of complying with SFM practices had increased from RM170.13 to RM267.80 m⁻³. On the other hand, there are various benefits of complying with SFM such as price premium, carbon credit and market access. For example, there was an increment in price premium, from USD121.8 to USD170.1 m⁻³ under CL and SFM practices respectively (Kollert & Lagan 2007). For

Table 2 Previous analyses of CL and SFM practices

Goods/ services	Variable analysis / method	Location	Value estimated		Source
			CL	SFM	
Sawntimber	Market access (export market) Input-output model	Peninsular Malaysia	–	Increase RM1.8 billion or ~20%	Ahmad Fauzi et al. (2007)
Timber	Price premium ANOVA	Sabah	USD121.8 m ⁻³	USD170.1 m ⁻³	Kollert & Lagan (2007)
Timber	Operation cost present value	Peninsular Malaysia	RM117.05 m ⁻³	RM198.54 m ⁻³	Ahmad Fauzi et al. (2002)
Timber	Operation cost present value	Peninsular Malaysia	RM170.13 m ⁻³	RM267.80 m ⁻³	Abdul Rahim et al. (2009)
Timber	Operation cost	Sarawak	RM27.94 m ⁻³	RM43.28 m ⁻³	Dagang et al. (2001)
Carbon trading	Carbon payment	Sarawak	–	RM30 ha ⁻¹	

CL = conventional logging; SFM = sustainable forest management

market access, Ahmad Fauzi et al. (2007) found that there was market access in export market by almost 20% of export increases from sustainably produced timber products. As for carbon credit, Dagang et al. (2001) revealed that with SFM practices, forest owners or concessionaires could potentially receive carbon credit at about RM30 ha⁻¹ and this could be considered as an incentive to timber producers in complying with SFM practices.

Timber market analysis has been carried out in previous studies. The analysis internalises the monetary value of externality effects at the social level. For example, in minimising the externality effects from timber harvesting operations, additional activities and procurement need to be taken into consideration due to the more stringent criteria that need to be complied with in the timber harvesting procedure. Therefore, this will also increase the operation costs. Abdul Rahim et al. (2009) quantified the incremental cost of compliance with the additional activities and procurement in line with the SFM practices. Their results revealed that operation costs had increased from RM170.13 to RM267.80 m⁻³ under CL and SFM practices respectively (Table 2). A recent study by Abdul Rahim and Mohd Shahwahid (2011) found that the cost of water treatment had increased from RM0.65 to RM1.88 m⁻³ (under CL practices) and RM1.26 m⁻³ (under SFM practices) resulting from timber harvesting activities. This is a crucial issue that requires further analysis and discussion because if there is a significant distortion in the

market, government intervention will be one of the best solutions in tackling the problem.

This study has made use of some of the previous findings in order to create certain scenarios under the SFM practices in examining the market and welfare economic impacts. This can be done by linking the related indicators from previous findings with SFM elements and appropriate explanatory variables in the timber market model. This is vital in order to establish the link between previous findings and the timber market model.

Most of the studies conducted either locally or abroad have revealed that there is an incremental cost in operating SFM other than the cost reduction in the timber production (Schwarzbauer & Rametsteiner 2001, Ahmad Fauzi et al. 2002, Linden & Uusivuori 2002, Woon & Tong 2004, Abdul Rahim & Mohd Shahwahid 2009). All of these possible changes are directly related to the harvesting regulations and additional guidelines on timber harvesting activities. In general, this will reduce the volume of timber that can be extracted from the forest, at the same time incurring higher cost of SFM practices. In other words, potential harvesting volumes may be reduced when SFM practices are implemented. Nevertheless, in the long run, the sustainable level of production may exceed the possible level of production in later years if the environmentally harvesting systems were to be continued (Thang 2007). Due to the economic reasons in terms of gains and losses in practising SFM, timber producers should acknowledge that

there are some economic advantages when they participate in SFM practices.

Referring to the issues discussed above, it is essential to understand the market in terms of its relationship with its major parameters. In the case of Sabah, forest resources have significantly contributed to the economic development. The forestry sector has been the backbone of Sabah's economy since the 1960s (McMorrow & Mustapha 2001). Although the forestry sector's contribution to Sabah's gross domestic product (GDP) has been declining since the 1990s this sector has remained an important sector for the economy. Therefore, it is crucial to investigate the various impacts of SFM practices on the timber market in Sabah because it has been implementing SFM since the 1990s. In this study, an attempt was made to incorporate the potential impacts of SFM practices at the private and social levels.

