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SAWN TIMBER MARKET AND THE IMPACT OF SUSTAINABLE FOREST MANAGEMENT PRACTICES IN PENINSULAR MALAYSIA

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This paper examines the economic impact on sawn timber market in Peninsular Malaysia under the scenarios of sustainable forest management (SFM) practices. Autoregressive distributed lag (ARDL) approach test was employed using time-series data from 1980 to 2015, comprising of five scenarios: (1) 24% reduction in harvested area, (2) 25% increase of the domestic price of sawn timber, (3) 47% increase in input cost, (4) incorporated with scenarios (1), (2) & (3) and (5) 10% increase in contribution of forestry and harvesting activities to total gross domestic products (CGDP). The result revealed that the supply and export of sawn timber had a positive impact on SFM. Even though domestic demand was affected by the increase of prices, the value could be used to compensate for the loss volume of timber. These findings are important to policymakers in order for them to reach a benchmark regarding an appropriate method to sustain forest resources. Based on the scenarios imposed under SFM practices, it was found that it is possible to boost sawn timber industry without compromising efforts to sustain and conserve forest resources.

Keywords: ARDL bound test, harvested area, production, demand, raw material

INTRODUCTION

Sawn timber is well anchored in Malaysia as an ongoing subsector of the timber industry. In 2012, there were 671 sawmills located in Peninsular Malaysia, 172 in Sabah and 170 in Sarawak. Exports of sawn timber in 2012 amounted to RM 1.22 billion, primarily to Thailand (RM 192 million), Netherlands (RM 115 million), Singapore (RM 96 million), UAE (RM 72 million) and South Africa (RM 58 million) (Forestry Statistics Peninsular Malaysia 2012). Hence, to meet domestic and international demand, Malaysian government has taken initiatives to ensure the continuity of forest resources by joining the International Timber Trade Organisation (ITTO). Malaysia has been registered with ITTO since 1990, thus adhering to strive for an international trade of tropical timber from sustainably managed forests (Samsudin & Heyde 1995).

Accordingly, Malaysian forest resources are carefully managed according to the principle of SFM practices to achieve a balance between development and conservation. Thus, timber-based products and services can be obtained in perpetuity. In order to ensure a continuous supply of timber for timber-based production, harvesting is regulated by area control and volume method, which are prescribed in the management plans (Chiew-Thang 1987). The National Forestry Council allocates an annual felling coupe to each state based on forest inventory data, net area of production forest and silvicultural practices in place.

In order to achieve SFM, there is a need for substantial reduction in the annual coupe or allowable cutting rate within the country. In recognition of the need to strengthen SFM practices, Malaysia has undertaken a critical step to reduce the annual coupe (AAC) in the country (Woon & Tong 2004). Furthermore, the annual coupe has been reduced from 71,200 ha per annum for Peninsular Malaysia during the Fifth Malaysia Plan (1985–1990) to 42,870 ha per annum during the Eighth Malaysia Plan (2001–2005). For the Ninth Malaysia Plan (2006–2010), the annual coupe was set at 36,940 ha. This shows that the annual coupe has been steadily declining, due to efforts taken towards conservation strategy to ensure sustainable timber production and to comply with SFM (Mohd-Shahwahid & Awang-Noor 2002 Woon & Tong 2004). This is the fundamental pillar of Peninsular Malaysia's commitment to SFM (MTC 2007).

Other than reducing AAC, the stringent criterion for SFM is harvesting operations that affect timber volume, which can be extracted. In addition, Peninsular Malaysia banned export of timber since 1972 for ten species and completely banned for all species, beginning 1985 (Tachibana 2000). The accessible forestland in Malaysia has slowly given way to agriculture, especially oil palm plantation, new satellite towns and other forms of land use, which simultaneously created conflict between agriculture production and forest management (Ahmad-Fauzi et al. 2010).

As a result, it has affected the supply of Malaysian timber, which is the raw material for sawn timber. The shortage of timber production has had an impact on the production of sawn timber. The role of timber as raw material for sawn timber caused the diminishing of sawn timber production. According to Forestry Statistics Peninsular Malaysia (2012), overall timber production fluctuated with decreased trends, from 4.5 million ha in 2004 to 3.7 million in 2009. The production showed increased trends from 3.7 million in 2009 to 4.5 million in 2012. During the same range of year, the quantity of timber imports increased from 0.034 million m^3 to 0.035 million m^3, to equip shortage of timber production (Table 1). As a result, the production and consumption of sawn timber showed deficit trend mostly from 2003 to 2012 (Table 2).

Table 1 Timber productions, consumptions and trades in peninsular Malaysia (million m^3)

Year	Total timber production	Consumption by sawmills	Total timber consumption	Timber import	Surplus/ deficit
2003	4.419	5.519	6.279	0.340	(2.20)
2004	4.572	6.082	6.860	0.080	(2.37)
2005	4.405	5.106	5.736	0.072	(1.40)
2006	4.693	6.445	6.991	0.112	(2.41)
2007	4.220	4.381	4.980	0.070	(0.83)
2008	4.028	3.681	4.203	0.078	(0.25)
2009	3.686	3.131	3.600	0.034	(0.05)
2010	4.161	3.892	4.496	0.023	(0.36)
2011	4.171	3.920	4.601	0.021	(0.45)
2012	4.467	4.772	5.480	0.035	(1.05)

Production + import = total consumption (domestic + export); source = Forestry Department Peninsular Malaysia

Table 2 Sawn timber productions, consumptions and trades in peninsular Malaysia (million m^3)

Year	Total sawn timber production	Consumption		Total sawn timber consumption	Sawn timber import	Surplus /deficit
		Domestic	Export			
2003	2.928	2.689	1.048	3.737	0.575	(1.38)
2004	3.200	2.682	1.137	3.819	0.665	(1.28)
2005	3.236	2.751	1.198	3.949	0.689	(1.40)
2006	3.019	2.945	1.104	4.050	0.746	(1.78)
2007	2.668	2.731	0.812	3.544	0.547	(1.42)
2008	2.387	2.029	0.944	2.973	0.395	(0.98)
2009	2.081	1.361	0.793	2.153	0.312	(0.38)
2010	2.659	2.107	0.879	2.986	0.294	(0.62)
2011	2.675	2.501	0.993	3.494	0.268	(1.09)
2012	2.790	2.758	0.963	3.721	0.295	(1.23)

Production + import = total consumption (domestic + export); source = Forestry Department Peninsular Malaysia

The main reason for the decreased trend was possibly due to the shortage of timber supply resulting from the increase in local demands for high value-added manufactured goods as well as the obligations of SFM practices (Norini 2001, Zuhaidi et al. 2007). The effect on timber markets, due to compliance with SFM practices, is still open for debate. The capability of forest plantation to support the domestic timber industry is limited, as the availability of land is not adequate, especially in Peninsular Malaysia. Awang-Mohdar & Ahmad-Zuhaidi (2005) stated that, in spite of the high demand for timber in a worldwide setting and the upsurge of price throughout the years, forest plantations in Malaysia are developing at a very slow pace. Thus, the issue is still debated between SFM and the timber-based industry.

