Timber Trade Policy and Industrialisation: Implication for Forest Harvest and Environment in Malaysia

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Abstract

Shortage of timber input for processing industries is the main issue facing the Malaysian forest sector. The need to implement policies which will ease the pressure on timber shortage and induce the expansion of forest sector industry, development of rubberwood sector in Malaysia is becoming increasingly urgent. The Malaysian government has announced and implemented three main policies: timber market restriction, encourage utilisation of rubberwood and promotion of lesser-known timber species (LKS). Application of timber market restriction policies has a considerable dispute; firstly because of widespread disagreement over the effect on efficiency of utilisation of timber that lead to timber harvest and deforestation and secondly it will undermine the government effort to promote utilisation of rubberwood and lesser known species. In this thesis, an attempt has been made to enlarge the available empirical knowledge of such effect through a multi-sectoral forest - rubberwood sector model simulation. An analytical framework is developed, focusing on three major product of the forest sector; log, sawnwood and plywood, and two major products of rubberwood sector; rubberwood log and sawn rubberwood. The framework is used to developed an empirical model of forest-rubberwood and analysed the effect of market restriction policy on forest harvest behaviour, sawnwood and plywood development, rubberwood sector development and change in forest cover. The production, consumption and export of timber, sawnwood, plywood, rubberwood and sawn rubberwood, and change in forest cover have been examined in relation to a number of market policies: export taxes, export ban and import ban, and other alternative policies; royalty, exchange rate, wood utilisation efficiency and subsidies. A series of simulations was undertaken to describe the effect of these policies. The analysis suggests that export restriction on processed timber product will reduced the timber harvest and improved the forest cover but will hinder or distort the development of rubberwood sector and utilisation of less timber species.

Related to the deforestation, the notion of environmental Kuznets curve is also examined. The results does not support the existence of this notion for Malaysia.

In addition to sectoral analysis, an extended analysis using species harvest was undertaken, as a new approach to investigate efficiency of utilisation of wood resource and forest cover. The results show that promotion of species utilisation will not be achieved with the implementation of market restriction policy on forest products. Species analysis also indicate that in the absence of full data on the quantity of forest harvest, species harvest data would be a good alternative to estimate the effect of policies on forest cover.

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It is not complete without saying that the upbringing and prayers of my parents have had a hand in anything good that I ever did, including this study. For them I raise my hands in fervent prayer: "My Lord! Bestow on them your mercy even as they cherished me when I was small " (Bani Israil 17:24)

While the above mention helped me immeasurably to complete this thesis, they are not responsible for any deficiencies that may remain. That responsible is mine alone.

Sintok, September 14, 2000.

Declaration

Except where otherwise indicated,
this thesis is my own work

Barudin Muhamad
September, 2000

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Chapter 1

INTRODUCTION

Malaysia is committed to developing its forest sector industries and subscribes to the International Timber Trade Organisation (ITTO) for a firm stand on the need to " reverse the trends in the flow of unprocessed raw materials from developing countries" in favour of having them locally processed (Maskayu,1990). Local processing has a 'conservation dimension' that should not be overlooked. Sustainable management of the tropical forest will not be feasible without assisting the producing countries in developing and modernising their timber industries and investment in the manufacturing of high value timber products.

One of the key determinants of the future development of down-stream industries is the sustainable and secure supply of raw materials. Access to a reliable supply of trees for raw material will continue to remain an important success factor in the sector. Log supply from natural forest is dwindling and will be further reduced as state governments adhere to the National Forest Policy and implement the annual coupe for logging from Permanent Forest Estate (PFE). A sharp fall in natural log production also is expected due to the clear cutting of state lands and reliance on the PFE for remaining supplies.

Given the key issue of raw material constraint which could affect the overall competitive position of the burgeoning wood based cluster, the Malaysian government has embarked upon three important policies: restriction on timber market, promotion of lesser-known timber species and development and encouragement of the use of rubberwood

There are two major market restriction policies currently implemented by the Malaysian government: restriction on log export and restriction on intermediate processed timber products such as sawn timber, plywood and veneer. These policies were implemented in stages beginning from 1972.

The first stage of the policy was the implementation of a log restriction policy. Peninsular Malaysia introduced a ban on log export in 1972 when the wood processing industry sought relief from the government due to intense competition for logs in the domestic market. At the beginning, only ten of the most popular species fell under this policy and the government raised the export tax on remaining species to 15 percent. Additional species were brought under the ban in 1973, 1978, 1979 and 1983. As of January 1,1985, export of all logs other than those of small diameter was banned. In 1988, to support the availability of logs for domestic industries, the log import to Malaysia was exempted from tax which had previously been imposed at the rate of 20 per cent.

The second stage of the policy was the implementation of levies and restrictions on processed products, such as sawntimber, veneer and plywood. The announcement was made by the government on 9 March 1990. The main objective of this policy is to ensure sufficient availability of timber materials for use in the downstream industry, with the intention of adding value to wood products. The imposition of export levies on sawntimber would also give the domestic wood-based industries a price advantage over similar industries located elsewhere.

The export levy on sawntimber from Peninsular Malaysia was implemented in stages beginning in June 1990. As rubberwood is the main species required by furniture industries, the government has decided that priority should be given to restricting its export. For this reason, sawn rubberwood was the first timber species to be subjected to export levy, which applied to all sizes. Extension of the levy to another 21 species of sawntimber and all other species of veneer exported from Peninsula Malaysia came into effect on 1 Sept 1991 (See Table A 1.1 of Appendix 1).

In 1993, in view of the continued high demand for raw materials for the downstream wood-based processing mills, the export levy imposed on selected species of sawntimber and veneer was further reviewed, effective from 1st October 1993 (see Table A 1.2 of Appendix 1). A two-tier levy on sawntimber was introduced, the applicable rate depending on the method of drying, either kiln dried

(KD) or air dried (AD). The export levy on Chengal and Damar Minyak sawntimber was increased from RM120 per cubic metre to RM250 per cubic metre, either KD or AD. The sawntimber export levy on 17 species was raised from RM120 per cubic metre to RM180 per cubic metre for AD timber while for KD timber, it was maintained at RM120 per cubic metre. The export of strips of Jelutong, Sepetir, Kembang Semangkok, Nyatoh, Ramin, Dark Red Meranti, Light Red Meranti and Red Meranti is prohibited, except for low grade. Sawntimber of other species which was previously subjected to an export levy of RM60 per cubic metre is now subject to an export levy of RM40 per cubic metre, whether KD or AD. Dressed timber, finger jointed and laminated sawntimber of rubberwood are subjected to an export levy RM80 per cubic metre. Similar timber products from species other than rubberwood are subject to an export levy of RM40 per cubic metre.

An export levy of RM40 per cubic metre is imposed on utility plywood. This is to ensure an adequate supply for the construction and housing sectors. The export levy on veneer is maintained at RM120 per cubic metre. Owing to the anticipation that all sawn rubberwood will be fully utilised locally for the production of furniture and panel products, the export of sawn rubberwood was disallowed, effective from January 1994.

To ease the timber supply problem, the Malaysian government has also exerted a great effort to establish forest plantations and encourage the utilisation of rubberwood from rubber plantations. Timber supply from rubber plantations now has become an important source of raw material for the wood-based industries. Rubberwood has become a substitute raw material for some timber species in the industries. Rubberwood is now increasingly used as the raw material for a variety of secondary and tertiary wood-based products. It is especially popular with furniture manufacturers.

One of the crucial questions in the shortage of timber supply is the way the timber is being utilised. Timber has traditionally been sold under names, which were already well known, and their utilisation was never in doubt. What was not known was simply not utilised. As a result, there was a great deal of wastage during logging. Hundreds of potentially valuable trees were left behind uncut or often simply burnt in the logging operation. To break the market dominance of the popular timber species or prime species, the government has taken action to promote the utilisation of lesser-known timber species by classifying the timber species according to suitability of use.

1.1 The Problem

Malaysia will continue to adopt the strategy of incentives and command and control measures. These policies will be fine-tuned to encourage industries to restructure into those industries with greatest potential (Abdullah, 1994). The moves by the Malaysian government to continue the incentive and command and control measures on sawnwood and other timber products would have an effect on wood processing development and the pattern of wood used in the industry. These policies might promote impressive development of wood processing capacity, but the central impact of this policy on the forest sector will be to create wasteful and inefficient processing operations. Thus, in the short term, the policies will reduce the forest harvest, but they will not do so in the long term, as more wood will be needed by the inefficient mills (Gillis,1988b; Barbier et al., 1995; Manarung et al., 1997).

Another aspect of concern about the timber market restriction policy is the effect on rubberwood development and promotion of timber species utilisation. The development and diversification in forest industries will allow increasing use of the vast timber species available in Malaysia. Most of the industries use various timber species in their production process and substitution of species is possible (Kumar, 1989). Due to the substitution effect, it is anticipated that

i. the timber market restriction policy will discourage the utilisation of less valuable timber and lesser-known timber species; and
ii. the timber market restriction policy also will undermine the government effort to achieve greater utilisation of rubberwood.

The right relative prices of rubberwood and lesser-known timber against prime timber species are essential if the potential of rubberwood and lesser-known timber species as wood-based industrial material is to be fully realised, so that the greater portion of rubber trees and lesser-known timber species felled are channelled into the production of processed products.

1.2. Objective of the Thesis

The primary objective of this thesis is to examine how the current timber trade policies on processed timber products, which are intended to promote sector industrialisation, will affect Malaysian forest harvest and timber related deforestation. The timber trade market model related to forest harvest is well known from many previous studies on Malaysia (Vincent,1989), Peninsular Malaysia (Vincent,1992), Indonesia (Barbier et al., 1995; Manarung et al., 1997). However, the model and methodologies used for understanding the relationship between forest industries, market policies and deforestation needs a new framework. This new framework will need to extend key definitions of issues and concepts as discussed above. For example, no existing studies have yet explicitly included in the model and investigated if there exists a local wood substitute for natural forest. Thus, the model presented in this thesis will expand on the existing model in two ways. First, given the importance of the rubberwood sector, the thesis would include the supply and demand of rubberwood products as a domestic substitute for natural log in Malaysia's sawnwood industry. Secondly, the thesis will model explicitly the natural forest production and rubberwood production and link the harvest of logs from the natural forest to deforestation in Malaysia.

Within a new framework of supply and demand, this thesis seeks to answer the following questions :

i. What is the impact on forest harvests, processed wood-based industries, development of rubberwood and timber species utilisation caused by current timber trade policies in Malaysia ?
ii. What is the effect and contribution of the rubberwood sector to the forest harvest?
iii. How are (i and ii) related to the deforestation in Malaysia?
iv. How do changes in industrial and trade policies, the processed wood industries, forest harvesting and deforestation linked in Malaysia?

Another objective of the thesis is to explore the impact of industrialisation and market policies on species utilisation in Malaysia.

1.3. Plan of the Thesis

This thesis has eight chapters, which are organised as follows:

Chapter 1. Introduction

This chapter outlines background issues, explains the research objectives and presents an outline of the thesis.

Chapter 2. Background of Malaysia Wood Sector and Deforestation .

This chapter establishes a broad framework for study of the wood sector in Malaysia. There are four sections, covering the main areas of concern on which it is necessary to provide important background information, for subsequent chapters of the thesis. The first concerns the natural forest resource. This section explains the institutional structure, forest-policy and administration which govern forest land use in Malaysia. The second section highlights the importance of the rubberwood sector as a source of wood for wood-based industries and the status of rubberwood as a substitute wood material for natural forest species. The rubberwood section also describes government efforts to establish and encourage use of rubberwood in wood-based industries. The discussion notes the distinctive features of the natural forest and rubberwood sectors as sources of wood for the wood-based industries.

Wood-based industries, a related area to the forest harvest and the focal point for the study are introduced in the third section, which discusses the status of the industries, their market structure and the policy and raw material position of the industries. Coverage of the industries is only selective, covering important products which are relevant to the product market model. The final section looks at the processes that have resulted in forest change in Malaysia. It outlines the main activities, such as commercial agriculture, land development and policies that contribute to the process of change.

Chapter 3. Literature Review.