METHODOLOGY

The development of the timber market model is based on the theoretical framework of the supply and demand model. The model covers domestic and export markets. Previous researchers (Kumar 1981, 1983, Daniels & Hyde 1986, Kinus 1992, Mohd Shahwahid 1995, Ismariah 2001, Abdul Rahim & Mohd Shahwahid 2009) have attempted to develop this model. Based on the economic theory and practical knowledge, the timber market for domestic and export markets equations are specified as follows:

$$\text{Timber supply} = f(\text{price of timber, harvested area, input cost}) \quad (1)$$

$$\text{Domestic demand for timber} = f(\text{price of timber, industrial production index, substitute price}) \quad (2)$$

$$\text{Export demand for timber} = f(\text{own price, substitute price, exchange rate}) \quad (3)$$

The first attempt to develop a simple supply and demand model for the timber market was made by Kumar (1981, 1983) and Daniels and Hyde (1986). This theoretical model has been improved by new researchers for accuracy and reliability purpose. First, in equation 1, Mohd

Shahwahid (1995) improved the model by considering royalty of timber as a proxy of input cost for timber supply. However, royalty of timber is fixed for a very long period of time and is not solely an independent variable. This is because royalty charge is based on per volume of timber being extracted from forests. Hence this can affect the accuracy of this proxy variable. For this reason, this study has employed wage and salary as a proxy variable for input cost of timber supply model. The major contribution of this study is the incorporation of externality effects, translated into monetary value, for analysing the market and welfare economic impacts in the timber market. This was done by linking the monetary value of externality effects with an input cost used in the model. This is considered a significant contribution as none of the previous studies have considered the monetary value of externality effects on the timber market modelling. Second, previous studies by Daniels and Hyde (1986) and Mohd Shahwahid (1995) applied forest inventory and area open for harvesting variables as determinants of timber supply. However, these variables could not give direct relation on timber supply. For example, area open for harvesting could not represent the total volume of timber being extracted from forest. It is noted that not all areas in the forest opened for harvesting are being extracted. Hence this study has modified the model by using harvested area of timber in the forest as an explanatory variable of timber supply.

In equation 2, Kumar (1981, 1983) used national income of GDP as an explanatory of demand model for timber. However, this variable is inaccurate for this particular product as timber from forest is under intermediate product used by the timber processing mills and not for the end-user. Therefore this study applied industrial production index as this variable was more accurate in measuring industrial performance and would determine the demand for timber from industry.

For the case of Sabah, import demand for timber was not considered in the study as there was a surplus of timber supply for Sabah from the 1970s until the early 1990s (Forestry Department of Sabah 2008). At that particular period of time, Sabah was considered as an export expansion centre for the timber market. However, starting from the mid-1990s, Sabah has faced deficit in its timber supply. Hence, Sabah has been importing

timber from Sarawak, Malaysia and Kalimantan, Indonesia but only in small volumes (Forestry Department of Sabah 2008). In addition, since this study employed the time-series data analysis from 1970 till 2008, the import demand model for timber had to be excluded due to the inadequacy of time-series data.

Supply of timber model estimation

From the original timber supply model in equation 4, we can rewrite this equation using a loglinear form. Equation 5 estimates the total supply of timber from natural forest. TS_{t-1} is included in equation 6 to measure the dynamic specification effects.

$$TS_t = \alpha_0 DP_t^{\alpha_1} AH_t^{\alpha_2} IC_t^{\alpha_3} \varepsilon_t \quad (4)$$

$$\ln TS_t = \alpha_0 + \alpha_1 \ln DP_t + \alpha_2 \ln AH_t + \alpha_3 \ln IC_t + \varepsilon_t \quad (5)$$

$$\ln TS_t = \alpha_0 + \alpha_1 \ln DP_t + \alpha_2 \ln AH_t + \alpha_3 \ln IC_{t-1} + \alpha_4 \ln TS_{t-1} + \varepsilon_t \quad (6)$$

where

- TS_t = supply of natural forest timber
- DP_t = domestic price of timber
- AH_t = harvested area in natural forest
- IC_t = total salaries and wages paid in logging industry
- TS_{t-1} = lag supply of timber supply by one year
- t = years
- ε_t = error term
- \ln = natural logarithm

The total supply of timber for natural forest should be positively related to the natural forest timber price and harvested area in natural forest. We use the natural forest timber price due to the differences in the value of price between natural forest timber price and plantation forest timber price. TS_t is the supply of natural forest timber as endogenous or dependent variable. DP_t is the price of natural forest timber, an important variable in determining the quantity of natural forest timber supply. AH_t is the natural forested area opened for harvesting. IC_t is total salaries and wages paid in the logging industry representing the production cost. In equation 6, TS_{t-1} is included. This is the previous year's supply of natural forest timber which has an influence

on the natural forest timber supply. This variable is added into the model to achieve a dynamic specification. This approach is applicable to the rest of the model used in this study.

Internalisation of externalities and external cost

There is a need to minimise environmental impacts and resource degradation by ensuring that economic agents bear the full costs of their activities. Thus this study has developed equations 7 and 8 in order to materialise it.

$$\begin{aligned} \text{Input cost under the scenario of SFM} = \\ \text{Input cost} + \text{cost of internalising the} \\ \text{externalities} \end{aligned} \quad (7)$$

$$\begin{aligned} \text{Input cost under the scenario of SFM} = \\ \text{Input cost} + \text{external cost of timber} \\ \text{harvesting} \end{aligned} \quad (8)$$

Equation 7 measures the element of additional activities needed to minimise the impact of timber harvesting activities. This will definitely incur some costs (Abdul Rahim et al. 2009). Hence these costs will be added up with the typical input costs used in order to capture the full costs of operational activities. On the other hand, equation 8 assesses the external cost of timber harvesting. The external cost reflects the additional cost incurred by the third party resulting from timber harvesting activities. For example, the cost of the water treatment would increase when the operation of timber harvesting took place as compared with the cost of water treatment without timber harvesting (Abdul Rahim & Mohd Shahwahid 2011). This is due to the soil erosion and forest degradation which can deteriorate the quality of the river water. The incremental cost of treating the river water will be added up with the typical input costs of timber harvesting activities to provide a full cost.