According to Abdul Rahim et al. (2012a), in a study on the impact of SFM practices on supply of timber in Sabah, Malaysia, harvested areas revealed elastic responses towards total production, which became the significant determinant supply of sawn timber in Sarawak. Once SFM is imposed on a harvested area, a decrease in harvested levels had an immense impact on forest products market over an increase in operational costs. These findings became comprehensive in designing optimal forest policies. Therefore, the enforcement in reducing harvested area need to be reviewed in order to discover solutions so that trade-off between sustainability of natural forest resources and profitability can be made.

In addition, increased production costs by using an environmental machine during harvesting and the implementation of minimum wages in timber-based sectors have to be discussed between policymakers and producers. Suppliers will be motivated to produce timber-based products because there is mutual benefit, which helps them to make a profit in a sustainable manner. In many profit-based sectors such as the timber-based industry, forecasting is important in order to predict future conditions. Forecasting has become one of the most critical factors in developing foresight, formulating corporate strategies, planning effectively and succeeding in business as a whole (Makridakis 1996).

A few scenarios under SFM practices need to be analysed in order to know whether the changes in production and consumption of sawn timber under SFM practices have the potential to complement future growth of the sawn timber industry. In terms of sawn timber production, forecasting studies have enabled the industry to produce and keep inventory of timber-based products, to meet consumption from domestic and international markets (Makridakis et al. 1998). Without such information, the sawn timber industry in Peninsular Malaysia may fail to meet the demand of consumers and lose export transactions , resulting in financial loss and poor reputation.

Thus, the ability to anticipate future consumption of sawn timber from Peninsular Malaysia is an essential element in the timber-based industry to fulfill the need of customers. Forecasts are useful to understand the timber-based industry which change over time as a result of rapid development throughout the world (Hetemaki et al. 2004, Hanninen 2004). The study on sawn timber industry is crucial as Malaysia is now complying with SFM practices and facing a shortage of timber supply as raw material for sawmills. This study attempted to determine the determinant of the sawn timber market and forecast the impact of SFM practices, incorporated with several scenarios under SFM practices in Peninsular Malaysia.

MATERIALS AND METHODS

Model framework

The sawn timber market can be described in terms of an expanded model developed by Mohd-Shahwahid (2006). The market model consists of sawn timber market supply, domestic demand, export demand and import demand. A schematic presentation of an integrated model of sawn timber market in Peninsular Malaysia is illustrated in Figure 1.

This study developed two major processes to estimate the determinant of the sawn timber market model, imposing the scenarios under SFM practices towards integration of sawn timber in Peninsular Malaysia. The sign of the equation depends on a theory where positive signs are expected for variables such as production of timber-based products, technology, harvesting areas, income variable (domestic and foreign), exchange rate and the price of the substitute's variable, while variables such as price of timber-based products and input cost are expected to be negative.

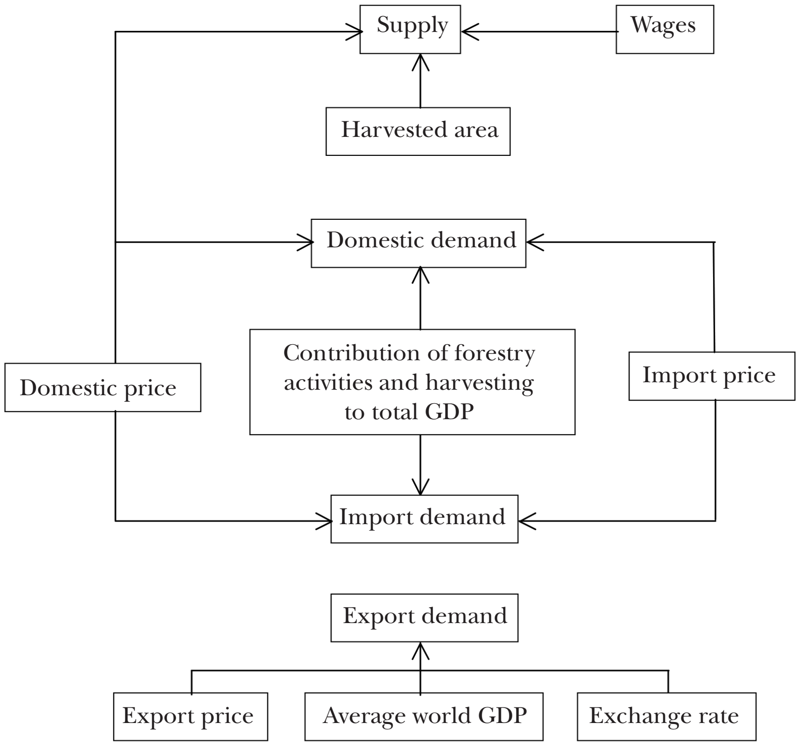


Figure 1 Integrated modelling of sawn timber market in Peninsular Malaysia

Model estimation

As shown in Figure 1, four models were applied for the sawn timber market: supply, domestic demand, export demand and import demand. Model estimation covered all four models, as specified below:

Supply of sawn timber

$$TSB_t = \alpha_0 * DB_t^{\alpha_1} * AH_t^{\alpha_2} * WB^{\alpha_3} \quad (1)$$

$$LTSB_t = \alpha_0 + \alpha_1\, LDB_t + \alpha_2\, LAH_t + \alpha_3\, LWB_t + \varepsilon_t \quad (2)$$

where TSB_t = total supply of sawn timber, DB_t = domestic price of sawn timber, AH_t = harvested area in natural forest, WB_t = total wages paid in sawmill, t = years, ε_t = error term and L = logarithm. The original model of the sawn timber supply in equation 1 can be transformed by using a log linear form. Equation 2 estimates the total supply of sawn timber, positively related to the harvested area and price of sawn timber. TSB_t is the supply of sawn timber as an endogenous or dependent variable. DB_t is the price of sawn timber, which is an important variable in determining the quantity of sawn timber supply. AH_t is the natural forested area, which opens for harvesting in order to produce timber as raw material for sawn timber. WB_t is the total wages paid by sawmills and simultaneously represents the production cost.