This chapter reviews literature on two key areas of the study. First, it reviews the relevant literature on the theoretical concept of forest harvest, market restrictions and related empirical studies. A partial equilibrium approach is used to explain the theoretical concepts of market restriction. The empirical evidence is focused on tropical rain forest products, particularly in Malaysia, although attention is also given to studies of forest products from other countries. Secondly, this chapter reviews the concept of deforestation, environment Kuznets curve and some related research that has been conducted.

Chapter 4. Forest Product Model and Deforestation for Malaysia

This chapter introduces a model of the forest product sector for Malaysia and explains the reason for adopting it. The chapter comprises a section on the general overview of the model and a section on modelling the supply and demand relationship of the model. The modelling section is divided into sub-sections that derive specific demand relationships for each product. The main purpose of the model is to examine the demand and supply of the raw material and intermediate product sectors for major hardwood products in Malaysia. The model differs from previous studies (Kumar, 1979,1986; Vincent, 1989, 1992) in two respects. It considers explicitly the competition between rubberwood and hardwood and secondly it models explicitly the natural forest production and rubberwood production. This chapter also highlights deforestation and forest cover relationships that link to the forest product sector.

Chapter 5. Statistical Analysis.

This chapter describes the source and the nature of the data used in the thesis and explains some relevant computations. This chapter provides estimated relationships for the Malaysia forest product model and deforestation model of chapter 4, and evaluates the significance of variables used in the computation of the model relationship. Econometric methods are used to estimate the coefficients of the model using time series data for the period 1961 - 1994. However due to variation in data availability, this period is not applicable to all estimations.

Chapter 6. Policy Analysis.

The model of the forest sector described in the last chapter consists of a set of equations which has been specified and estimated independently of each other. Taken one at a time, these equations are of limited use for forecasting and describing the behaviour of the Malaysia forest sector. In order to analyse the sector it is necessary to take into account the simultaneous interaction of supply and demand on the whole forest and rubberwood sector, i.e., to view the sector as a complete system. This is done by simulating the model as a whole, i.e., by solving as a simultaneous system the set of equations that comprises the model.

The objective of this chapter is to simulate and evaluate the effect of different policy instruments using this simultaneous system. The instruments used were trade policies and alternative policies. The trade policy instruments were export tax, export ban and import ban. The alternative policy instruments were royalties on forest harvest, wood utilisation efficiency, concession area, subsidies and exchange rate policy. All these alternative policy variables are exogenous in the model discussed in chapter 5.

The simulations were performed on the forest sector, rubberwood sector and forest-rubberwood sector. To simulate and evaluate the effect of different policy measures, the estimated model structure in chapter 5 was calibrated to a base year data set, which is assumed to represent a benchmark equilibrium of the Malaysian forest sector. This benchmark equilibrium serves an important purpose. Policy appraisals were done on the basis of pairwise comparison of simulated and benchmark equilibrium. By comparing the simulated and benchmark values of the endogenous variables in the model, we can determine how the sector behaves and provide measures for comparison. The year 1990 was selected as the base year for the calibration of the equations, that was prior to the implementation of a market restriction policy on timber products (see the introduction to this chapter). However, for the rubberwood sector alone, calibration of the simulation equations was done for the base year 1994, after the implementation of a second tax policy on sawn rubberwood.

Chapter 7: Species Analysis.

The discussion in Chapter 4, Chapter 5 and Chapter 6 is based wholly on aggregate timber production, which encompasses a wide range of species, but without referring to the effect on timber species themselves. Thus, in this chapter, attention is focused on timber species. The objective of this chapter is to investigate the effect of policies discussed in chapter 6 on the efficiency of species utilisation. It examined the efficiency of timber utilisation base on species. This chapter also examines the conflict between the policy promoting timber species utilisation and conservation of tree species. This chapter introduces a species approach in investigating the forest cover relationship. As an introduction to this chapter, a discussion is presented of tree species diversity in Malaysia, which is useful information for the discussion of species analysis.

Chapter 8. Summary and Conclusion

This chapter provides a summary of the thesis, its objectives, findings, policy implications and recommendations, and direction of a future research.

1.4. Summary and Conclusion.

The government policy of restrictions on the timber market to ease the supply of timber resource to the industry needs further investigation. It not only causes more pressure for more timber supply because of inefficient processing operations but it is also anticipated that the policy will undermine the effort to increase the supply of timber resources from lesser-known timber species and to encourage the utilisation of rubberwood. Thus, this thesis expands on the existing timber trade model and methodologies by incorporating the rubberwood sector and species utilisation to analyse the effect on forest sector industrialisation, forest harvest and timber related deforestation.

Chapter 2

BACKGROUND OF MALAYSIA WOOD SECTOR AND DEFORESTATION

This chapter establishes a broad framework for study of the forest sector in Malaysia. There are four sections, covering the main areas of concern on which it is necessary to provide important background information, for subsequent chapters of the thesis. The first concerns the natural forest resource. This section explains the institutional structure, forest-policy and administration which govern forest land use in Malaysia. The second section highlights the importance of the rubberwood sector as a source of wood for wood-based industries and the status of rubberwood as a substitute wood material for natural forest species. The rubberwood section also describes government efforts to establish and encourage use of rubberwood in wood-based industries. The discussion notes the distinctive features of the natural forest and rubberwood sectors as sources of wood for the wood-based industries.

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2.1. Forest Land Use

Table 2.1 gives the status of forest land use in Malaysia for the year 1992. In that year, the area under forest in Malaysia was estimated at 19.4 million hectares or 58.4% of the country's land area. Of the forested land, 6.0 million hectares are in Peninsular Malaysia, 4.6 million hectares in Sabah and 8.7 million hectares in Sarawak. Of the 19.4 million hectares of forest, 16.8 million hectares are dipterocarp forests while 1.7 million hectares are freshwater swamp forest and 0.6

million hectares are mangrove forest. Currently, plantation forest accounts for only 146,000 hectares of the total forest.

The use of forest land in Malaysia is classified into three main categories: Permanent Forest Estate (PFE), Stateland Forest (SLF) and National Parks and Wildlife Sanctuaries. The PFE represents a total of 12.6 million hectares of the country's forest. 4.7 million hectares in Peninsular Malaysia, 3.4 million hectares in Sabah and 4.5 million hectares in Sarawak. About 11.23 million of the PFE are classified as productive forest. These forests are managed in accordance with principle of sustained yield under approved guidelines for sustainable forest management and development for the production of wood and non-wood products.

In 1992, Malaysia had a total of 5.5 million hectares of SLF. A total of 0.7 million hectares of the SLF was located in Peninsula Malaysia, about 0.8 million hectares in Sabah and 3.9 million hectares in Sarawak. These forests have been earmarked for conversion into various development projects and as such are subjected to intensified logging in order to maximise the exploitation of their timber resources.

Since the 1930s, many wildlife sanctuaries and nature reserves have been established to conserve biological resources. It has also been estimated that of the total land under forests, about 1.3 million hectares are reserved as national parks and wildlife sanctuaries. Out of these, 0.6 million hectares are located in Peninsular Malaysia, of which 190,000 hectares overlapped with protective PFE. In Sabah, national parks and wildlife sanctuaries take up about 0.3 million hectares of forest land, of which 140,000 hectares are located in the PFE. Sarawak has about 0.3 million hectares of its forest as national parks and wildlife sanctuaries.

Table 2.1 Forest land Use in Malaysia, 1992 (million hectares)

Region	Permanent Forest Estate	Plantation Forest[a]	National Park and Wildlife Sanctuaries	Stateland Forest	Total Forested Land
Peninsular Malaysia	4.697	0.068	0.608	0.724	6.029
Sabah	3.350	0.070	0.378	0.839	4.637
Sarawak	4.500	0.008	0.290	3.915	8.713
Malaysia	12.547	0.146	1.276	5.478	19.379

a: The Plantation Forest in Peninsular Malaysia is established within the Permanent Forest Estate.

Source: Malaysia (1993b).

In addition to the forest, substantial areas in Malaysia are under agricultural tree crops. A total of 5.4 million hectares in the country are planted with perennial crops such as rubber, oil palm, coconut and cocoa. Out of Malaysia's total land area of 32.86 million hectares, about 72% are under forest and tree plantation (Table 2.2). These plantations are similar to afforested land. For instance, rubber plantations covering 1.8 million hectares in 1992, provide valuable timber when old rubber trees are felled for replanting.

Table 2.2 Area Under Tree Cover in Malaysia, 1992 (million hectares)

Region	Land Area	Natural Forest	Plantation Forest	Tree Crops	Total Area Under Tree Cover
Peninsular Malaysia	13.160	5.958	0.068	4.619	10.645
Sabah	7.370	4.440	0.070	0.390	4.900
Sarawak	12.330	8.710	0.008	0.420	9.138
Malaysia	32.860	19.108	0.146	5.429	24.684

Source: Malaysia (1993b).

2.1.1 Forest Management

Malaysia has 13 states: Sabah , Sarawak and 11 states in Peninsular Malaysia. Malaysia practices a federal system of government in which federal and state powers and functions are clearly defined in the constitution. Certain provisions of the Malaysian constitution have fundamental significance for forests and forestry. A particular emphasis is that the constituent states of the federation have jurisdiction over land, agriculture, and forestry. Although the federal government may introduce legislation relating to these matters for the purposes of ensuring uniformity of law and policy between the states, such laws cannot be enforced unless separately introduced by the state legislatures (Mohamed Suffian, 1976). The states own and have control over their forests: they gazette (or degazette) reservations, they issue logging concession licences, and they collect royalties from logging operators; on the other hand, federal responsibility in this area is limited to research and to providing services, advice, and training (Salleh, 1983). Thus, Malaysia has 13 separate forest policies independent of federal government control. Each state has its own forestry department with broadly similar responsibilities. Co-ordination in the eleven states of Peninsular Malaysia is much stronger than in the eastern states of Sabah and Sarawak.

No attempt was made to formulate a national forest policy in the immediate post-colonial period, although foresters in particular continued to stress the need for such a strategy (e.g. Setten, 1962; Anon, 1967; Anon, 1968). Land development in the Peninsula continued apace during the 1960s, and it was not until the end of the 1960s that the federal government began to recognise the need for a rational land-use policy and for a better knowledge of the forest resource base. This awareness had two immediate results (although both were confined to the Peninsula): a forest inventory was undertaken during 1970-2 and a land capability classification (LCC) was completed in 1970. The LCC was heavily biased in favour of agricultural development, with the result, in short, that areas of mostly poor soils and steep terrain were assigned to forests, leaving the lowlands for agricultural development. The adoption of the LCC had two fateful results: firstly, forests on land deemed better suited to agriculture were rapidly degazetted and cleared; and secondly, logging has progressively moved into the hills, although no proven or suitable management system has yet been devised for the hill forests.

The need for PFE became increasingly apparent during the late colonial period, which witnessed a considerable expansion of timber operations. An interim forest policy that provided for a PFE comprising protective and productive forest reserves was introduced in Peninsular Malaysia in 1952. In Sabah and Sarawak, new legislation and policies were introduced in 1953-4, provision being made for the establishment of PFEs-Sarawak's PEE to comprise forest reserves, protected forests, and communal forests, Sabah's to comprise protection, communal, domestic, amenity, and mangrove forests.

In recognition of the importance of the forest for the nation, the National Forest Policy (NFP) was formulated in 1976. The NFP consolidates and updates the forestry policies and legislation of the 1920s and 1930s to provide for scientific management and control of the protective forest. The NFP ensures uniformity in the implementation of all forest management, conservation and development strategies by all states toward achieving common national objectives. The NFP formed the policy basis to establish in each state a PFE for productive forests, SLF, protective and amenity forests. After much negotiation, the National Land Council endorsed a NFP for Peninsular Malaysia in 1978. This provided for a PFE comprising protective, productive, and amenity forests. The federal government considered it to be desirable to incorporate the new policy in legislation, hence a National Forestry Act (Laws of Malaysia, Act 313) was proclaimed in 1984 to provide 'for the administration, management and conservation of forests and forestry development within the States of Malaysia and for connected purposes'. The Act applies throughout Malaysia and provides for the establishment of a PFE. As noted earlier, however, that the Act is not binding on the states unless gazetted as a state law, and it appears that several states have not been prepared to do this.