Failure in taking into consideration the externality elements may lead to the timber production from natural forest being managed without being sustainably produced. In other words, the optimum level of quantity and price of timber will not be achieved. Most of the previous studies, especially studies using econometric modelling, had ignored the internalisation of the full costs in their researches. Therefore, the research outcome of this study could represent

the optimal level estimation of quantity and price in the timber market.

Domestic (local) demand model estimation

From the original timber demand model in equation 9, we can rewrite this equation using a loglinear form. Equation 10 describes the estimated total domestic demand for timber from natural forests. DD_{t-1} is included in equation 11 to measure the dynamic specification effects.

$$DD_t = \alpha_0 DP_t^{\alpha_1} IPI_t^{\alpha_2} WMP_t^{\alpha_3} \varepsilon_t \quad (9)$$

$$\ln DD_t = \alpha_0 + \alpha_1 \ln DP_t + \alpha_2 \ln IPI_t + \alpha_3 \ln WMP_t + \varepsilon_t \quad (10)$$

$$\ln DD_t = \alpha_0 + \alpha_1 \ln DP_t + \alpha_2 \ln IPI_t + \alpha_3 \ln WMP_t + \alpha_4 \ln DD_{t-1} + \varepsilon_t \quad (11)$$

where

- DD_t = domestic demand for timber
- DP_t = domestic price of timber
- IPI_t = industrial production index
- WMP_t = world import price of timber
- DD_{t-1} = lag of domestic demand for timber by one year
- t = years
- ε_t = error term
- \ln = natural logarithm

Domestic demand for timber should be negatively related to the price of timber and positively related to the industrial production index and world import price of timber. It is suggested that the lower the price paid, the higher is the volume of forest timber demanded domestically. On the other hand, higher world import price of timber would encourage further consumption of domestic timber. Similarly, higher industrial production index (IPI) would also promote timber processing mills (i.e. sawmills, plywood and veneer mills) to demand for more domestic timber. Instead of using Malaysian income, IPI was used in this study because timber was considered an intermediate good. Industrial production index is also used to measure the economic growth of the timber-based manufacturing industries and it should therefore be positively related to the domestic demand of timber. World import price of timber is used to measure the cross-price elasticity in terms of substitution effects. This variable

is included in order to fulfil the theoretical economics requirements. DD_t is the dependent variable for domestic demand for timber, which is influenced by the domestic price of timber (DP_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 model estimation

From the original timber export demand model in equation 12, we can rewrite this using a loglinear form. Equation 13 is expected to estimate the total export demand for timber from natural forests. Similar to previous models, XD_{t-1} is included in equation 14 to measure dynamic specification effects.

$$XD_t = \alpha_0 XP_t^{\alpha_1} MKA_t^{\alpha_2} ER_t^{\alpha_3} SWP_t^{\alpha_4} \varepsilon_t \quad (12)$$

$$\ln XD_t = \alpha_0 + \alpha_1 \ln XP_t + \alpha_2 \ln MKA_t + \alpha_3 \ln ER_t + \alpha_4 \ln SWP_t + \varepsilon_t \quad (13)$$

$$\ln XD_t = \alpha_0 + \alpha_1 \ln XP_t + \alpha_2 \ln MKA_t + \alpha_3 \ln ER_t + \alpha_4 \ln SWP_t + \alpha_5 \ln XD_{t-1} + \varepsilon_t \quad (14)$$

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 by one year
- t = years
- ε_t = error term
- \ln = natural logarithm

A negative relationship is expected for the export price of timber whereas positive relationship is expected for exchange rate, market access and the price of its substitute good, namely, world softwood timber. MKA measures the ratio of market access, for example, the ratio of total timber exports of Sabah to total timber imports by the importing countries that imported timber from Sabah. There is a positive relationship between timber export demand and MKA . This is because the higher ratio shows that timber from Sabah is preferred by 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-1}).

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 an equation below:

$$\ln TS_t = \ln DD_t + \ln XD_t \quad (15)$$

To analyse the timber market model, this study estimates timber supply, and the demand for domestic and export markets. Then timber supply and demand will be re-estimated simultaneously followed by a 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 the system of equations approach. This approach estimates the supply and demand parameters by solving reduced-form equations. From equation 15, a partial equilibrium of quantity and price of timber can be generated. In addition, the producer and consumer surpluses that represent welfare economic impacts are also quantified.