Domestic demand of sawn timber

$$TDB_t = \alpha_0 * DB_t^{\alpha_1} * CGDP_t^{\alpha_2} * IB_t^{\alpha_3} \quad (3)$$

$$LTDB_t = \alpha_0 + \alpha_1\, LDB_t + \alpha_2\, LCGDP_t + \alpha_3\, L\, IB_t + \varepsilon_t \quad (4)$$

where TDB_t = domestic demand for sawn timber, DB_t = domestic price of sawn timber, $CGDP_t$ = contribution of forestry activities and harvesting to total GDP, IB_t = world import price of sawn timber, t = years, ε_t = error term and L = logarithm. The original model of domestic demand of sawn timber in equation 3 can be transformed by using a log linear form. Equation 4 describes the estimated total domestic demand for sawn timber. It suggested that the lower the price, the higher the volume of sawn timber demand, domestically. The import price becomes the substitute price to the domestic demand of sawn timber. It is suggested that the higher the world import price of sawn timber, the higher the consumption of domestic demand of sawn timber. Similarly, the high amount of contribution of forestry activities and harvesting to total gross domestic product (CGDP) would promote sawn timber processing mills, (i.e. veneer and plywood mill), demanding for more domestic sawn timber. A previous study (Abdul-Rahim et al. 2012b) used the industrial production index (IPI) as an explanatory demand for timber. Hence, the present study used CGDP, a variable that shows the growth of sawn timber industry. The CGDP is positively related to domestic demand of sawn timber.

Export demand of timber-based products

$$TEB_t = \alpha_0 * EB_t^{\alpha_1} * ER_t^{\alpha_2} * AWB_t^{\alpha_3} \quad (5)$$

$$LTEB_t = \alpha_0 + \alpha_1 LEB_t + \alpha_2 LER_t + \alpha_3 LAWB_t + \varepsilon_t \quad (6)$$

where TEB_t = export demand for sawn timber, EB_t = export price for sawn timber, ER_t = exchange rate, AWB_t = average world gross domestic product, t = years, ε_t = error term and L = logarithm. The original model of export demand of sawn timber in equation 5 can be transformed by using a log linear form. Equation 6 estimates the total export demand of sawn timber, which is likely to show a negative relationship to the export price for sawn timber. As for ER and AWB, both are expected to show positive sign. In this study, the AWB showed the global countries that consumed sawn timber from Malaysia.

Import demand of timber-based products

$$TIB_t = \alpha_0 * IB_t^{\alpha_1} * DB_t^{\alpha_2} * CGDP_t^{\alpha_3} \quad (7)$$

$$LTIB_t = \alpha_0 + \alpha_1 LIB_t + \alpha_2 LDB_t + \alpha_3 LCGDP_t + \varepsilon_t \quad (8)$$

Where TIB_t = import demand for sawn timber, IB_t = import price of sawn timber, DB_t = domestic price of sawn timber, $CGDP_t$ = contribution of forestry activities and harvesting to total GDP, t = years, ε_t = error term, L = logarithm. The original model of import demand of sawn timber in equation 7 can be transformed by using a log linear form. Equation 8 estimates the import demand of sawn timber. It suggests that the lower the price, the higher the volume of sawn timber demand, domestically. The import price of sawn timber complements the import demand of sawn timber, i.e. the higher the world import price of sawn timber, the lower the consumption of domestic sawn timber. However, the high amount of CGDP promotes sawn timber processing mills (i.e. veneer and plywood mill), demanding for more import of sawn timber. The CGDP refers to the contribution of forestry activities and harvesting to total GDP (CGDP). The CGDP is positively related to the import demand of sawn timber

Autoregressive distributed lagged (ARDL) bounds test

This approach involves estimating the error correction version of the ARDL model for variables under estimation (Pesaran et al. 2000). The entire ARDL model and can be written as follows:

$$\Delta \text{In } Y_t = \alpha_0 + \sum_{i=1}^{p} \varphi_i \Delta \text{In } Y_{t-i} + \sum_{i=0}^{p} \delta_i \Delta \text{In } X1_{t-i} + \sum_{i=0}^{p} \theta_i \Delta \text{In } X2_{t-i} + \sum_{i=0}^{p} \vartheta_i \Delta \text{In } X3_{t-i} + \gamma_1 \text{In } Y_{t-1} + \gamma_2 \text{In } X1_{t-1} + \gamma_3 \text{In } X2_{t-1} + \gamma_4 \text{In } X3_{t-1} + \varepsilon_t \quad (9)$$

where Δ = difference operator, In = natural log, p = lag order, and ε_t ε_t = assumed serially uncorrelated. Equation 9 is the error-correction version related to ARDL, as the terms with summation signs ($\sum$) represent the short-run dynamics, while the second part (term with μ's) corresponds to the long run (co-integration) relation. The null hypothesis in equation 9 is defined as H_0: H_0: $\gamma_1\ \gamma_1 = \gamma_2\ \gamma_2 = \gamma_3\ \gamma_3 = \gamma_4\ \gamma_4 = 0$, indicating the nonexistence of the long-run relationship.