2.1.2. Forest Harvest

Forest harvesting activities in Malaysia, whether in PFE or SLF, have been given to concessionaires. Areas opened for harvesting annually in the PFE are identified in advance and demarcated in various felling blocks based on annual felling coupes. Each concession is given only one coupe to harvest each year. The size of one coupe rarely exceeds 4,000 hectares.

In harvesting practice, all the concessionaires have to follow guidelines issued by the government. However, because the responsibility for land use, conversion and management rest with the state government, the individual states often ignore the advice or guidelines for forestry management from the National Timber Council (NTC). The harvest area is not followed. Data for Peninsular Malaysia show that during the Fifth Malaysia Plan (FMP) period, the area of PFE harvested was 588,000 hectares, which was 232,830 hectares or 65 percent more than the total coupe given by NTC. In the first year of the Sixth Malaysia Plan (SMP), the total area of PFE harvested was 99,411 hectares, which was 47,161 hectares or 90 percent more than the total annual coupe given by NTC (Table 2.3).

Table 2.3 Total Annual Harvest of Permanent Forest Estate (PFE) for States in Malaysia for the Periods 1986-1990 and 1991-1992 (Hectare)

	Period				
	1986-1990		1991-1992		
States	Allowable Cut According to MTC	Actual Area Harvest	Allowable Annual Cut According to MTC	Actual Area Harvest, 1991	Actual Area Harvest, 1992
Johor	48,150	48,801	4,500	5,925	1,898
Kedah	26,850	26,838	4,365	5,295	2,234
Kelantan	44,050	171,173	6,900	29,975	8,528
Melaka	550	669	-	-	-
N. Sembilan	14,650	48,038	2,630	4,249	1,280
Pahang	79,050	142,369	12,240	24,504	11,930
Perak	64,950	78,847	9,235	10,957	6,943
Perlis	650	802	-	-	50
P.Pinang	-	-	-	-	-
Selangor	26,400	24,911	2,130	6,318	823
Terengganu	50,700	46,382	10,140	12,188	5,932
W. P	-	-	-	-	-
Sabah	na	na	na	na	na
Sarawak	na	na	na	na	na

Source: Malaysia (1993a)

With land matters falling within the power of states, the states not only approve area concessions larger than the areas advised by the NTC but also de-gazette the PFE to become SFL (Table 2.4). The reasons for over harvesting are political (Jonish, 1992) as well as dependency of states on the agriculture and forestry sector.

Table 2.4 Permanent Forest Estate (PFE) Repealed by States in Malaysia (Hectare).

States	Malaysia Planning Stage				
	R.M 3	R.M 4	R.M 5	R.M 6	Total
Johor	5,150	5,810	12,928	-	23,898
Kedah	575	3,489	1,233	15	5,312
Kelantan	-	34,994	52,962	-	87,956
Melaka	715	-	1,093	-	1,808
N. Sembilan	1,036	9,259	5,256	650	16,201
Pahang	188,473	75,552	12,418	3,897	280,340
Perak	48,093	-	38,077	173	86,343
Perlis	336	4,419	1,731	212	6,698
P.Pinang	-	-	156	106	262
Selangor	2,506	2,908	13,731	5,654	24,799
Terengganu	72,351	5,257	3,185	-	80,793
Sabah	na	na	na	na	na
Sarawak	na	na	na	na	na

Source: Malaysia (1993a).

Three different silvicultural systems have been utilised in Malaysia since the emergence of organised forestry in the early 1900s: the Regeneration Improvement Felling System (RIFS) that was practised until the Japanese occupation, the Malayan Uniform System (MUS) that was used between 1949 and 1980, and the Selective Management System (SMS) that was introduced in 1977.

The RIFS, a polycyclic logging system introduced into Peninsular Malaysia from Burma and India, was well suited to ensure a steady supply of heavy hardwoods, poles, and firewood (Whitmore 1984, p. 97). Prior to felling, unwanted species were cut or girdled to promote the regeneration of desired species; subsequently, several 'cuts' of desirable species were made, relatively few trees being felled at any one time. The system proved extremely successful, providing some of the best regenerated forests in the Peninsula (Ismail 1966, p. 229). However cutting only a few trees at any one time was commercially unattractive to logging operators with substantial capital investments in new technology, and so for economic reasons the RIFS was replaced by a new mono-cyclic system, the Malayan Uniform System (MUS), which was geared to harvesting relatively large quantities of timber.

The essential elements of the MUS were a pre-felling sampling to establish the presence of an adequate stock of desirable seedlings, the removal of all mature and marketable trees in a single cutting of all trees down to 45 cm dbh for all species and releasing the selected natural regeneration of varying ages. This felling operation was followed by poison-girdling of defective relics and uncommercial species down to a minimum dbh of 15 cm. The area was then left for regeneration for the next harvest cycle. Regeneration produced an even-aged forest of desirable species that could be logged after some 70-80 years. The MUS was introduced into Sabah and Sarawak in the 1950s and is still utilised in a modified form.

The MUS was developed to manage the lowland dipterocarp forests and has been successfully applied, but since the 1960s, in the Peninsula, logging has moved progressively into the hill dipterocarp forests and it is there that most of the permanent forest estate is concentrated. The MUS has been found to be unsuccessful in the hill forest because of the comparatively more difficult terrain, uneven stocking, lack of natural regeneration after logging, heavy seedling mortality due to felling damage on the steep slopes, and the risk of soil erosion and water catchment losses. By the late 1970s, most easily accessible lowland forest in Peninsular Malaysia had been logged and the remaining virgin forests are found on steeper slopes. Consequently the SMS was introduced in the late 1970s.

The SMS involves the use of pre-harvest inventory to identify those trees selected for harvesting, followed by one of three (hence 'selective') procedures: if adequate adolescent trees are present, a thirty-year bicyclical felling system is followed; if this is not the case, the MUS is used; and if seedling numbers are inadequate to ensure regeneration, enrichment planting is undertaken or 'compensatory' plantations are established. This new system was introduced mainly for economic reasons-essentially because the much shorter cutting cycle meant that more timber could be harvested. The official government position, however, is that the SMS was introduced.

i. for silvicultural reasons, because regeneration from seeds was considered to take too long, because seedling regeneration in the hill forests was patchy and seedlings on steep slopes were often destroyed by logging (Lee,1982), and because the cheapest and most effective poison-girdling agent, sodium arsenite, was banned;

ii. for ecological reasons, because 'a mixed forest crop offers the best cover for soil and water conservation' and helps to conserve genetic resources (Anon, 1990, p.18);

iii. only in part for economic reasons, because many species that formerly were not marketable can now be utilised (Salleh, 1988. p.135; Anon, 1990, p.19).

In the late 1980s the MUS was replaced in most parts of the Peninsula by a Selective Management System (SMS) with a felling cycle of 30 years (Chin, 1989). The felling cycle in Sarawak's mixed dipterocarp and peat-swamp forests is 25 and 45 years, respectively (Chin, 1989, p.5; Anon, 1990, p.19). An eighty-year cutting cycle is still employed in Sabah.

A successful polycyclic felling programme depends on ensuring that no more than 30 per cent of intermediate-sized residual trees are damaged and that seedlings and saplings are not extensively destroyed. In practice, however, most logging operations are highly destructive, hence these conditions are often not met. Dawkins and Philip (1998) reported that, even though Malaysia has solved technical problems and devised managerial and silvicultural rules for the successful regeneration of forest following logging, enforcement of this rule which is essential, is not commonly achieved. All too often, unskilled or unsupervised logging teams leave excessive and unnecessary damage when felling, which hinder the recovery of forest. Government officials acknowledge that current management problems include an inadequate number of trained staff to enforce harvesting regulations, insufficient knowledge of how to manage the hill forests for sustainable production, and a paucity of data on the impact of different harvesting systems on residual stands.

2.2. Rubberwood Sector

2.2.1. Rubberwood Resource.

The rubber tree (*Hevea brasiliensis*), a species which is indigenous to Brazil, can now be found in some 24 countries. Table 2.5 gives the rubber plantation statistics for the year 1996. The figures show that most of the world's plantation stock of the rubber tree is in the Asean region. Malaysia, Indonesia and Thailand have in their possession about 75 percent of the total rubber plantation worldwide. Indonesia has the largest area of rubber plantation (2 million ha) followed by Thailand (1.5 million ha) and Malaysia (1.4 million ha).

Until recently the most important product from the rubber tree was its latex and efforts to improve the tree concentrated upon increasing the latex yield. Typically, following an exploitation period of about twenty five to thirty years, the trees are felled for replanting with higher yielding clones. Rubber trees grow to a height of 25 m and generally have straight trunks. At the time of felling, the girth varies between 100 to 110 cm at a height of 125 cm from the ground and gives 0.62 m^3 of stump wood and 0.4 m^3 of branch wood. An average of 300 rubber trees will be available per hectare.

Until recently, most of the timber was used as fuel. With the depletion of tropical forests, leading to a shortage of timber for many industrial and engineering uses, however, attention has turned towards rubberwood as an alternative source of timber. Tree felling operations were previously considered as a burden on the plantation owner, but this attitude changed in the late 1970s and rubberwood is now proving viable. In the 1980s rubberwood became an important resource in the wood-based industries. According to Flynn (1995):

> 'The industrial use of rubberwood has become so important that it really overshadows the rubber production function, and growers have modified their rotations to emphasise woodfibre production '

The main use is sawnwood. Recently rubberwood, has been increasingly used to produce particle board, plywood and medium density fibre board. According to Paechana and Sinthuharat (1997), rubberwood logs with a diameter of more than 20 cm are used for the veneer industry, rubberwood logs with a diameter 15-20 cm are used for sawn timber, and rubberwood logs with a diameter less than 15 cm are used for particle board. These panel products are major raw materials for the furniture industry.

The standing stock of rubberwood worldwide is estimated to be 697 million m^3. This calculation is based on a conservative yield of 100 m^3 wood per hectare from a total of 6.97 million hectares of rubber plantations. This estimate is much lower compared to the yield per hectare of rubberwood based on Malaysian plantations (see Table 2.9).

However the volume of rubberwood logs for sawntimber is limited to those greater than 15cm in diameter. Based on this figure, FAO estimated that one hectare of rubber can produce about 43 m^3 of logs for sawn timber at replanting period at the age of 25-30 years. The production potential of rubberwood varies depending upon numerous factors that influence the annual growth, such as planting density, planting materials and management regimes. Using this estimate, the total volume of available logs for sawn timber production would be around 300 million m^3. Using a replanting rate of 3 percent per year, the annual availability amounts to 9 million m^3.

Table 2.5 World Rubberwood Stock in 1996 (m^3)

Countries	Area (ha)	Rubberwood Stock[1]	Supply Potential[2]
Indonesia	2,089,297	89,839,771	2,695,193
Thailand	1,519,228	65,326,804	1,959,804
Malaysia	1,470,000	63,210,000	1,896,300
China	395,000	16,985,000	509,550
India	356,000	15,308,000	459,240
Vietnam	303,000	13,029,000	390,870
Nigeria	205,000	8,815,000	264,450
Sri Lanka	162,000	6,966,000	208,980
Philippines	87,915	3,780,345	113,410.4
South America	62,640	2,693,520	80,805.6
Cameroon	53,000	2,279,000	68,370
Cote Di Voire	49,524	2,129,532	63,885.96
Myanmar	48,563	2,088,209	62,646.27
Cambodia	44,500	1,913,500	57,405
Congo Dem. R.	40,000	1,720,000	51,600
Bangladesh	25,000	1,075,000	32,250
Liberia	25,000	1,075,000	32,250
Ghana	22,000	946,000	28,380
Gabon	9,700	417,100	12,513
Brunei Drsm	2,500	107,500	3,225
Congo, Rep.	2,500	107,500	3,225
Cent Africa Rep.	1,200	51,600	1,548
Total	6,973567	299,863,381	8,995,901

1. base on rubberwood logs that suitable for sawntimber at the rate of 43 m^3 per hectare at replanting period at the age of 25-30 years..
2. base on replanting rate of 3 per cent per year.

Source: FAO(1997).