RESULTS

Econometric analysis is capable of providing a quantitative analysis for the actual economic phenomenon based on the concurrent development of theory and observation, related by an appropriate method of inference (Gujarati 2003). Since this analysis uses time-series data, it is necessary to identify whether the data are stationary or otherwise. For this reason, the unit root test has been conducted using the Augmented Dickey-Fuller (ADF) test and the Philips-Perron (PP) unit root test.

Unit root test on time-series data

It is necessary to test the order of integration of each variable in a model. This is to determine how many times the variables need to be differentiated in order to produce a stationary

series. It is essential to note that testing for stationary condition for a single variable is very similar to testing a linear combination of variable cointegration to form a stationary and equilibrium relationship (Harris 1995).

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 integration order of the data. In this study, the optimal lag length of the ADF test was chosen based on automatic selection by the Schwartz Information criterion (SIC), while the Newey-West Bandwidth criterion was used for the optimal lag length selection in the PP test to ensure that errors are white noise.

Table 3 shows that all of the variables are non-stationary in levels. Thus we could not reject the null hypotheses of a unit root in both series and this appeared to be stationary after taking first difference of the ADF and PP tests. This result was consistent for both ADF and PP tests used in this study. Therefore, higher order of differencing was not required for this set of data. The results implied that I(1) variable existed in the data for Sabah, Malaysia but not the I(2) variable.

Estimated coefficients of timber market model

The Sabah timber market model (i.e. supply function, domestic and export demand functions) as a whole appeared to fit the data well (Table 4). Table 4 indicates the empirical results of the estimated supply, domestic and export demand equations in Sabah.

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

For the timber supply function, the estimated coefficients of DP, IC and AH were statistically significant at 5, 10 and 1% levels respectively. These variables are known as policy variables as they are proven to be statistically important determinants of timber supply. For IC, the result suggested that for every 10% increase in average IC, *ceteris paribus*, timber supply would decrease by 2.6%. The significant coefficient of IC verifies the *priori* assumption that cost is a burden for

Table 3 Results of unit root test

Variable	Level (trend and intercept)		First difference (trend and intercept)	
	ADF	PP	ADF	PP
TS	-2.7662	-2.7661	-6.7447***	-6.7925***
DP	-1.7952	-1.9130	-5.3324***	-5.3040***
AH	-2.1366	-2.1859	-6.4999***	-6.4850***
IC	-1.9522	-2.0232	-4.6381 ***	-4.7055***
DD	-1.0352	-1.1653	-5.8809***	-5.9283***
IPI	-2.2110	-2.2169	-6.9489***	-7.2930***
WMP	-2.4706	-2.2618	-5.9392***	-6.1511***
XD	-2.9340	-2.2226	-4.1160**	-3.8290**
XP	-2.9653	-2.6258	-5.3292***	-12.1981***
ER	-1.5749	-2.7713	-8.3372***	-8.2401***
SWP	-3.2183	-2.4544	-4.3764***	-4.3701***
MKA	-1.5804	-2.6564	-4.1314**	-5.9621***

***Significant at 1%, **significant at 5%; ADF = augmented Dickey-Fuller test; PP = Philips-Perron test; TS = supply of natural forest timber; DP = domestic price of timber; AH = harvested area in natural forest; IC = total salaries and wages paid in logging industry; DD = domestic demand for timber; DP = domestic price of timber; IPI = industrial production index; WMP = world import price of timber; XD = export demand for timber; XP = export price for timber; ER = exchange rate; MKA = market access

Table 4 Results of timber market modelling

Supply function
$\ln TS = 2.5390 + 0.3016 \ln DP - 0.2584 \ln IC + 0.4687 \ln AH + 0.6532 \ln TS_{t-1}$
(0.03)** (0.08)* (0.00)*** (0.00)***
$r^2 = 0.80$; Adj. $r^2 = 0.78$; DW = 1.85; Ramsey RESET test = (0.14);
Heteroskedasticity test = (0.88); Wald test = (0.01)**
Domestic demand function
$\ln DD = -0.2011 - 0.4615 \ln DP + 0.5107 \ln IPI + 0.6733 \ln WMP + 0.8019 \ln DD_{t-1}$
(0.17) (0.21) (0.32) (0.00)***
$r^2 = 0.97$; Adj. $r^2 = 0.97$; DW = 1.93; Ramsey RESET test = (0.86);
Heteroskedasticity test = (0.54); Wald test = (0.00)***
Export demand function
$\ln XD = 4.4172 - 0.0171 \ln XP + 1.822 \ln MKA + 0.4068 \ln SWP + 0.9164 \ln REER$
(0.98) (0.08)* (0.79) (0.38)
$- 4.7538 DM + 0.2335 \ln XD_{t-1} + 0.4811 AR(1)$
(0.19) (0.03)** (0.02)**
$r^2 = 0.93$; Adj. $r^2 = 0.92$; DW = 1.80; Ramsey RESET test = (0.22);
Heteroskedasticity test = (0.53); Wald test = (0.00)***

***Significant at 1%, **significant at 5%, *significant at 10%; values in parentheses are p values

timber producers. In other words, a larger value in IC in turn reduces the volume of timber to be produced.