Scenarios under SFM practices

The forecasting process was done from 2013 to 2020, and the forecast of exogenous variables resulted namely as a baseline. However, to see the impact of SFM towards sawn timber, the baseline results were not sufficient to achieve the main purpose of the study. Thus, all the forecasted exogenous variables (baseline) have imposed five scenarios to be adapted from previous studies. Also, the scenarios under SFM practices were incorporated in the sawn timber market model, as discussed below:

(1) Reduction by 24% in harvested area

The percentage of reduction in harvested area was adapted from a study conducted by Ahmad Fauzi et al. (2002). This scenario reflected the foregone revenue from buffer areas, referring to riverine and steep areas. The licensee contractors and harvesting crews incurred an opportunity cost from unearned timber income from buffer areas. Under conventional practices (CP), the forgone revenue from buffer areas only took 5.19% with MYR 216.26 ha^{-1}. However, under Malaysian criteria (MC) and indicators (I) for SFM practices, it took 24.33% with MYR 2,065.60 ha^{-1}. A reduction by 24% in harvested area was taken as Scenario 1.

(2) Increase by 25% in domestic price

This scenario reflected the domestic price market in Peninsular Malaysia by assuming that the domestic price might fetch a premium price. In other words, these simulated prices were the price of timber when best practice environmental resource management was adapted and when price distortion was remedied. A study done by Kollert & Lagan (2007) revealed that Sabah timber achieved a premium price for high-quality timber of 27–56%. Lower-quality timbers also fetched a premium price, however, the difference was less pronounced (2–30%). Thus, for this scenario, 25% of increasing domestic price in average, by a range of 2–56%, was selected.

(3) Rise by 47% in input cost

This scenario reflected the implementation of SFM practices in conducting the timber-extracting activities from forest areas (Abdul-Rahim et al. 2009). The cost of SFM implementation was higher than conventional logging. The incremental average per ha total cost increased by 46.8% to MYR13, 573 ha^{-1}. Wage was referred as the input cost in this study which increased by 47%.

(4) Integration of scenarios 1, 2 and 3

This scenario represented incorporation of all three scenarios, to see the effect of integration. The main purpose was to measure overall performance of the scenarios reflected to real situation.

(5) 10% increase in contribution of forestry and harvesting activities to total gross domestic products (CGDP)

Based on NATIP (2009), the policy targeted a growth rate of export earning of 6.4%, annually. Assuming that the productivity of timber from SFM practices being extracted from the forest increased, a 10% increase was imposed on CGDP as representing the growth rate of the timber-based industry in Peninsular Malaysia.

Data sources

This study employed annual data from 1980 to 2015 on sawn timber industry (price, quantity, volume and wages), collected from the Forestry Statistics Peninsular Malaysia, published annually. The endogenous data (ER and average world GDP less endowment forest) were obtained from World Development Indicators (2012).

RESULTS AND DISCUSSION

Unit root test

Two-unit root augmented Dickey and Fuller (ADF) and Phillips and Perron (PP) tests were conducted to determine the order of the series. Based on Table 3, most variables were stationary in the first difference at 1% significance level and nonstationary in other levels. All series appeared to be stationary after the first differencing, i.e. I(1). However, some variables were stationary at other levels. Since ARDL was mixable between I(0) and I(1), the test could proceed to co-integration.

ARDL result for sawn timber market model

ARDL bound test and level relation represented sawn timber market model (supply, domestic demand, export demand and import demand). The ARDL bound test demonstrated co-integration of variables in the long-run, while long-run co-integration established the coefficients in the long- and short-runs for each model, and eventually applied for the next forecasting process.

According to De Vita & Abbot (2002) and Kollias et al. (2008), the estimated coefficients obtained from the regression process represented the relationship between dependent and

Table 3 Unit root test

	Augmented Dickey Fuller (ADF)		Phillips Perron (PP)	
	Level			
	Intercept	Intercept & trend	Intercept	Intercept & trend
LTSB	-1.774643	-2.796481	-1.774643	-2.888236
LTDB	-3.826016*	-3.861350**	-2.806759*	-2.678098
LTEB	-0.903818	-3.003240	-1.123379	-3.230380*
LTIB	-1.350421	-4.103768**	-2.158259	-4.103768**
LHA	-1.101416	-13.31621***	-2.909449**	-11.87045***
LCGDP	-0.959451	-1.698779	-0.962181	-1.698779
LWB	-4.975479***	-5.011444***	-4.975479***	-5.01144***
LER	-1.239657	-1.534608	-1.324199	-1.534608
LAWB	-1.886281	-2.514198	-1.989534	-2.641972
LDB	-0.440943	-2.796481	-1.774643	-2.888236
LEB	-1.558308	-1.348263	-1.644067	-1.457532
LIB	-1.457066	-2.791204	-1.919520	-3.134069
	First difference			
LTSB	-5.947991***	-6.223817***	-5.931779***	-5.931779***
LTDB	-5.399168***	-5.298229***	-9.415549***	-9.282953***
LTEB	-5.926098***	-5.764920***	-5.933615***	-5.774676***
LTIB	-4.947690***	-4.856417***	-10.68251***	-10.47406***
LHA	-7.958220***	-7.810621***	-40.52229***	-38.72472***
LCGDP	-5.702508***	-4.147577***	-5.709055***	-5.758754***
LWB	-7.071785***	-7.449866***	-20.83005***	-31.09326***
LER	-4.927341***	-4.853408***	-4.892867***	-4.813527***
LAWB	-7.436453***	-7.338466***	-7.457197***	-7.360647***
LDB	-5.947991***	-6.223817***	-5.931779***	-5.931779***
LEB	-5.698934***	-5.556327***	-5.718116***	-5.874258***
LIB	-3.319633**	-3.254902*	-6.709532***	-6.581235***

***, ** & * denotes significant at 1%, 5% & 10% levels, respectively, LTSB = logarithm total supply of sawn timber, LTDB = logarithm domestic demand for sawn timber, LTEB = logarithm export demand for sawn timber, LTIB = logarithm import demand for sawn timber, LHA= logarithm harvested area, LCGDP = logarithm contribution of forestry activities and harvesting to total GDP, LWB = logarithm total wages paid in sawmill, LER = logarithm exchange rate, LAWB = logarithm average world gross domestic product, LDB = logarithm domestic price of sawn timber, LEB = logarithm export price for sawn timber, LIB = logarithm import price of sawn timber

independent variables, whereby variable's sensitivity arose when the coefficients were significantly larger than one. On the other hand, weak effects were discovered when the coefficients were significantly below one.