2.2.2. Rubberwod in Malaysia

The rubber tree was introduced into Malaysia in 1876 for the specific purpose of producing latex. The cultivation of this tree crop has been very successful. Demand for rubber rose rapidly at the turn of the century, thanks to the invention of the automobile. A number of factors enabled Peninsular Malaysia to take advantage of this opportunity. Most fundamental were favourable climatic and soil conditions found throughout the country at elevations up to 300m. Rubber trees require an equatorial climate, with bright sunshine, even temperatures (24^0-28^0C), annual rainfall totalling 1800-4000 mm and varying little during the year, and a lack of destructive winds (Hill, 1982). They grow best in soils that are well-drained and "friable, deep, well-oxidised and acid in reaction (pH 4 to 6.5)" (Ooi,1976). Rubber does not require nutrient-rich soils, because harvested latex is equivalent to only 0.4-0.6 percent of the annual dry matter produced by rubber trees (Hill, 1982). Harvesting latex removes 7 kg/ha/yr of nitrogen, 1.2 kg/ha/yr of phosphorus, and 4 kg/ha/yr of potassium, much less than removals in the case of rice (42-141 kg/ha/yr, 8-37 kg/ha/yr, 28-90 kg/ha/yr, respectively) (Sanchez, 1976). Cumulative uptake of nitrogen by rubber trees is only 1529 kg/ha by age 10, whereas most soils on which rubber is grown in Peninsular Malaysia contain 4.6-11.6 tons/ha of nitrogen in the top 50 cm of soil (Hill, 1982).

Other factors included political stability, which is needed for investment in a crop that does not begin producing until six years after planting and has not paid back initial capital costs until after 10-15 years; excellent transportation (navigable rivers, and a railway system on the west coast); available labour, due to immigration from India; and experience with the crop, which had been introduced to Peninsular Malaysia on a trial basis as early as the 1880s (Barlow, 1978). Together, these factors made it possible to raise the capital, mostly foreign and British, needed to finance development of private estates. These estates were responsible for most of the initial growth in plantations.

The earliest estates were located on the basis of accessibility and ease of establishment, which meant that many were on land formerly occupied by other crops (for example, tapioca, pepper, and gambier). In at least one state, Negeri Sembilan, the government (in 1904) made abandoned lands available for rubber planting on special terms (Barlow, 1978). Expansion into virgin forests began early in the development of the rubber industry. In 1897, the colonial government made forested land available for rubber planting on a permanent lease basis, with payment of an initial premium and an annual quit rent being required (Barlow, 1978). The charges were extremely low considering the high rates of return expected from plantations (Barlow, 1978).

Malay peasant farmers were quick to recognise the potentially high returns to rubber. They started converting their subsistence crops and also clearing forest land to rubber. Despite various policies discriminating against Malays (Barlow, 1978, 1985; Lim, 1977) , Malay smallholdings grew to 40 percent of the area in rubber in Peninsular Malaysia by 1932. There is probably no more compelling evidence of the fundamentally strong returns to rubber cultivation during this period.

Expansion of rubber plantations slowed markedly during 1932-1966 due to national and international economic and political events. During 1932-1966, the area of estates actually decreased by a slight amount. The net increase in area in rubber during this period, nearly 0.5 million ha was due to a more than doubling of the area in smallholdings. By 1961, the area of rubber in smallholdings exceeded the area in estates.

The rapid expansion of smallholdings was mainly due to change in the government policy towards smallholders. After independence, both federal and state governments reversed the long-standing colonial bias toward estates and enacted policies more favourable to smallholders. For example, the Rubber Research Institute of Malaysia (RRIM) focused more of its research on smallholders' problems and expanded its outreach efforts to them (Barlow and Jayasuriya 1986). Its Smallholders Advisory Service, which began modestly in 1934, grew to become its largest division. Later RRIM and the Rubber Smallholders and Development Authority (RISDA) , provided plantation subsidies to smallholders to plant rubber.

More importantly, the new policies included ones at both federal and state levels that called for a direct government role in the establishment of new smallholdings via land development schemes. Barlow (1978) provides an excellent review of these government programmes. This policy led to the establishment of Federal Land Development Authority (FELDA) in 1956 and also *state* and *fringe schemes* by state governments which were predominantly based on rubber cultivation (further discussion on FELDA schemes is presented in section 3.4).

Table 2.6 shows the planted area of natural rubber in Malaysia in 1994. The figures show that, smallholdings constitute 83.6 percent of total rubber area. Most of this is in Peninsular Malaysia.

Table 2.6 Malaysia: Planted Area of Natural Rubber by Sector ('000 Hectares)

Region	Sector	1990	1992	1994
Peninsular	Estate	342.4	308.8	276.7
Malaysia	Smallholding	1,180.3	1,163.1	1137.9
Sabah	Estate	5.4	4.5	4.5
	Smallholding	85.7	86.7	89.7
Sarawak	Estate	0.9	0.8	0.8
	Smallholding	208.3	210.3	212.3
Total	Estate	348.7	314.1	282.0
	%	19.1	17.7	16.4
	Smallholding	1,474.4	1,461.1	1,439.9
	%	80.9	82.3	83.6

Source: Malaysia (1995)

2.2.3. Rubberwood Utilisation

Rubberwood is classed as a medium light hardwood, in the same group as Meranti (Shorea sps), the most abundant and demanded species in Malaysia, and Acacia mangium (main species in plantation forest in Malaysia). According to Sekhar (1995), rubberwood is very near to the weight and shear properties of teak in India, and fairly comparable in other properties, except in suitability as posts. However, rubberwood has to be used cautiously where compressive forces along the grain come to play. Comparative suitability figures of rubberwood to teak are given in Table 2.7.

Table 2.7 Comparative Suitability Figures of Rubberwood to Teak (Parameters Rating Taking Teak as 100)

Properties	Rating
Weight or heaviness	93
Strength as a beam	62
Stiffness as a beam	77
Suitability as a post	52
Shock resisting ability	75
Shear	92
Surface hardness	74
Splitting coefficient	75

Source: Sekhar (1995)

Although rubber plantations in Malaysia have been in existence for over one hundred years, the industrial utilisation of rubberwood as a raw material for the wood processing industries is relatively recent. In the past, rubberwood was considered to have no significant economic value and was traditionally used for firewood and charcoal manufacture. However, since the 1960s rubberwood has been used for processing into blackboard cores and also converted into chips for pulp and paper making.

One of the reasons very little attention was given to development of the rubberwood processing industry before the 1970s was the buoyant timber trade in indigenous species. However, with the worldwide concern for the environment and the pressure against the cutting down of tropical trees for timber and depletion of indigenous species, rubberwood has become one of the very few 'environment friendly tropical timbers' that is acceptable as a renewable resource in Malaysia. Realising the importance and potential of the rubberwood resource, the Ministry of Primary Industries made a decision to form a Rubberwood Research and Utilisation Committee (RRUC)[1] in January 1978 to spearhead and co-ordinate research and development activities aimed at facilitating and encouraging the utilisation of rubberwood.

Through co-ordination of research and development and promotional efforts of members of the committee, rubberwood has emerged as an important source of raw material in wood-based industries. Table 2.8 gives the main users of rubberwood logs in Malaysia for the year 1992.

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[1]RRUC initially comprised members from Rubber Research Institute of Malaysia (RRIM), Forest Research Institute of Malaysia (FRIM), Malaysian Rubber Industry Board (MTIB) and Standard Industrial Research of Malaysia (SIRIM). The Committee was subsequently expanded to include other relevant organisations, i.e. University of Agriculture (UPM), Malaysian Industrial Development Authority (MIDA) and the Malaysian Rubber Producers Council (MRPC).

Table 2.8 Utilisation of Rubberwood Logs by the Wood Based in Malaysia, 1992

Industry	Volume used (m^3)	% used
Sawnwood	1,078,000	0.589
Plywood/veneer	69,600	0.038
Medium Density Fibreboard	285,360	0.156
Chipboard	63,900	0.035
Cementboard	32,400	0.018
Charcoal	300,000	0.164
Total	1,829,260	-

Source: Malaysia (1994).

2.2.3. Rubberwood Development

Rubberwood's production potential is dependent upon numerous factors that influence the annual growth of rubber trees, such as clonal variation and planting density. Clonal variation can be a big influence on the amount and type of wood. A vigorous clone will not only produce a large total amount of wood but it will also give a better recovery rate for sawntimber because of larger individual log size. Planting density also assumes great importance in wood production. Results from density trials show that higher densities encourage good bole high development, reduce wind damage and increase total wood production.

The task of developing and recommending a high quality clone that has the potential to produce both high latex yield as well as good timber yield has been given to the Rubber Research Institute of Malaysia (RRIM). The traditional planting recommendation in rubber industry was based on the Enviromax approach which is to suit the weather, disease and soil type. For example the PB 355 clone is suitable for planting in the central and northern region of Peninsular Malaysia. After two decades of recommending clones and planting materials using the Environmex planting recommendation, the current RRIM method of selection give more weightage to selecting clones which have potential for high latex as well as good timber production. As a start, the RRIM has identified a total of sixteen clones which are considered suitable for both latex and timber production. These clones have been measured to give 'big log' timber volume (clear bole volume) ranging from 0.42 m^3 to 0.93 m^3 (Table 2.9).

Table 2.9 Recommended Clones Which Have Potential for Latex Yield and Timber Production

Clone	Mean yield of latex over 5 years production	Clear bole volume (m^3)	
		per tree	per ha[a]
PB 355	1607	.93	279
PB 235	1964	.83	249
RRIM 931	2085	.68	204
RRIM 921	1393	.63	189
RRIM 929	3143	.60	180
RRIM 928	3119	.59	177
RRIM 2014	2007	.53	159
RRIM 936	2106	.49	147
RRIM 911	1557	.46	138
RRIM 2002	2348	.44	132
RRIM 2016	2582	.43	129
RRIM 2015	2760	.43	129
PB 359	1802	.42	126
RRIM 2001	2850	.41	123

Note:
[a]Calculations are based on the average of 300 trees per hectare
Source: Ong et al. (1996)

The wood volume in Table 2.9 is derived from a 22-24 year old rubber tree[2]. The big log volume is the portion of rubberwood log which is suitable for the production of sawntimber. The 'small log' volume is used for the production of chips and pulp. According to RRIM estimates (RRIM, 1996) the volume of big log is equal to the volume of small log available.

[2]22-24 years is the economic life of a rubber tree in term of latex production. Unlike natural forest, rubberwood is not suitable for sawntimber production if kept longer, because of low quality wood. The quality of rubber log depends on the age of the rubber trees at replanting. Tree stands aged between 20 to 25 years would provide wood of better quality, while those older than 25 years tend to have heartrot and hollow logs.

2.3. Wood -Based Industry

Soon after Independence, the Malaysian government embarked on industrialisation. There were at least two major reasons for such a move: rapid population growth and a need to diversify the economy from heavy dependence on primary commodities, rubber and tin. Thus, during the decade of 1960s, manufacturing was the most rapid growth sector of the economy. It is estimated that during the 1960s nearly 40% of the GDP growth was attributed to the industrial sector which included wood and related industries. In the 1970s the growth rate of the industrial sector increased further, contributing about 49% of the GDP (Osman Rani and Haflah Piei, 1990).

During the Fifth Malaysia Plan period (1986-1990), the development of the manufacturing and industrial sector was greatly bolstered by the Industrial Master Plan (IMP). Covering the period 1986-1995, the IMP provided a long term plan for the development of specific sub-sectors of the industries, policy measures, and areas of focus. Twelve sub-sectors of the industry, comprising seven resource-based industries which included wood based, and five non-resource based industries, were identified as priorities (Table 2.10)

Table 2.10 Priority Subsectors of the Industrial Master Plan.

Resource-based	Non-resource-based
1. Food processing	1. Electrical and electronic
2. Rubber	2. Transport and equipment
3. Palm oil	3. Machinery and engineering product
4. Wood-based	4. Ferrous metal
5. Chemicals and petrochemicals	5. Textiles and apparel
6. Non-ferrous metal products	
7. Non-metallic mineral products	

Source: Sham (1993).