On the other hand, DP and AH had positive coefficients. Based on the estimation, an increase of 10% in AH, *ceteris paribus*, increased the timber supply by 4.7%. AH appeared to be highly significant at the level of 1%, indicating the high elasticity relative to other policy variables. There was a direct relationship between timber

harvesting activities and timber supply. The State Government of Sabah took proactive action when the rate of annual allowable cutting (AAC) showed declination in the early 1990s. This action might to some extent pull down the timber supply altogether by bringing the forests to a sustainable level. Results from this study confirmed some of the general themes and conclusions in the previous studies (see Jamal & Mohd Shahwahid 1997, Abdul Rahim & Mohd Shahwahid 2009).

For example, Jamal and Mohd Shahwahid (1997) mentioned that the decreasing trend of timber supply in Peninsular Malaysia since 1992 was due to the implementation of SFM. Similarly, Abdul Rahim and Mohd Shahwahid (2009) concluded that SFM could give substantial effects on timber supply.

In the domestic demand equation, the sign of the coefficients estimated on DP, IPI and WMP were as expected. However, the results of the coefficients for IPI and WMP were insignificant. These results were similar to the results estimated in the study conducted by Mohd Shahwahid (1995). Unlike the timber supply function, DP was not an important determinant of the domestic demand for timber in the domestic market. This could be due to the higher willingness to pay from timber processing mills in getting their raw materials since it was a seller's market. Price factor did not affect the demand for timber. On the other hand, the one-year-lag dependent variable was significant at the level of 1%.

Although the coefficients in the model produced the expected signs, the estimates obtained for the export demand equation were not consistent with the *priori* theory. The result indicated that own price, substitute price and exchange rate were not significant determinants of the export demand for timber in the international market. However, the export demand function was significantly dependent on the market access and one-year-lag dependent variable. The estimated coefficient of market access was high, indicating the high market access elasticity of export demand for Sabah timber. An increase of 10% in the market access increased the quantity export demand by 18%. This might be due to the good quality of timber that could be produced from Sabah's certified forests. Forest management certification in Sabah has achieved a market premium for certified timber particularly for high quality hardwoods (Kollert & Lagan 2007).

Validation of the timber market model in Sabah

The overall fit of the equations between the explanatory variables and dependent variable could be explained by the values of r-square. This is an important criterion in evaluating the quality of regression. For example, the value of r-square obtained from the estimated supply equation was 0.80. This implied that 80% of the

variation in timber supply could be explained by the explanatory variables in the model, while the remaining 20% could be explained by other variables (Table 4).

Other diagnostic tests that were carried out for the timber supply, domestic and export demand equations were the serial correlation, heteroscedasticity, Ramsey RESET and Wald tests (Table 4). The results of the Durbin-Watson (DW) and heteroscedasticity tests showed no evidence of serial correlation and heteroscedasticity problems. The Ramsey RESET test proved that the equations were stable and had no functional misspecification. The Wald test is important to test whether the estimated equations have a long-run relationship between independent and all explanatory variables. The result showed that the model was cointegrated at 1% significant level.

The root mean square error (RMSE) and Theil's inequality tests demonstrated that the deviations of simulated variables were quite close to the average sizes of the variables for the timber supply (TS), domestic demand (DD) and export demand (XD) equations. A historical simulation was carried out throughout the sample period of study to ensure the adequacy of the model in forecasting and policy analysis. The detailed tests and results are presented in Table 5. The values of bias proportion were equal to zero, indicating the non-existence of a systematic bias for TS, DD and XD. Figures 1a, b and c show the actual, fitted and residual graphs of the timber supply, domestic and export demand equations respectively. This result provided strong evidence that the equations were stable between the dependent and all independent variables.

Timber price and quantity equilibrium

Table 6 presents the empirical average simulated values calculated from the timber partial market equilibrium model from 1995 till 2008. Hence the impact analysis comprised four scenarios: (1) reduction by 24% in harvested area, (2) increase by 49% in external cost of timber harvesting, (3) increase by 47% in the cost of internalising the externalities and (4) 20% gain in market access. The percentage of the reduction in harvested area and percentage gained in market access were adopted from the study conducted by Ahmad Fauzi et al. (2002) and Ahmad Fauzi et al. (2007) respectively. According to Ahmad Fauzi et al. (2002), the total harvested area for timber

harvesting decreased by 24% resulting from the implementation of SFM practices. The remaining two scenarios (i.e. increase by 49% in external cost of timber harvesting and increase by 47% in the cost of internalising the externalities) have already been discussed earlier in this paper.

Table 5 Historical simulation of timber model

	TS	DD	XD
Root mean square error	0.16	0.17	0.61
Theil's inequality coefficient	0.005	0.005	0.02
Bias proportion	0.000	0.000	0.000
Variance proportion	0.004	0.005	0.01
Covariance proportion	0.95	0.99	0.98

TS = timber supply; DD = domestic demand; XD = export demand

In this impact analysis, the equilibrium price was calculated from the estimation of the timber market model at market equilibrium (see equation 15). After substituting the equilibrium price into the supply or demand model, the equilibrium quantity was obtained. In other words, from the estimated coefficient, the equilibrium price and quantity of timber could be further quantified. Therefore the average timber market equilibrium points for price and quantity were RM211 m⁻³ and RM1.97 million m³ respectively. These points corresponded with the baseline scenario.