ARDL bound test

After the stationarity of all variables was determined, the ARDL co-integration test was implemented on the sawn timber market model. This test was done to analyse the long-run co-integration between the variables in the models. As shown in Table 4, all sawn timber market models were co-integrated due to the nature of test statistics, which was greater than the upper bound of the bound's test critical values for each commodity. The F-statistics for each market model was 5.560 (supply) at 5%, 4.948 (domestic) at 10%, 5.187 (export) at 5% and 6.161 (import) at 5% significant level, respectively. This portrayed that all market models were co-integrated and proved that there was a long-run correlation among the variables.

Table 4 Cointegration test

Market model	Lagged structure	F-statistic	Significant level	Bound critical values (unrestricted intercept and no trend)	
				I(0)	I(1)
Supply (LTSB)	(1,0,0,1)	5.560**	1%	5.333	7.063
Domestic (LTDB)	(1,1,1,0)	4.948*	5%	3.710	5.018
Export (LTEB)	(1,2,0,1)	5.187**	10%	3.008	4.150
Import (LTIB)	(1,1,1,0)	6.161**			

Each market model had 3 explanatory variables: *** = significant at 1%, ** = significant at 5% and * = significant at 10%

Long-run cointegration

Econometric diagnostics are shown in Table 5. The coefficients were the elasticities of the respective market models. The coefficients for all variables showed correct signs for each market model, which was consistent with the theory. In the supply model (LTSB), harvested area (LHA) was significant with 5% (elastic). The results showed that the harvested area (LHA) had significant determinants on supply of sawn timber (LTSB). This was believed to be a direct impact of timber harvesting activities, as raw material in producing sawn timber. According to Sangkul (1995), about 51% of sawn timber was recovered from 20-year-old plantation teak trees with diameters of 9 to 20.5 cm, found in Thailand. According to economic theory, prices always have a positive relation with supply. Supply increased as price increased and vice versa. The domestic price of sawn timber (LDB) was not a significant determinant of its supply. The result contradicted previous studies on supply and demand relationships for timbers in Indonesia, where timber price influenced the supply of timbers (Hashim 1998, Ariffin 1994).

In domestic demand of sawn timber, domestic prices (LDB) and CGDP were not significant. This showed that price is not the importing factor in determining domestic demand. On the other hand, the CGDP did not influence the domestic demand for sawn timber. The result revealed that CGDP, which referred to the growth of the timber-based sector, had no effect on domestic demand of sawn timber. The insignificance of CGDP in influencing the domestic demand for sawn timber was explained by consumer tastes and preferences (Prestemon & Abt 2002). Consumers may prefer sawn timber for one year and then ignore it the next. This finding was similar to that of Mohd-Shahwahid (2006) who reported that industrial production index (IPI) did not influence the demand for timber.

According to Zikri (2009), in the long-run, national income also presented no effect on timber consumption. The insignificance of national income on timber-based consumption may be explained by the fact that logging concession holders, who produce timber-based, and the investors in timber-based industry are under the same hands. As a result, the consumption of timber-based consumption is likely to be vertically determined by investments in the timber industry instead of the effect of an aggregate income level.

In export demand of sawn timber, the coefficient of exchange rate (LER) was not statistically significant for a sawn timber export model (LTEB). The result of this study was similar to that of Zikri (2009), which revealed that the real exchange rate failed to explain the variations in forest product exports, probably because Indonesia had adopted various exchange-rate systems. A similar trend was observed in Malaysia, as Malaysia also adopted various exchange-rate systems during the period.

Theoretically, the increment in export price of commodities would lead to decrease in its export demand and vice versa. As shown in Table 4, the export price for sawn timber (LEB) was negative and had a highly significant relationship with total export demand for sawn timber (LTEB) at 1% significant level and elastic. This showed that the producers from the sawmill sector would export more internationally, based on the export price of timber-based products. However, the results contradicted those of Abdul-Rahim et al. (2012a) and Shahwahid (2006) who reported

Table 5 ARDL coefficient for long-run elasticity

	Market model			
	Supply	Domestic	Export	Import
Constant	0.580	13.499***	-6.947	-16.04
Domestic price (LDB)	0.333	-0.270	-	0.553
Import price (LIB)	-	0.084	-	-0.851**
Export price (LEB)	-	-	-1.250***	-
Harvested area (LAH)	1.273**	-	-	-
Input cost (LWB)	-0.015	-	-	-
Contribution of forestry activities to Total GDP (LCGDP)	-	0.094	-	1.357*
Average world GDP (LAWB)	-	-	1.025*	-
Exchange rate (LER)	-	-	1.456	-

Each market model had 3 explanatory variables: *** = significant at 1%, ** = significant at 5% and * = significant at 10%

that export price insignificantly reflected the total exports of timber. The reason behind this is that the international price was slightly higher than the price offered within the country.

Next, the average world GDP for sawn timber (LAWB) was significant at 10% level towards total export demand for sawn timber (LTEB). In addition, LAWB had elastic as LAWB increased, increasing Malaysia's total exports of sawn timber. The result showed that LAWB became a significant determinant.

Henceforth, the findings revealed that the import price for sawn timber has become a significant determinant of the total sawn timber import demand. This finding was similar to that of Shahwahid (2006), who reported that the import price of timber was statistically significant. The production of timber decreased to the area of forest opening for logging and is expected to shrink in the future. In addition, the utilisation rate of the timber to produce raw material was poor and has become an additional factor. Based on the circumstances previously mentioned, imports of timber-based products would turn out to be extremely important. This is because, in order to meet domestic demand, manufacturers were forced to import sawn timber to meet the domestic demand. Furthermore, there was a long-run relationship between CGDP and the import demand model for sawn timber (LTIB) by a 10% significance level, respectively. The CGDP measured the growth of the sawn timber industry. The result indicated that the sawn timber industry grew when the demand increased in local and international markets.

After the determination of the long-run coefficient of variables, the error correction model (ECM) was estimated to determine the existence of the long-run relationship (Table 6). The ECM was the measurement for the speed of adjustment, in which the dependent variable was adjusted to change the independent variables, before converging into equilibrium level.