The wood-based sector has played a significant role in the Malaysian economy in terms of employment and output value. In 1981, wood-based exports amounted to RM4.4 billion, accounting for 30% of total manufacturing exports and 8.5% of the

GNP. The sector ranked third, behind petroleum, palm oil and palm oil products in the nation's total exports and accounted for 20.9% of total manufacturing sector employment. In recent years, however, the sector has undergone some major structural changes and has been a focal point in Malaysia's attempt to add more value to its natural resources and in expanding the manufacturing sector. The sector has developed into a major foreign exchange earner for Malaysia with export trends showing a significant shift from primary products (log and sawn timber) to high value-added secondary and tertiary products (plywood/veneer, moulding, panel products and furniture). In 1994, the sector again emerged as one of the main foreign exchange earners amongst the commodity and petroleum export sectors, exporting RM113.5 billion worth of timber and wood-based products, accounting for 5% of total manufacturing exports and 7.3% of the GNP. The contributions come from at least nineteen types of industry (Table 2.11).

Table 2.11 Timber Processing Mills, 1980-1994.

Type	1980	1990	1991	1992	1993	1994
Sawmill	603	686	693	697	704	711
Plywood/Veneer	30	40	43	44	45	49
Furniture factories	55	224	283	300	427	446
KD plants	106	100	104	120	120	120
Moulding factories	103	91	96	97	105	105
Wood preservation plant	68	90	90	117	117	117
Rattan/bamboo product factory	n.a	40	45	45	93	90
Parquet flooring plant	11	23	25	25	25	25
Laminated board plant	3	14	16	16	16	16
Blockboard plant	9	12	12	12	12	12
Wooden house prefabrication	7	9	10	10	10	10
Wooden toy manufacturers	n.a	5	6	6	6	6
Particle board factories	2	3	4	4	7	7
Match factories	4	3	3	4	4	4
Wood wool slab factories	1	3	3	1	1	1
Chipboard plants	4	3	3	4	4	4
Medium density fibreboard plant	n.a	2	2	2	4	5
Woodcemboard plant	4	2	2	1	1	1
Pencil factory	1	2	2	3	2	3

Source: Malaysia (1995).

2.3.1 Major Wood-Based Industry

As indicated in Table 2.11, the wood-based industry is still dominated by the primary processing activities of sawnwood, veneer and plywood production. In the

1990s, however, downstream processing activities such as moulding, furniture and joinery manufacture increased significantly.

2.3.1.1 Sawnwood

Sawnwood is the first stage in wood processing, and it involves the conversion of sawlog into sawn pieces usually exceeding 5mm in width. The sawnwood industry in Malaysia is over sixty years old and is the oldest in the wood-based industry, licensing having been first introduced in 1928. However it gained impetus only after 1931 following the development of trade between British Malaya and China. The industry slumped during the Second World War and did not received a fresh boost until the 1950s during the Korean War commodity boom. Since 1976, however, sawnwood exports appear to have stabilised at the 3 million m^3 level.

Generally, the sawmill industry is dominated by small-sized, family-run enterprises. Many sawmills still use older equipment and bandsaws although some more advanced mills are equipped with fully automated bandsaw headrigs. Sawn timber is mainly produced for export although it is also used domestically for the construction industry and as input for downstream processing, i.e for moulding, joinery and furniture making. It is produced in various sizes and species and exported either as graded or ungraded sawn timber.

Currently, the sawnwood industry is the largest wood processing industry in Malaysia. Table 2.12 gives a profile of sawmills in Malaysia. In 1994 there were a total of 1145 sawmills in Malaysia with a total installed capacity of 25 million m^3 per year. 711 mills were located in Peninsular Malaysia with an installed capacity of 8.5 million m^3, 226 in Sabah with an installed capacity of 11 million m^3 and the remaining 208 mills in Sarawak with an installed capacity of 5.5 million m^3. The sawnwood sector is faced with over capacity from the limited supply of logs and low recovery rates. The sawnwood production in all regions is far below the production capacity. Table 2.13 shows that the total production in 1994 was around 30 per cent of installed capacity. Peninsular Malaysia recorded utilisation of more than 50 per cent, but Sabah and Sarawak achieved only 20 per cent.

Table 2.12 also shows that, in terms of recovery rate, Peninsular Malaysia recorded a better performance. Based on 1994 log intake, the recovery rates averaged at about 65% for Peninsular Malaysia, 40-45% for Sabah and 38-42% for Sarawak.

Table 2.12 Profile of Sawmill in Malaysia, 1980-1994

Region	1980	1990	1991	1992	1993	1994	Cap[a]	Recov[b]
Sabah	221	227	202	216	201	226	11	40-45
Sarawak	89	147	188	237	210	208	5.5	38-42
P. Malaysia	603	686	693	697	704	711	8.5	65
	913	1060	1083	1150	1115	1145	25	

[a] Capacity installed
[b] Recovery rate in per cent of log intake.
Sources: Malaysia (1995); MIER (1994).

Table 2.13 Malaysia Sawnwood Production, 1960-1994 ('000 m^3)

Year	Malaysia	Peninsular Malaysia	Sarawak	Sabah
1960	1396	1037	283	75
1970	2780	2062	631	86
1980	6233	4955	741	536
1990	9156	6513	733	1910
1991	8926	5610	913	2403
1992	9482	5566	1119	2797
1993	9200	4903	1442	2855
1994	8703	4733	1722	2248

Source: Malaysia (1995).

The late 1970s saw the development of rubberwood as a wood resource in wood based industries. The sawnwood sector's production of sawn rubberwood increased from merely 20,000 m^3 in 1983 to more than half a million m^3 in 1994. Almost all production comes from Peninsular Malaysia. Due to the size of the rubberwood logs and unsuitable mills, the recovery rate for rubberwood sawn timber is very low, around 40%.

2.3.1.2 Plywood and Veneer

Plywood is assembled from veneer sheets of regular dimension and uniform thickness. The sheets are stacked so that a perpendicular grain direction occurs between the sheets. The alternating grain gives the sheet its strength. The stack is then flat pressed or moulded into the final product. Besides plywood, veneer is also used in the production of furniture and panels. It is used in conjunction with particleboard for the production of cabinets and, in the laminated form, is used extensively in the construction industry for structural purposes

The plywood and veneer industry is the second largest wood processing industry in Malaysia. Of the 120 licensed mills operating in 1994, 49 mills were located in Peninsular Malaysia, 65 mills in Sabah and the remaining 47 in Sarawak . Total installed capacity based on log intake per annum is 11.0 million m^3 of which 2.5 million is in Peninsular Malaysia, 6.0 million in Sabah and 2.5 million m^3 in Sarawak (see Table 2.14). The rate of entry and exit in this industry is low due to the need for relatively high levels of investment.

Table 2.14 Number of Plywood and Veneer mills in Malaysia, 1980-1994.

Region	1980	1990	1991	1992	1993	1994	Cap[a]	Recov[b]
Sabah	9	33	31	37	49	65	6	50-60
Sarawak	3	7	19	39	41	47	2.5	50-60
P. Malaysia	36	40	43	44	45	49	2.5	60
Total	48	80	93	120	135	161	11	

[a] Capacity installed
[b] Recovery rate in per cent of log intake
Source: Malaysia (1995); MIER (1994).

The plywood and veneer mills in the Peninsular Malaysia are generally small compared to those in East Malaysia. Most of them were established in the late 1960s and early 1970s and were designed for processing large diameter logs from natural forests. However, changes in resource supply pattern as a result of the dwindling stock of a high quality logs has forced some mills to upgrade their processing machinery and technology.

Recovery rates of about 60% are common in Peninsular Malaysia while those in Sabah and Sarawak are in the range of 50-60%. Over capacity due to log shortage is prevalent, especially in Sabah where mills operate at below 50% of their installed capacity. In Sarawak, the supply of raw material is better and mills can operate more than 60% of their installed capacity. Plywood and veneer mills are generally larger in East Malaysia with more than 90% having an installed capacity over 40,000 m^3 per year.

Plywood production has achieved a very rapid rate of growth, averaging 34 percent per year over 1960-1976. Between 1976 and 1983, the performance was less impressive, mainly because of lack of demand due to recessionary conditions in the export market. Production in the early 1980s was hovering around the 600,000-m^3 mark compared to 450,000-550,000 m^3 in the late 1970s. About 90% of the output come from Peninsular Malaysia, with Sabah and Sarawak sharing the remainder. Although the industry was set up before the second world war, it was only in the 1960s that it assumed an important role in export. On average about 60% of the plywood produced is exported. Growth of the home demand has been relatively slower than exports, averaging 13.7% per year, with Peninsular Malaysia consuming most of the home supplies. Ample log supplies and the availability of cheap labour, together with rising demand from the EEC and the USA during the 1966-1973 period, gave a boost to the industry.

Total plywood and veneer production for 1994 amounted to 5.6 million m^3 with Peninsular Malaysia producing 1.2 million m^3, Sabah producing 2.4 million m^3 and Sarawak 1.9 million m^3 (see Table2.15). The bulk of the plywood is the standard utility plywood with sanded and edge-trimmed surfaces. A small quantity is speciality plywood overlaid with decorative veneer or melamine, PVC and polyester; phenolic film-faced plywood is also manufactured.

Table 2.15 Plywood and Veneer Production, Malaysia 1980-1994 ('000 m^3)

Year	Malaysia	Peninsular	Sabah	Sarawak
1980	908	772	65	71
1989	1417	939	282	196
1990	1972	1207	570	195
1991	2297	1227	830	240
1992	3363	1368	1352	643
1993	4824	1345	2144	1335
1994	5635	1201	2485	1949

Source: Malaysia (1995).

2.3.1.3 Moulding

Timber mouldings are pieces of wood worked into an ornamental shape for panelling, framing and other decorative purposes. The more common ones are door jambs, picture frames, casings, architrave, and half and quarter rounds.

Currently there are some 210 wood moulding plants in Malaysia, 111 in Peninsular Malaysia, 78 in Sabah and 21 in Sarawak. The majority of the plants are small with installed capacities of less than 50m^3/day. They are usually located in existing sawmills, furniture or joinery mills. A good number of moulding plants also produce furniture and furniture components, in addition to joinery products. Table 2.16 shows the production of moulding for each region in Malaysia.

Table 2.16 Production of Moulding in Malaysia, 1989-1994, (m^3)

Year	Peninsular Malaysia	Sarawak	Sabah	Malaysia
1989	203,219	50,330	nil	253,549
990	178,036	48,015	nil	226,051
1991	205,139	43,907	166,200	415,246
1992	179,313	34,016	219,690	433,019
1993	207,508	34,289	252,155	493,952
1994	174,375	35,514	289,355	499,244

Source: Malaysia (1995).

2.3.2. Malaysia's Trade In Wood-Based Product

2.3.2.1 Export

Malaysia's exports of major timber products have been increasing steadily except for sawlogs and sawntimber. Export of logs declined from 65% of export value in 1985 to 45% in 1990 and down to 20% in 1994 in line with the ban on round log exports by Peninsular Malaysia and Sabah. The log ban is an effort by the government to promote downstream processing activities in the sector.

In contrast to logs and sawntimber, exports of other products like plywood, veneer, mouldings and furniture have been increasing rapidly as the timber sector moves into higher value added activities. The furniture sector has made the most impressive impact with an export share soaring from 0.3% in 1985 to 3% in 1990 and 11% in 1994. Similarly the export share of plywood soared from 4.5% in 1985 to 26% in 1994.

A total volume of 8.6 million m^3 of logs valued at RM2.56 billion or 19% of total timber products was exported in 1994. Compared to 1993's export, this represented a drop of 9% in volume and 12% in value. With an export ban policy in force in Peninsula Malaysia and Sabah, the entire log exports were from Sarawak. Major export markets in 1994 were Japan, Taiwan, South Korea and People's Republic of China.

Sawn timber exports registered a total volume of 4.6 million m^3 valued at RM4.1 billion in 1994. This represented a decline of 15% in volume and 6% in value compared to 1993. Sabah was the largest contributor with 1.8 m^3, followed by Peninsular Malaysia, 1.5 million m^3 and Sarawak, 1.3 million m^3. Malaysia's major export markets for sawn timber were Thailand, South Korea, Taiwan, Singapore, Japan and the Netherlands. The imposition of export tax at the end of 1990 saw a decline of exports in 1991.