After incorporating the first three scenarios of SFM practices through simulation analysis, the equilibrium quantity produced a negative effect (Table 6). Under scenario 1 where harvested area was reduced by 24%, the equilibrium

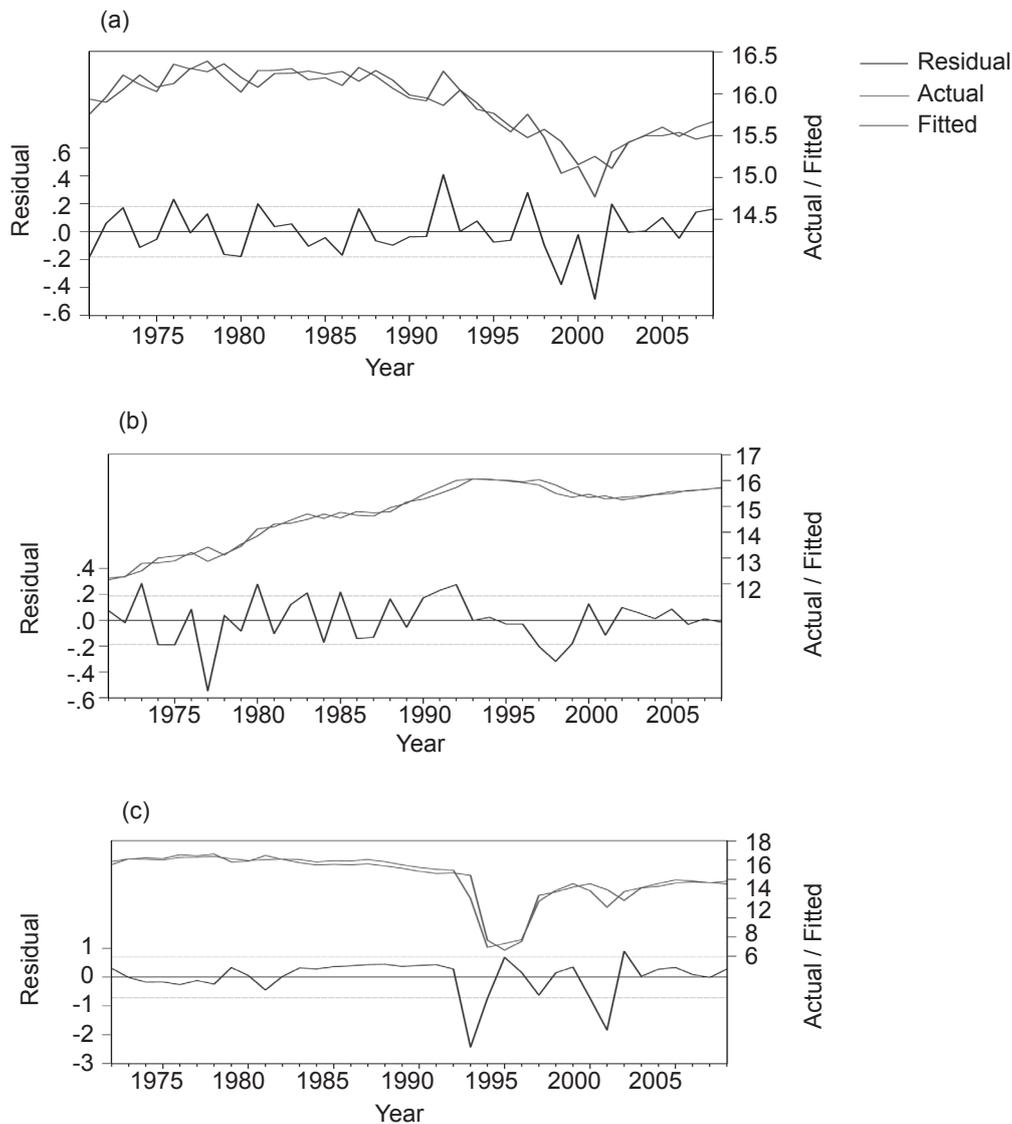


Figure 1 Simulation of timber (a) supply, (b) domestic demand and (c) export demand models

Table 6 Average simulated values due to SFM practices

	Variable unit	Equilibrium quantity (m ³)	Equilibrium price (RM m ⁻³)
Scenarios of % changes under SFM practice	Baseline scenario	1,965,301	211
	Reduction by 24% in harvested area	881,661	858
	Rise by 49% in external cost of timber harvesting	707,517	1420
	Rise by 47% in the cost of internalising the externalities	738,433	961
	Rise by 20% in market access	2,078,916	213