Diagnostic tests

In addition, the estimated regression for sawn timber market model had undergone the diagnostic tests to analyse the stability of the model (Table 7). The tests used were Breuch–Godfrey serial correlation LM test (testing for first-order autocorrelation), Ramsey RESET test, Cusum test and Cusum square test. Based on the tests employed, all regression models successfully passed the diagnostic tests. First, the residuals of the models were free from autocorrelation problems in the first order of autocorrelation. Second, the residuals were all homoscedastic. Moreover, the Ramsey RESET test concluded the models to be in correct functional forms. Last, the CUSUM and CUSUM square tests showed that the models were stable at 5% significance level.

3.3 Forecasting the impact on sawn timber

As previously mentioned in the projection procedures, the impact analysis comprised of five scenarios: (S1) 24% reduction in harvested area, (S2) 25% increase of domestic price of

Table 6 Error correction representation and variation in model

	Market model			
	Supply	Domestic	Export	Import
ECM (-1)	-0.236**	-0.881***	-0.335**	-0.798***
R-squared	0.8534	0.5486	0.9456	0.8485
R-bar-squared	0.8371	0.4282	0.9319	0.8023

*** = significant at 1%, ** = significant at 5% and * = significant at 10%

Table 7 Diagnostic test for sawn timber market model

Type of test	Supply	Domestic	Export	Import
LM test	0.644[0.429]	0.644[0.429]	0.124[0.728]	2.523[0.126]
Breuch-Pagan	1.588[0.218]	1.588[0.218]	0.616[0.438]	2.740[0.109]
Ramsey RESET test	0.697[0.411]	0.697[0.411]	0.134[0.718]	0.187[0.670]
Cusum test	Stable	Stable	Stable	Stable
Cusum square	Stable	Stable	Stable	Stable

The p-value for diagnostic test in parentheses: *** = significant at 1%, ** = significant at 5% and * = significant at 10%

sawn timber, (S3) 47% increase in input cost, (S4) integration of scenarios 1, 2 & 3 and (S5) 10% increase in CGDP. The discussion is divided into four parts: supply, domestic, import and export demand (Table 8), and the scenarios were imposed in year 2015.

Supply of sawn timber

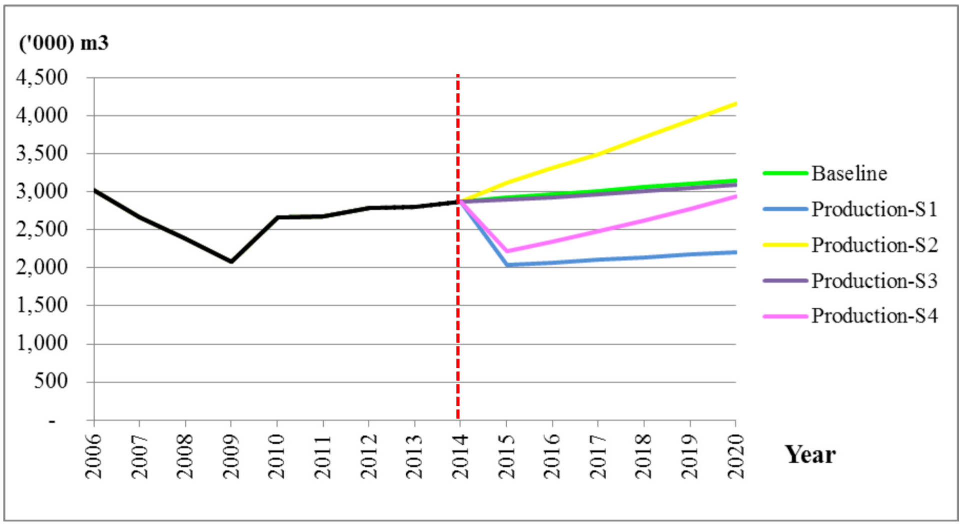
Figure 2 shows the time plot supply of sawn timber from 2006 to 2020. Four scenarios (S1, S2, S3 and S4) were imposed to forecast the supply of sawn timber in 2015 and produce five lines including the baseline. Once the scenario is imposed (starting from the red boundary line), the supply forecasts line for baseline (light green line), scenario 2 (yellow line) and scenario 3 (purple line) showed an increasing trend. However, the supply forecast line for scenario 1 (blue line) and scenario 4 (pink line) showed a decreasing trend. As predicted, each forecast line, represented by a scenario, showed an increasing trend. However, forecast line S4, incorporating three scenarios (pink line), expressed differently than the other two scenarios and baseline. Overall performance was a good predictor of the central tendency line, which absorbed each effect of the scenarios. This impact analysis, expressed in numerics, is shown in Table 9.

Based on the supply, the forecasted results of sawn timber did not reveal negative effects for any of the scenarios under SFM practices. The forecasted result of sawn timber supply constantly increased in trend, even with the imposition of the scenarios under SFM practices. The result suggested that SFM practices boosted the supply of sawn timber. In addition, the producers were willing to bear the increasing costs of sawn timber production in a sustainable manner. This is due to the high demand of sawn timber from domestic and international markets. According to Shamsudin & Othman (1995), Malaysia plays a dominant role in the international sawn timber trade. In 2012, Malaysia was one of the major suppliers of sawn timber other than Brazil and Cameroon, which has caused rapid construction activity in the United States (UN 2013). In addition, according to Dato' Dr. Jalaluddin Harun, director general of the Malaysian Timber Industry Board (MTIB), in an interview with the Top 10 of Malaysian Programs on 'A Driving Force in the Malaysian Timber Industry', Malaysia is the largest exporter of tropical sawn timber and plywood in the world. In addition, he claimed that timber products are a significant contributor to the Malaysian economy (Anonymous 2011).