Plywood exports recorded a new high of 3.0 million m^3 valued at RM3.3 billion in 1994, making up 25% of total exports of timber and timber products. This was an increase of 25 % in volume compared to the year 1993. Plywood exports have increased significantly since the mid 1980 recession. Sarawak contributed the largest export share of plywood (1.3 million m^3), followed by Sabah (1.2 million m^3) and the Peninsula (0.5 million m^3). Major markets for plywood exports were P.R. China, Japan, Singapore, Hong Kong, Taiwan United States and the United Kingdom. Export veneer in 1994 totalled 0.6 million m^3. Export contribution was mainly from Sarawak (0.4 million m^3) and Sabah (0.2 million m^3). Major export markets for veneer in 1994 were Taiwan, P.R China, Japan and South Korea.

Although the Malaysian moulding industry started in 1965, it did not make much progress until the 1970s. In 1977 the export earning amounted to about M$77 million compared only with M$5 million in 1968, representing a fifteen fold increase. Malaysia exported RM633 million of mouldings in 1994, an increase of 8% over the year 1993. Peninsular Malaysia dominated the exports, accounting for RM393 million, followed by Sabah with RM190 million and Sarawak, RM50 million. Major export markets for mouldings were Japan, the United States, Australia, Taiwan and South Korea.

Furniture is the fastest growing sector in the wood based industry. Exports of furniture exceeded RM1.5 billion in 1995, up 50% over 1993. More than 30% of the total exports were wooden furniture, with rattan furniture making up the rest.

The success of the furniture industry can be largely attributed to the use of rubberwood as an alternative to tropical timber and government support in developing the sector. Rubberwood furniture made up about 70% of total furniture export in 1994. Major markets for wooden furniture were the United States and Japan, followed by Singapore, the United Kingdom, Australia and Taiwan.

2.3.2.2. Import

With the exception of paper and paper products, Malaysia's wood-based industries are essentially export-oriented. However, Malaysia does import small amounts of timber, mainly as raw material for further downstream processing. Import volumes in 1994 included 142,000 m^3 of logs, 124,000 m^3 of sawn timber and 75,000 m^3 of plywood. Other imports included veneer, mouldings and furniture. A certain amount of intra-trade is also evident between Peninsular and East Malaysia. In 1994, Peninsular Malaysia imported 43,000 m^3 of logs and 10,000 m^3 of sawn timber from Sarawak as well as another 23,000 m^3 of sawn timber from Sabah. Imports of plywood included 32,000 m^3 from Sabah and 26,000 m^3 from Sarawak.

As for paper and paper products, Malaysia is essentially a net importer as the demand for these products has been on the rise. In 1993, for instance, Malaysia produced almost 700,000 tonnes of paper and paper board but consumed more than 1.5 million tonnes, accounting for a national shortage of 55%. Imports of paper and paper products in 1993 were worth RM1.25 billion, with the major import sources being Canada, Sweden and Finland.

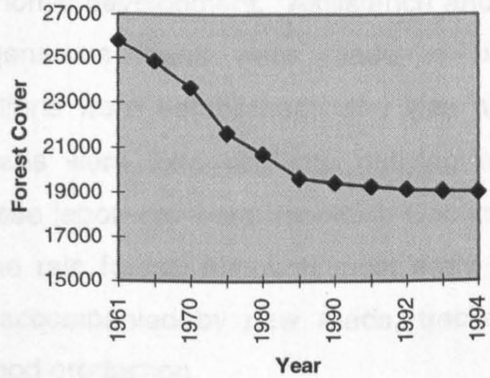
Given the sizeable outflow of foreign exchange due to imports of pulp and paper products and its future potential, the Malaysian government has identified this industry as a priority candidate for investment and development to cater for the domestic and export market. Malaysia's plans for this industry rely on the availability of Rubberwood and 60,000 hectares of land area that has been planted with fast growing species under forest plantation in Peninsular Malaysia.

2.4 Forest Changes

Malaysia displays a variety of different modes of forest exploitation, from pre-modern to modern era. Those from pre-modern times include hunting and gathering, swiddening collection of forest products for trade, and sedentary farming, while those of modern provenance include plantation agriculture, mining and timber extraction. The transition to modern resource-use regimes has resulted in mounting impact in terms of rapid forest change (Aiken and Leigh, 1995). Table 2.17 shows the total forest cover of Malaysia for the period, 1961-1994. This section outlines the processes and policies that have resulted in forest change in Malaysia, beginning from the early years of independence.

Table 2.17 Malaysian Forest Cover, 1961-1994 ('000 hectares)

Year	Forest Cover
1961	25820
1965	24860
1970	23660
1975	21652
1980	20683
1985	19608
1990	19419
1991	19248
1992	19133
1993	19056
1994	19000



Source: FAO (1996).

2.4.1. Commercial logging

Commercial logging is a major source of degradation of virgin forests and change of forest cover in Malaysia. Table 2.18 shows the total area of logging in Malaysia for the period, 1971-1993. This commercial logging is not only to serve timber export markets but also to supply wood-based industries which have grown rapidly in Malaysia. The country has developed into the world's leading exporter of sawn hardwood and a significant exporter of plywood and other wood products as well. The current status of wood-based industries has been discussed in section 2.3 in this chapter.

Table 2.18 Malaysia- Logging Area for 1971-1993 ('000 hectare)

Year	Area
1971	317
1975	714
1980	610
1990	658
1991	813
1992	538
1993	441

Source: Forestry Department (1992); Malaysia (1995).

2.4.2. Commercial Agriculture.

The development of commercial agriculture was a high priority of the colonial government to stimulate economic development. Assistance and encouragement came in several forms: generous loans were made to pioneer planters; experimental agricultural stations were established; land was alienated on very liberal terms; many new roads were extended into outlying areas; and large numbers of Indian and Chinese labourers were imported. Commercial agriculture spread at the expense of the rain forest. Although most early plantations were relatively small, they were accompanied by new roads, tracks, migration and settlements, and expanded food production.

The total area in agricultural use has increased steadily since 1904. Most of the commercial agriculture areas are in Peninsular Malaysia. The increase is directly attributable to rubber and oil palm plantations.

The Malayan rubber industry has been described as 'one of the greatest achievements of Western colonial enterprise' (Allen and Donnithorne 1957, p.106). Together with tin, it formed the backbone of the Peninsula's economy, and its impact on the landscape was profound.

The rubber plantation got off to a rather slow start, and the area devoted to it in 1897 was only 140 ha. The planters began to plant it more extensively following the collapse of the coffee industry in the late 1890s. The timing of the transition from coffee to rubber was fortuitous because it coincided with the initial growth of the American automobile industry, which greatly stimulated demand for pneumatic tyres and other rubber products.

As prices soared, the area devoted to rubber increased dramatically in the first two decades of this century: from about 4,500 ha in 1903 to some 405,000 ha in 1916, and then to more than 810,000 ha in 1921, when the crop represented about half of the world's rubber production and some three-fifths of all cultivated land in the Peninsula. During 1904-1932, the rubber area increased by 1.3 million ha, which was 86 percent of the increase in all-crops area.

Oil palm remained much less significant than rubber during 1932-66, representing only 14 percent of the increase in all-crops area. During 1966-1988, however, the increase in area of oil palm actually exceeded the increase in all-crops areas by 6 percent. Not only were new lands developed for oil palm, but oil palm replaced rubber on many existing plantations. In 1989, the area of oil palm exceeded the area of rubber for the first time.

Another tree crop whose area has expanded significantly since 1966 is cocoa. Total planted area in 1994 was about 300,000 ha, which is small compared to the total area of rubber and oil palm, accounting for 4 million ha. Table 2.19 shows the area under agriculture for Malaysia during the period 1960 -1994.

Table 2.19 Area Under Agriculture, 1960-1994 (million hectare)

Year	All Crops	Oil Palm	Rubber
1961	2.15	0.15	1.76
1970	2.74	0.29	1.83
1980	3.60	1.02	2.00
1990	4.77	2.03	1.82
1991	4.85	2.09	1.80
1992	4.86	2.17	1.77
1993	4.93	2.31	1.74
1994	4.97	2.35	1.72

Source: Malaysia (1995)

2.4.3. Land Development

Land development schemes have played a major role in Malaysia's programme of rural development and modernisation. The largest and most important of the institutions that have emerged to implement such schemes is the Federal Land Development Authority (FELDA), one of the largest and most profitable plantation companies in the world. More than 300 FELDA sponsored land development and resettlement schemes have been implemented in the Peninsular Malaysia. Most land development in East Malaysia has been conducted by state agencies, albeit generally in accordance with the FELDA model (FELDA has also been active in Sabah but not in Sarawak).

2.4.3.1. Land Development in Peninsular Malaysia

Land development in the Peninsular Malaysia has been motivated by a combination of social, political, and economic factors: most of the rural poor are Malays and since the mid-1950s the governing Malay elite has stressed the importance of rural development. FELDA was established in 1956 with the aim of improving the socio-economic status of the landless and the unemployed by promoting the settlement of new areas by landless rural people. Through 1966, FELDA schemes were predominantly based on rubber cultivation. The government paid for land clearing, road construction, rubber planting, and house building. Settlers were expected to repay about 80 percent of these costs, with payments to begin when trees were tapped. Settlers received a 99-year title to the land once they had paid off their debt. In 1960, FELDA's mandate to manage, in addition to establishing smallholding schemes was broadened. Although settlers continued to work toward ownership of their land, in some cases their activities came to be as strictly controlled as those of labourers on estates. Now a huge plantation company with a large bureaucracy and several subsidiary corporations, FELDA is charged with opening up new areas, bringing in settlers, and supervising the transformation of undeveloped land into large-scale schemes devoted to the production of, mainly, oil palm and rubber for export.

Originally, most FELDA schemes were relatively small, averaging about 1800 ha and accommodating some 400 settler families. It was hoped that these schemes would eventually result in the growth of small urban centres, thereby helping to retain second- and third-generation settlers in the predominantly rural areas. In part because this did not happen, the trend since the late 1960s has been towards ever-larger integrated regional development projects featuring both land development and urban growth centres. Jengka Triangle in Pahang was the first of the large-scale projects. Work began in 1968, and, by 1977, 24 separate FELDA schemes covering 121,700 ha had been established. Since the 1970s FELDA has been variously involved in several other, even larger, regional development projects. Prominent among these are the following: Pahang Tenggara (over 1 million ha), Johor Tenggara (0.30 million ha), Terengganu Tengah (0.44 million ha), and South Kelantan (1.17 million ha).

The pace of FELDA-sponsored land development has been very rapid since 1970, reflecting the government's emphasis on 'the modernisation of rural life (Malaysia 1971, p.1) and the increasing size of development projects. All in all, FELDA has developed some 847 705 ha of land, almost all of which was originally heavily forested (Table 2.20). In addition, a considerable amount of land has been developed by state authorities and the private sector.

Table 2.20 Land development by FELDA,1956-1990

	Period	Area (ha)
First Malaya Plan	1956-60	6,619
Second Malaya Plan	1961-65	48,269
First Malaysia Plan	1966-70	72,423
Second Malaysia Plan	1971-75	166,847
Third Malaysia Plan	1976-80	216,447
Fourth Malaysia Plan	1981-85	161,600
Fifth Malaysia Plan	1986-90	175,5OO+
Total		847,705

+ Estimate; includes 58,090 ha in Sabah.
Sources: Bahrin and Perera (1977. p.51); Malaysia (1971)

Much of the frontier region east and south of the Main Range has been transformed by land development schemes. Here, in little more than two decades, vast areas of forest have been replaced by uniform, serried rows of plantation crops that now march endlessly across the landscape. This great and sudden transformation owes relatively little to the initiative and resourcefulness of the settlers themselves. The contractors do the work of clearing and preparing the land for settlement. The speed of forest transformation and settlement was rather the product of the managerial and technical skills of a giant authority that is at one and the same time a profitable plantation company and an agent of modernisation. Mehinet (1986, p.63) has noted that these two roles are inherently conflicting and, in recent years, FELDA's split-personality complex has become more acute as the Authority has tended to divert increasing surpluses to growth and diversification at the expense of its objective of poverty amelioration.