SFM = sustainable forest management

quantity decreased from 1.96 million m³ under the baseline scenario to 0.88 million m³. Differently, the equilibrium price increased from RM211 m⁻³ under the baseline scenario to RM858 m⁻³. Under scenario 2 where the external cost of timber harvesting rose by 49%, the equilibrium quantity decreased from 1.96 million m³ under the baseline scenario to 0.71 million m³. In contrast, the equilibrium price increased from RM211 m⁻³ under the baseline scenario to RM1420 m⁻³. Under scenario 3 where the cost of internalising the externalities went up by 47%, the equilibrium quantity decreased from 1.96 million m³ under the baseline scenario to 0.74 million m³. In contrast, the equilibrium price increased from RM211 m⁻³ under the baseline scenario to RM961 m⁻³. On the other hand, under scenario 4 where the export market gained 20% of market access, the equilibrium quantity increased from 1.96 million m³ under the baseline scenario to 2.08 million m³. Similarly, the equilibrium price increased slightly from RM211 m⁻³ under the baseline scenario to RM213 m⁻³.

The results from the four scenarios related to the equilibrium price suggested that the domestic and export markets in Sabah could be potentially considered as offering a price premium averaging from 1 to 572%. In this context, the government could use this finding to formulate price premium mechanisms such as conducting programmes to educate consumers and to promote timber produced from forests that practise SFM.

It is suggested here that the price increase reflects the value of price premium for timber produced from SFM practices or certified forests in Sabah. Similar to results from previous studies

(e.g. Kollert & Lagan 2007), the price of timber produced by SFM practices or certified forest can potentially fetch price premium ranging from 2 to 56%. In addition, according to the Forestry Department of Sabah (2003), buyers had offered premium prices by 44% increment in price for certified timber.

Table 6 shows that the equilibrium quantity of timber has decreased by 55, 63 and 63% to 0.88, 0.71 and 0.74 million m³ respectively under the first three scenarios of SFM practices. This finding was similar to that of Schwarzbauer and Rametsteiner (2001) who reported that timber production would decrease in the long run due to SFM practices. This implies that the domestic timber processing mills may operate below production capacity. In addition, Woon (2001) reported that the total number of timber processing mills (i.e. sawmills, plywood and veneer mills) was expected to be drastically reduced due to SFM practices. However, when the market access scenario under SFM was simulated, the equilibrium quantity of timber increased by 6% to 2.08 million m³. This suggests the consequences of importing countries' decisions to start demanding timber produced from sustainably managed forests. In a recent paper, it was found that timber importers had started requesting for certified timber for corporate image or the final consumer demand (Anonymous 2010).

Based on these scenarios, the reduction in harvested area and incremental input cost due to internalising the full costs of externalities provided tremendous impact on the equilibrium quantity and the price of timber. This was due to the large coefficient values of AH and IC found compared with those in the study conducted by Mohd Shahwahid (1995) in Peninsular Malaysia.

The results of this study provided empirical evidence of the implication of SFM practices for the timber market in Sabah. As AH and IC are policy variables and have shown to be significant determinants on the timber quantity of supply, the Sabah State Government and Forestry Department can enact some mechanisms related to these variables to enhance the SFM practices.

The percentages of decrease in the equilibrium quantity of timber illustrate that timber production in Sabah has been managed not only to cater for the present needs but also for the benefit of future generations. Furthermore, the timber harvesting technique under the SFM practices and the priority in curbing damage enhance the process of regeneration of timber trees for the next cutting cycle. In this context, Thang (2007) forecasted that Malaysian timber production would increase in the long run due to the implementation of SFM. Regarding market access, Rametsteiner and Simula (2003) mentioned that timber produced from SFM practices could cater for environmental marketing and could be used as a tool for market access or gaining market advantage.

Welfare economic impacts

Based on the simulated values calculated earlier as given in Table 6, the average annual estimated values of welfare economic impacts were further determined (Table 7). The similar scenarios in the market impact analysis were adopted and simulated in this welfare economic impact analysis. The simulation results showed that the calculated

values of producer surplus and consumer surplus changed when the four scenarios under SFM practices were incorporated.

Under scenario 1 where harvested area was reduced by 24%, the producer surplus decreased from RM4.24 million under the baseline scenario to RM3.72 million. Similarly, the consumer surplus also decreased from RM128.98 million under the baseline scenario to RM88.36 million. Under scenario 2 where the external cost of timber harvesting rose by 49%, the producer surplus decreased from RM4.24 million under the baseline scenario to RM2.48 million. Similarly, the consumer surplus also decreased from RM128.98 million under the baseline scenario to RM20.42 million. Under scenario 3 where the cost of internalising externalities went up by 47%, the producer surplus decreased from RM4.24 million under the baseline scenario to RM3.32 million. Similarly, the consumer surplus also decreased from RM128.98 million under the baseline scenario to RM79.05 million. On the other hand, under scenario 4 where the export market gained 20% of market access, the producer surplus increased from RM4.24 million under the baseline scenario to RM4.57 million. Similarly, the consumer surplus also increased from RM128.98 million under the baseline scenario to RM130.54 million.