Table 8 The imposition of scenario for each exogenous variable

Exogenous variable	Scenarios imposed
Supply	S1, S2, S3, S4
Domestic demand	S2, S5
Import demand	S2, S5
Export demand	No scenario involved

S1 = reduction by 24% in harvested area, S2 = rise by 25% in domestic price, S3 = rise by 47% -percent in input cost, S4 = incorporated all S1, S2 & S3, S5 = rise by 10% in CGDP



Black line = available data, vertical line = threshold between historical data and forecasted data

Figure 2 Forecasting result on supply of sawn timber due to SFM practices in Peninsular Malaysia

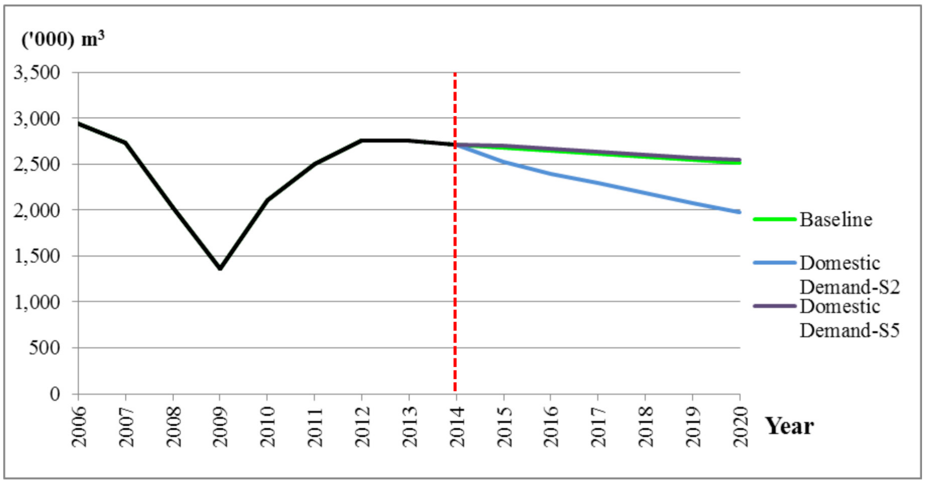
Table 9 Average forecasted values on supply of sawn timber due to SFM practices in Peninsular Malaysia

Year	2015			2020		
Variables	TS	Changes	%	TS	Changes	%
Unit	million m^3	million m^3	%	million m^3	million m^3	%
Baseline scenario	2.921	NA	NA	3.151	NA	NA
S1-reduction by 24% in harvested area	2.043	0.877	30	2.204	0.946	30
S2-rise by 25% in domestic price of sawn timber	3.112	0.191	7	4.161	1.010	32
S3-rise by 47% in input cost	2.899	0.022	1	3.097	0.053	2
S4-integration of S1,S2 & S3	2.213	0.708	24	2.932	0.219	7

S1 = scenario 1, S2 = scenario 2, S3 = scenario 3 & S4 = scenario 4, TS = total supply, changes = forecast value with scenario (S1, S2, S3 & S4) – baseline scenario, % = [forecast value with scenario (S1, S2, S3 & S4) – baseline scenario]/100, NA = not applicable

Domestic demand

For domestic demand of sawn timber, Scenarios 2 and 5 increased by 25% in domestic price and 10% in CGDP, imposed on the forecasted domestic demand line. Based on Figure 3, the baseline (green line), Scenario 2 (blue line) and Scenario 5 showed a decreasing trend. However, once Scenario 2 was imposed in the gap between baseline and Scenario 2, the forecast lines increased. These were due to the domestic price of sawn timber having a relatively high coefficient



Dark line = available data, vertical line = threshold between historical data and forecasted data

Figure 3 Forecasting result on domestic demand of sawn timber due to SFM practices in Peninsular Malaysia

value (0.270) compared with other variables, LIB (0.084). Scenario 5 (purple line) was above the baseline. This impact analysis, expressed in numerics, is shown in Table 10.

The domestic demand of sawn timber showed negative effects with scenarios under SFM practices. Imposing the domestic price (increased by 25%) gave way to decreased demand for domestic market. The result suggested that consumers imported sawn timber because the price from domestics was higher than the international market. Unstable domestic price forced consumers to choose imports.

Import demand

For import demand of sawn timber, the domestic price of sawn timber increased by 25 and 10% for Scenario 2 and 5 respectively in CGDP, and were imposed on the forecasted import demand line. Based on Figure 4, the baseline (green line), Scenario 2 (yellow line) and Scenario 5 (pink line) showed an increasing trend. However, once Scenario 2 was imposed, the gap between the baseline and forecast line became greater. This was due to the import price that had a high coefficient value (0.851) and was statistically significant at 5% compared with other variables, LDB (0.553). Scenario 5 showed that CGDP referred to the purchasing power of a sawn timber buyer. When the domestic supply was not enough to fulfil the demand, supply was imported internationally. This impact analysis, expressed in numerics, is shown in Table 11.

The import demand forecast results for sawn timber showed an increasing trend (Figure 4). In Scenario 2, which showed a 25% increase in domestic price of sawn timber, the forecasted result lines showed an increasing trend, while the baseline showed a decreasing trend. The percentage of average growth rate of forecast line for sawn timber was 8%. For premium price obtained from SFM practices, the results showed that domestic price was higher than import price of sawn timber. As a result, consumers tend to import sawn timber rather than purchasing from the domestic market.

Export demand

The forecast analysis involved the baseline scenario. Based on Figure 5, the export demand of sawn timber showed an increasing trend with an average growth rate of 1%. According to Shamsudin and Othman (1995), Malaysia plays an important role in the international sawn timber trade. In 1991, Malaysia was the world's biggest exporter of sawn timber, as 45% of exports came from Malaysia. In addition, based on Market Watch (2012), sawn timber became the third export earner in the timber trade and contributed to 12.4% of Malaysia's total timber export value in 2010. In 2012, the sector showed an improved performance, both in terms of volume and value. Import partners in the timber trade were Thailand (16%), The Netherlands (9%) and United Arab Emirates (6%) (Forestry Statistics Peninsular Malaysia 2012). Furthermore, due to growing construction

Table 10 Average forecasted values on domestic demand of sawn timber due to SFM practices in Peninsular Malaysia