2.4.3.2. Land development in East Malaysia

Most of the forest changes in the Peninsular Malaysia have resulted from land development. This has not been the case in East Malaysia, where logging and shifting cultivation have played the major roles in anthropogenic forest change. East Malaysia territories, Sabah and Sarawak remained largely undeveloped and heavily forested throughout the colonial period. Great primary forests still clothed more than three-quarters of the entire region when Sabah and Sarawak joined the Federation of Malaysia in 1963.

Shifting cultivation, not commercial agriculture or timber extraction, was the major process of forest change, and by the 1960s both territories exhibited extensive tracts of secondary forest. Forests in some areas were replaced by rubber cultivation and food crops but these and other land uses comprised only a small proportion of the total land area. However in the 1970s, increasing attention was given to land development in Sabah and Sarawak.

In Sarawak, integrated land development schemes featuring crops like rubber, oil palm, cocoa and, tea, and often including provision of facilities such as housing, piped water, and electricity, have since 1972 been implemented by three major state agencies: the Sarawak Land Development Board (1972-), the Sarawak Land Consolidation and Rehabilitation Authority (1976-), and the Land Custody and Development Authority (1981-). In addition, the Department of Agriculture (usually in association with other government departments) has been involved in assisting small farmers to improve or diversify their agricultural activities; several areas have been targeted for coordinated development under the Malaysian government's Integrated Agricultural Development Projects programme and the Fifth Malaysia Plan 1986-1990 (Malaysia, 1986) called for greater emphasis on both in situ development of smallholdings and the resettlement and regrouping of communities so as to foster rural growth centres and small-scale industries. Most of the development schemes have followed the FELDA model, and much encouragement has been given to private-sector investment.

By 1981, state agencies had developed some 19,700 ha of land for mainly rubber, oil palm, and cocoa (Malaysia, 1981, p.35), and the area under those crops in 1985 was 40,000 ha according to Colchester (1989, p. 55). Some schemes have been implemented in newly cleared areas, some in already settled areas, but this land development remains a minor cause of forest conversion-at least when compared with logging and shifting cultivation (Aiken and Leigh ,1995).

In Sabah, prior to the 1970s, relatively little attention was given to rural development. It was not a high priority of the post-war British colonial administration (1946-63), and the pace of change was rather slow during the period of the first two national plans (1966-75), although the incidence of rural poverty remained very high. A major change occurred in 1976 when the Berjaya Party assumed office, and thereafter poverty alleviation through rural development was given much greater emphasis (Voon, 1981). In addition to implementing various programmes in existing agricultural areas, government policy also called for a speeding up of land development and settlement schemes in underdeveloped areas, and this was to be achieved in large part through resettlement of isolated communities of mostly shifting cultivators.

The Sabah Land Development Board (formed in 1969) soon emerged as the major agency of land development, and by 1978 it had brought some 32,500 ha of land under, mainly, oil palm, although attracting settlers to the schemes remained a major problem. FELDA has also been engaged in land development in Sabah: it was responsible for planting some 37 200 ha of new land with oil palm and cocoa during 1981-5 and was developed another 58,090 ha during the Fifth Malaysia Plan period and is expected to further develop in a current development programme.

Chapter 3

LITERATURE REVIEW

This chapter reviews literature on two key areas of the study. First, it reviews the relevant literature on the theoretical concept of forest harvest, market restrictions and related empirical studies. A partial equilibrium approach is used to explain the theoretical concepts of market restriction. The empirical evidence is focused on tropical rain forest products, particularly in Malaysia, although attention is also given to studies of forest products from other countries. Secondly, this chapter reviews the concept of deforestation and Environmental Kuznet Curve and some related research that has been conducted.

3.1. Forest harvest

3.1.1. Forest Harvest - Private Landowner

This section[1] addresses timber management by private landowners responding to market incentives. It first examines the basic static optimal rotation model for even-age stands, its analytical history, its comparative statics, and its elaboration. It also describes some economic variables that have strong impacts on timber harvest behaviour. These may be effectively used as forest policy tools or they may be used for other purposes with the unintended result that timber harvest may be altered.

Choice of the optimal age at which to harvest an even-age stand has been central to traditional forest economics, and an array of competing criteria have been proposed for selecting the optimal rotation. In the traditional forestry literature, timber supply from the forest is set according to the principle of sustained yield. Under this principle the forester chooses a strategy which yields the highest sustainable output from a normal forest while maintaining a constant vintage structure in the forest. The notion of

[1] This section in part draws on Montgomery and Adams (1995)

traditional sustainable harvest has changed since the introduction of the Faustmann harvest model. The model assumes that given a tree that is growing in value, one must determine the timing of harvest and the optimal rotation, that maximises some measure of net return. This model serves as the cornerstone for the economics of timber management.

In its simplest form, the Faustmann model assumes that the timber landowner chooses the harvest age that maximises returns to the fixed factor of production which is taken to be the land. This return is variously known as bare land value or soil expectation value (SEV). Stumpage price and interest rate are determined by market equilibrium and are taken as given by the landowner. The model is static in the sense that price and interest rate are assumed to be constant over time. As a result, if the current best use of the land is for timber production, its best use in the future will also be for timber production and the optimal harvest age will be the same for current and future stands. The model is

$$\max F(A) = \frac{PQ(A) - C}{e^{rA} - 1} - C \qquad (3.1)$$

where A is harvest age, P is the stumpage price, C is a fixed per-acre cost incurred at the beginning of the rotation (it includes the cost of cleanup and preparation of the site and establishment of a new stand), $Q(A)$ is the volume yield function for a stand of trees (giving volume of timber per unit area) with $Q_A > 0$ and $Q_{AA} < 0$ over the relevant range, and r is the interest rate. The necessary condition for the optimal rotation age is

$$PQ_A = r[PQ(A) + F(A)] \qquad (3.2)$$

Given that $Q_{AA} < 0$, the sufficient condition for maximisation is satisfied as long as $F(A) \geq 0$. Equation (3.2) says that landowners will postpone harvest as long as the value of the incremental growth of the stand, PQ_A , is greater than the opportunity cost of the timber and the land. The opportunity cost of the timber is the forgone interest earnings on the income from current harvest, $rPQ(A)$, while the opportunity cost of the land is the forgone interest earnings on the value of the bare land, $rF(A)$.

In this simple model, price, interest rate, and establishment cost are the sole exogenous influences on optimal harvest age. An increase in the interest rate or a one-time unanticipated increase in the stumpage price will lead to shorter rotations. In both cases this is because the marginal opportunity cost of postponing harvest rises relative to the incremental gain. Intuitively, landowners face a trade-off. Shorter rotations given a rising interest rate reduce the impact of discounting on future returns and maintain present value, but also subject costs in future rotations to a lower discount factor as well. Increasing the stumpage price will increase the present value of timber, leading loggers to shorter rotation times. This will reduce the overall volume extracted because the trees will be smaller. An increase in the stand establishment cost *C* results in longer rotations as landowners try to reduce the present value of these costs by pushing them further into the future. Because *F(A)* falls as *C* rises in equation (3.2) *for any stand age*, harvest age must increase to reduce PQ_A and raise *Q* to re-establish the equality.

The formulation of the Faustmann model, used up to this point, has been simplified to focus attention on basic behavioural implications. The bulk of forest harvest literature has been built on the Faustmann harvest model and examines the effect of changes in various economic parameters on the optimal management of the forest (Jackson, 1980; Chang, 1983; Nautiyal and William, 1990; Hyde and Newman, 1991; Thiele, 1995; and Theille and Wiebelt, 1994).

One of the most examined economic parameters is the impact of timber taxation. Three broad forms of timber taxation are commonly examined: (i) an *ad valorem* system in which a fixed percentage tax is levied against the market value of the stand (land plus timber) each year; (ii) yield taxation where a fixed percentage tax is levied on the value of timber harvested; and (iii) a site or land value tax levied annually on the market value of the land only. In the analysis of tax impact it is common to assume that the full effect of the tax is incorporated in reduced soil expectation value (full tax capitalisation). This need not be the case, however, if tax-induced timber supply reductions raise market stumpage prices. In this way some portion of the tax burden may be passed along to timber consumers.

If the tax rate is *T, the ad valorem* tax effectively augments the interest rate (Fairchild, 1935). From the preceding comparative statics analysis we know that raising the interest rate reduces the optimal rotation. In the light of this rotation-shortening effect and the practical problems of paying an annual tax for a parcel that produces revenue only at lengthy intervals, some states have adopted instead a yield tax. The yield tax is comparable to a percentage reduction in the stumpage price, leading to a longer rotation, The third alternative, the site or land value tax, leads to a scale reduction in bare land value and is neutral with respect to rotation age.

Taxation of timber and/or timberland, regardless of the form, induces some reduction in site value. Unless comparable burdens are placed on land values in alternative uses, the tax may occasion a shift from forest to non-forest use. Taxes with forms like the *ad valorem* or yield tax can also influence both the extensive and intensive margins of forest use by driving the site value negative. At the extensive margin, existing stands of timber might be harvested but not replaced except by natural regeneration. At the intensive margin, some silvicultural investments designed to increase the volume or quality of harvests would become uneconomic.

The analysis of timber harvest has been extended to include a wide array of non-timber benefit in addition to timber. Analyses by Hartman (1976), Strang (1983) and Snyder and Bhattacharyya (1990) have considered the optimal harvesting strategy for a forest that provides value while standing as well as when harvested. Standing timber may provide wildlife habitat, water yields, recreation opportunities, visual amenities, and the sequestration of atmospheric carbon. If the values of these non-timber benefits were known and assignable to landowners, they would appear in the Faustmann calculus. Where timberland owners deviate from the Faustmann rotation because of professed concern for non-timber outputs, the value of the non-timber outputs that accrue to landowners may be inferred as the opportunity cost of " suboptimal" timber management.

Under a timber-non timber management regime, the landowners will hold the stand just to the point where the incremental benefits from both timber output and non-timber output are equal to the incremental opportunity costs of holding both timber and land.

3.1.2. Forest Harvest-Public Landowner

The Faustmann model assumes private ownership of the forest land (Faustmann, 1849). The landowner has full control over the decision whether to harvest, leave or clear for an alternative use. However many forests, particularly tropical forests are owned by the government. The forest harvesting is only done by the agent, normally called concessionaire. The concessionaire's harvest decision is governed by the agreement and by the timber rent obtained from the harvest. If the concessionaire's right on the land is equivalent to private ownership, then the harvest behaviour will follow the pattern discussed above. If not, the harvest decision will be based on timber rent.

Timber rent is defined as the difference between total revenue from timber sales and total cost of harvesting and delivery. Therefore, the timber rent can be very substantially influenced by the factors that change the price of timber and the cost of harvest, such as the difficulties of harvest. Easy terrain, and proximity to roads, mills and ports are major sources of large timber rents. Expansion of infrastructure, the development of lower-cost logging technologies, and increase in the number of species and sizes of roundwood accepted by the market have combined to increase rent over time. The importance of timber rent lies in its impact on the efficiency of land use and forest management. Page et al. (1976), Schmithusen (1976), Ruzicka (1979) and Vincent (1998) have argued that the fees that forestry agencies levy to capture timber rents can affect marginal harvesting decisions and result in inefficient harvest levels if they are not set appropriately. Page et al. (1976) pointed out that a government's failure to set timber fees at levels comparable to competitive stumpage values can destroy rents by artificially maintaining the viability of inefficient logging firms.

3.2 Market Restriction Policy on Timber Products.

A substantial number of tropical timber-owning nations have enacted bans or similar provisions constraining the export of crude logs and intermediate processed timber products (see Lindsay, 1989; Waggener et al., 1990; Barbier et al., 1995; Goodland and Daly, 1996). The politics surrounding these log and intermediate processed products export embargoes are complex and difficult to resolve for several reasons. First, logs and intermediate timber products are raw materials; their export precludes obtaining the multiple economic benefits of value-added manufacturing. Second, the market structure, domestic and export market, significantly influences the effectiveness of any export ban. Third, and perhaps the most important, national, state, and private interests are served to varying degrees by limiting commodity export (Jones et al., 1994). Thus a decision to restrict timber trade will benefit some but not all market participants. Private interest groups, domestic primary and secondary manufacturers and others who would benefit from such protection advocate protection. This protection would presumably reduce demand for - and price of - the raw material for industry, thereby easing raw material shortages and allowing domestic processors access to raw material at lower prices. Environmental organisations have supported this position, anticipating a reduced timber harvest from forest lands through the elimination of foreign buyers (Goodland and Daly, 1995).