These results indicated that the variations in AH and IC were the causes of reduction in the calculated values of the producer and consumer surpluses. This situation would bring about a loss in the economic welfare of the timber market in Sabah. The economic welfare in this study refers to the calculated values of total social benefits.

Table 7 Average welfare impacts due to SFM practices (RM)

	Item	Producer surplus	Consumer surplus	Total social benefit
Scenarios of % changes under SFM practices	Baseline scenario	4,237,779	128,984,944	133,258,723
	Reduction by 24% in harvested area	3,723,642	88,363,535	92,471,697
	Rise by 49% in external cost of timber harvesting	2,478,934	20,422,871	22,901,805
	Rise by 47% in cost of internalising the externalities	3,322,063	79,051,749	82,373,812
	Rise by 20% in market access	4,568,420	130,539,126	135,107,547

SFM = sustainable forest management

Hence this finding implies that when the timber industry complied with SFM practices, there will be a reduction in the economic welfare of the stakeholders in the timber sector, with an exception if they make a gain in their timber market access. With SFM, greater investment has been placed in sustaining environmental services but has brought less significant economic benefits to timber producers (Cubbage et al. 2010). This is one of the implications that have already been predicted from SFM practices.

From another point of view, the wealth of society associated with the demand functions of forests such as recreation, wilderness and nature conservation would increase other than the production of wood (Solberg et al. 1996). However, if the timber production from forest has to be expanded, it will require the operation to be within the context of sustainability. Although the SFM policy diminishes the welfare of the timber industry, it also enhances the forest conservation goal of the country (Tumaneng-Diete et al. 2005).

Owing to the gain in market access, the simulation showed that the calculated values of consumer and producer surpluses increased when the advantage of market access (rise by 20% percent in market access) was incorporated. The consumer surplus increase by 1% and the producer surplus increase by 8% would bring economic welfare gain to stakeholders in the timber industry. This is because timber produced from a sustainably managed forests will give consumers a credible guarantee that the timber is produced from an environmentally responsible and socially beneficial forest (Perera et al. 2006). Hence the loss value in economic welfare under the first three scenarios of SFM practices could be offset by the market access that could potentially be realised in the Sabah timber market. In fact, timber producers in Sabah have been given the incentive of a reduction in royalty payment by 25% in order to encourage them to comply with SFM practices (Forestry Department of Sabah 2008).

CONCLUSIONS AND POLICY IMPLEMENTATIONS

The results of the timber market modelling in Sabah showed that harvested area, market access and input costs were the main variables having significant impacts on the equilibrium price

and quantity process, which in turn affected the producer's profits under SFM practices. Moreover, SFM practices will certainly affect the stakeholders in the timber-based industry as their interests normally require trade-offs. According to Rametsteiner and Simula (2003), the interests of different stakeholders were rarely fully mutually reinforcing. Moreover, the context of SFM deals with different stakeholders related to natural forests. Thus in this study, stakeholders in the timber sector had been included and evaluated.

For a partial equilibrium timber market analysis, the results showed that compliance with SFM practices reduced the supply of timber. However, the price levels were pushed up in the partial equilibrium process. Hence the equilibrium price and quantity of timber increased and decreased respectively reflecting the optimum level when internalising the externalities from timber harvesting activities considered. In other words, the optimum level of quantity and price also represents the value of environmental resources. Based on these scenarios, the incremental costs with respect to SFM practices are likely to affect the market and economic welfare more than decreasing the harvested levels. However, Schwarzbauer and Rametsteiner (2001) found that a decrease in harvested levels gave an immense impact on the forest products market than an increase in the operational costs due to SFM practices.

The simulation results of partial market equilibrium revealed that producers could potentially fetch price premium in the Sabah timber market when the four scenarios under SFM practices were incorporated. If this to be realised, one should expect that all the producers in the timber sector will choose to comply with SFM practices. Therefore, price premium is required to offset the foregone value of incremental cost of internalising the externalities by minimising forest damage from timber harvesting activities. Ignoring externality effects would lead to market failure. In that case, government intervention is needed in order to alter the distortion of market equilibrium.

The policy variables used in the Sabah timber market model (i.e. harvested area and input cost) are significant and inelastic. Only market access is significant and elastic. Generally, exogenous shocks in these policy variables would have small impact on the equilibrium price and

quantity of timber as well as on the economic welfare of timber industry. The results indicated that stakeholders in the timber industry world incurred losses in the economic welfare due to SFM practices. However, with some incentives that the government could offer and the increasing international demand for timber produced from SFM practices, this could offset their losses. As a result, this may give all the stakeholders in the timber industry some motivation to comply with the SFM policy. Consequently, forest resources of non-timber forest products (NFTPs) and environmental services will also be protected and hence will potentially generate income for the society and government in the future.

Besides that, the existence of market access from consumers that consumed only timber produced from SFM practices could create a potential niche market. This would give timber producers some advantage in their economic welfare. Hence the Sabah State Government should consider green premium, market access and several incentives to offset the timber producers' full costs pertaining to SFM practices. Therefore stakeholders from the timber sector and others which represent the society as a whole could at least gain some mutual benefits.

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