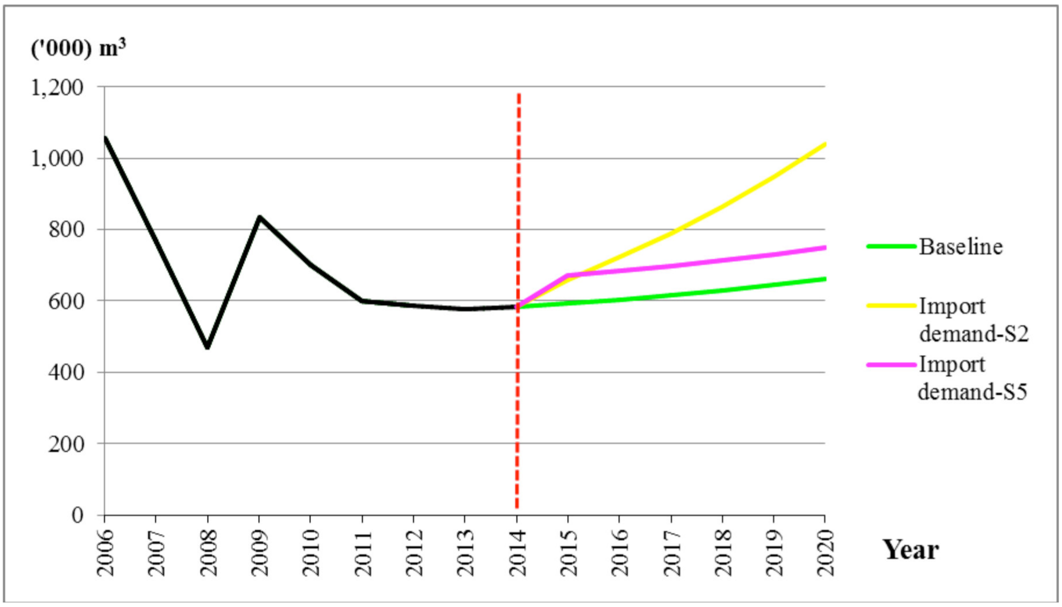
Year	2015			2020		
Variables	TD	Changes	%	TD	Changes	%
Unit	million m^3	million m^3	%	million m^3	million m^3	%
Baseline scenario	2.675	NA	NA	2.520	NA	NA
S2-Rise by 25% in domestic price of sawn timber	2.529	0.146	5	1.978	0.543	22
S5-Rise by 10% in CGDP	2.701	26	1	2.544	24	1
S3-Rise by 47% in input cost	2.899	0.022	1	3.097	0.053	2

S2 = scenario 2, S5 = scenario 5, TD = total domestic demand, changes = forecast value with scenario (S2, S3 & S5) – baseline scenario, % = [forecast value with scenario (S1, S2, S3 & S4) – baseline scenario]/100, NA = not applicable

Table 11 Average forecasted values of import demand of sawn timber due to SFM practices in Peninsular Malaysia

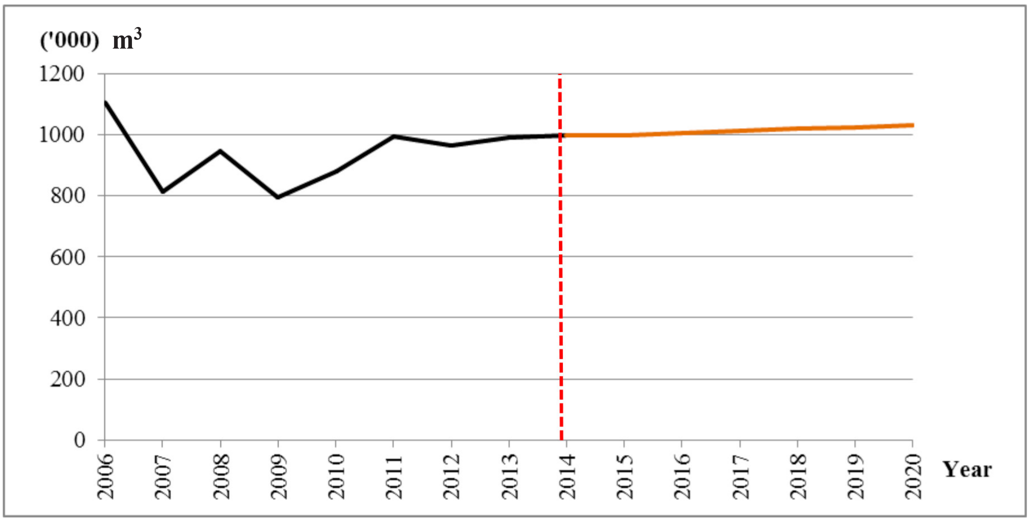
Year	2015			2020		
Variables	TI	Changes	%	TD	Changes	%
Unit	million m^3	million m^3	%	million m^3	million m^3	%
Baseline scenario	0.593	NA	NA	0.661	NA	NA
S2-rise by 25% in domestic price of sawn timber	0.658	0.064	11	1.039	0.378	57
S5-rise by 10% in CGDP	0.672	0.079	13	0.749	0.088	13

S2 = scenario 2, S5 = scenario 5, TD = total domestic demand, changes = forecast value with scenario (S2, S3 & S5) – baseline scenario, % = [forecast value with scenario (S1, S2, S3 & S4) – baseline scenario]/100, NA = not applicable



Dark line = available data, vertical line = threshold between historical data and forecasted data

Figure 4 Forecasting result on import demand of sawn timber due to SFM practices in Peninsular Malaysia



Dark line = available data, vertical line = threshold between historical data and forecasted data

Figure 5 Forecasting result on export demand of sawn timber in Peninsular Malaysia

industries, the United States imported mainly from Malaysia, Cameroon and Brazil as the major supplier of tropical timber.

CONCLUSIONS

The study examined sawn timber market incorporated with SFM practice scenarios in Peninsular Malaysia. The findings showed that the supply trend of sawn timber increased with the imposition of scenarios under SFM practices. Thus, the production of sawn timber has been successfully growing due to SFM practices. The findings also showed that manufacturers produced more sawn timber under the SFM practices. This is because the demands for environmental-friendly or 'green' products have increased at an international level, especially in developed countries. New Zealand, The Netherlands, Belgium and Australia have introduced public timber procurement policies which require the certification of imported timber products, as the originator of sustainable sources (Parikka-Alhola 2008). Certification for SFM practices is critical for long-term access to key markets in Europe, United States and Japan, as they are the major countries that import sawn timber from Malaysia.

The domestic demand of sawn timber reduced among local producers. When domestic price increased (premium price), the sawn timber consumer imported from the international producers. As a result, import demand increased due to SFM practices. The decline in domestic demand and increase in import demands put the development of the sawn timber market in good condition. The findings also showed that Malaysia has a great demand for exporting sawn timber to fulfil the international market. This trend is equally beneficial to domestic and international markets. As a whole, the sawn timber market was capable to grow together with SFM practices.

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