Government on the other hand, in an attempt to capitalise on the increasing global demand for hardwood products, have developed programmes to encourage economic development based on forest resource industries. They believe that the consequent expansion of primary and secondary manufacturing of unprocessed logs can enhance forest based economic development and increase employment opportunities. Thus, export of raw materials is viewed as a lost opportunity for economic development. The restriction is also based on the view that it is necessary ' to maintain a viable domestic wood processing industry' (Lindell, 1978). Another argument for restriction is that it will encourage foreign firms to invest and operate in developing countries, thereby accelerating the technology transfer that will improve the efficiency of the industry. A theoretical explanation of timber trade restriction and its effect is provided in the following section.

3.2.1. Theoretical explanation of market restriction

In this section, we will use a partial equilibrium approach to explain the effect of timber market restriction on forest harvest. In this approach, the timber market is modelled using ordinary demand and supply analysis (Greenway,1990; Park and Cox, 1985; Barbier et al., 1991). The analysis focuses on two trading regions; an exporting region and an importing region (rest of the world), with a single traded commodity, timber. There are separate supply and demand conditions in the two regions that show the motive for trade between timber producing country and the rest of the world. To simplify the analysis, the restriction is assumed to be a complete ban on timber export by the producing country. Figure 3.1 is used to explain the main features of the effect of a total export ban. In Figure 3.1, S is the domestic supply curve of hardwood, D is the domestic demand curve , P^m is the domestic equilibrium price, the price at which the domestic demand is equal to supply if no trade takes place. The world price, P^w, is above P^m indicating that timber is exportable. At P^w , domestic supply is greater than the domestic demand and the difference is available for export. In a situation of unrestricted trade, the exporting country will produce OQ_3 hardwood. OQ_1 will be consumed in domestic market, while the remaining Q_1Q_3 is exported.

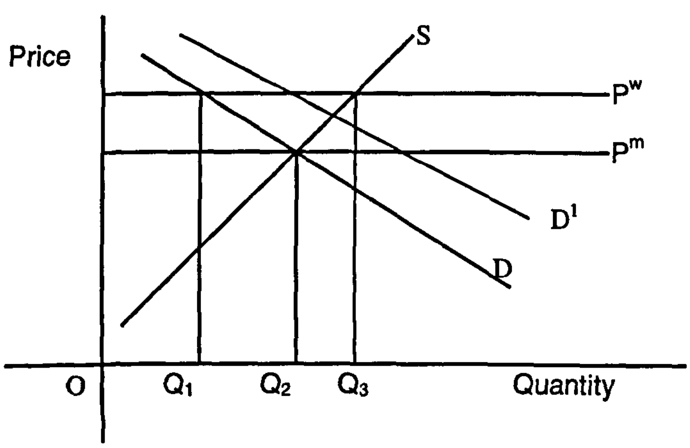


Figure 3.1 Effect of Timber Export Ban on Logging Sector

The imposition of a log ban changes the market situation. Elimination of world demand in the domestic market causes the domestic price to fall to P^m. The restriction imposes a cost on the logging sector that the timber producer must sell at a price below what it would otherwise receive, thus production is reduced by Q_2Q_3 to OQ_2 . All the timber produced is consumed by the domestic producers of processed wood products.

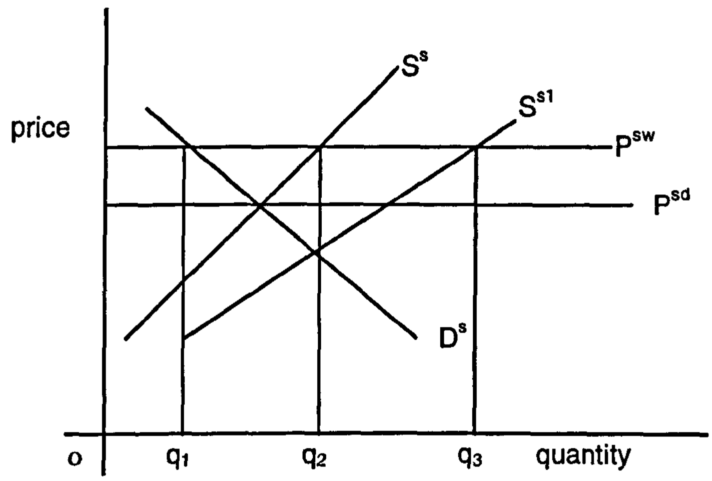


Figure 3.2 Effect of Timber Export Ban on Processing Sector

The secondary effect from the log ban policy is on the intermediate processed wood sector. This effect is explained using Figure 3.2. S^s is the supply curve before the implementation of the log ban, D^s is the domestic demand for sawnwood, P^{sw} is the world price of sawnwood and P^{sd} is the domestic equilibrium price. In a situation of no restrictions on log exports the domestic sawnwood producer will produce oq_2 sawnwood of which oq_1 is consumed domestically and q_1q_2 is exported. The domestic user of hardwood will pay the same price as offered in the world market, P^w.

The processing sector of the forest industry derives the benefit from log export ban since it can buy logs at prices below what it would otherwise have to pay. With the log price reduced to P^m, the processing sector will experience lower cost of production and expand exports. As a result, the supply curve will shift out to S^{s1}. Domestic sawmills will produce oq_3 of sawnwood, of which q_1q_3 is now exported. However domestic consumption will remain at oq_1. The primary wood processing industries will therefore enjoy an increase in profit for a similar quantity of production produced before the implementation of the log export ban. In addition, the industries will also be protected against competition from foreign producers of a similar product.

While intermediate processors (i e. sawmills) enjoy the benefit of the log export restriction, the situation is different for domestic users of intermediate products, in the downstream industries (e.g. furniture, construction, etc.). Thus, the log export ban benefits only the intermediate product producers but not the domestic users of intermediate wood products. The domestic users have to pay for the intermediate products at the world price. Thus, unlike intermediate products producers, downstream wood-processing industries do not enjoy comparable protection.

3.3. Timber trade Policy and Timber Utilisation

The discussion of the effect of timber trade restriction on timber utilisation could be divided into two, the direct effect and the indirect effect. Figure 3.1 shows the direct effect of the trade policy on forest harvest and log export restriction in the short term. As the price falls, the log producer will produce less. However, some (Barbier et al., 1995; Gillis, 1988, Repetto, 1988 and Vincent, 1990), argue that reduction in production will not be followed by a reduction in harvest area, because where heterogenous wood species exist, the most valuable species will be cut down first and more area will be open, thus causing a lot of wood waste in the field. In other words, the wood utilisation is not efficient[2].

There will be an indirect effect on harvest due to change in domestic demand for logs. Reduction in log price due to LEB will attract more firms to enter the processed wood sector, thus increasing the demand for log causes a shift in demand curve to the right (from D to D^1) and a rise in log price above the initial domestic equilibrium, p^m. The log producer will respond with more production of log from the forest. Of concerns in relation to this phenomenon now is efficient utilisation of wood at the processed level[3]. The processed industry contains firms of unequal efficiency (whether on account of differences in scale of operation, underlying technology, or the quality of management).

[2] The loggers operate efficiently at private marginal cost (MCp) = Social Marginal Cost (MCs) = Marginal Revenue (MR), however increased wood waste that leads to more logging area opening up causes environmental damage that increases social cost, thus the wood utilisation is not socially efficient because MCp = MR < MCs (for furthur discussion see Hyde and Sedjo, 1992).
[3] Given resources and underlying technology, the industry is efficient if it produces on the production frontier; also given resources and underlying technology, the firm or industry is more efficient if it can produce more than others.

Gillis (1988a, 1988b) and Barbier et al. (1995) argued that, low log prices give inefficient firms the opportunity to enter the market. Such firms will utilise more wood to produce one unit of processed product. Thus, production of a similar quantity of processed wood products to that produced before the log export restriction will require more wood to be produced.

The magnitude of direct and indirect economic effects of restriction timber and timber products exports depends on several factors: These factors according to Greenway (1990) are: (i) shifts in supply and demand in response to the price changes; (ii) opportunities for substitutions; (iii) adjustment to the tax payment; and (iv) the level of industry expansion and the magnitude of associated direct and indirect effects.

3.4. Empirical Studies

Several empirical studies have investigated the effect of timber export restriction with respect to the level of protection to domestic industries, the welfare effect and also the effect on deforestation. Related to protection, the studies show that the effective protection level to domestic processing is very high. A study on the Malaysian timber market has shown that the effective rate of protection for sawnwood for a period 1979-1982 was 30-33 percent and the effective rate of protection for plywood for the same period was 44-58 percent (Shahwahid, 1986). The estimates were based solely on the protection provided by export taxes on logs and by import tariffs on processed products (as of 1978, 20 percent on sawnwood and 25 percent on plywood). The study also shows that if the effects of quantitative restrictions on log exports are included, effective rates of protection are much higher. At a recovery rate of 56 percent it was calculated that the effective rate of protection was 272 percent. This level of protection is widely different to situations when no export tax is implemented. It was reported that the effective rates of protection for Peninsular Malaysia's sawnwood industries of -2 percent in 1963, -9 percent in 1965, and -5.5 percent in 1969 (Vincent,1986).

Shahwahid's studies also describe the entrance of firms into sawmill industries due to the protection effect. During the period of log restriction (1972-1985) the number of sawmills increased at a more rapid rate, 2.8 percent per year, compared to the rate of the previous period (1960-1972) which was at 1.7 percent per year.

A study by Gillis (1988b) on Indonesia's timber market shows that the export tax structure created an effective rate of protection of 222% for plywood manufacturers. In contrast to timber export restriction, a free log market situation, gave no protection to the primary processing industries.

There is controversy and debate over the effect of changes in log prices, with particular reference to the effect on two frontiers, welfare and deforestation. The welfare argument assumes that the reduced log price is not compensated by the domestic policy of charging a realistic stumpage price. Gillis (1988b) reported that the drop in export revenue to the Indonesian government from diverting log exports was not compensated by any gain in value-added in sawmilling, resulting in a loss of US$15 per m^3 at world price. Another study on Indonesia (Manarung and Buongiorno, 1997) found that the log export ban policy has indeed promoted the development of the plywood and sawnwood industries. Nevertheless, in terms of total export revenue alone, the country would have been better off without the export ban. In total during the period 1981 to 1989, Indonesia lost $2.5 billion in export revenue due to the log export and ban policy. Revenue increases resulting from exporting more plywood and sawnwood were less than the losses in log export taxes. Although some 4,000 new jobs were created in the sawmills and plywood mills with the ban for the same period, about 14,000 jobs were lost in the logging operations. Gross value added for the plywood and sawnwood industries was raised by the log export ban by $2.2billion. The increase in gross value added resulted from the lower domestic price of log obtained by banning log exports. However the stumpage values were depressed by $2.6 billion with the ban.

Another study by Vincent (1992) on the log-export restriction imposed by Malaysia in 1985, indicated that, although the export restrictions seemed to stimulate growth in the processing industries and employment, the economic costs were high. On an average annual basis, Peninsular Malaysia lost US$6,100 in economic value-added, US$16,600 in export earning, and US$34,300 in stumpage value for every sawmill job created by the log-export restriction. Kishor and Constantino (1993,1996) found that removal of LEBs in British Colombia and Costa Rica led to substantial monetary gain in the long run.

A study by Park and Cox (1985) shows that a proposed partial export ban of logs would result a net loss about $20 million to Washington State, because lower revenue and reduced gains from trade would outweigh the estimated benefits to manufacturers and exporters. Jones et al. (1994) provide similar results on proposed restriction by Pennsylvania; they also argue that the state would lose as a result of the reduction of forest harvest.

A study by Vincent (1989) indicated that the large export tariffs on log, sawnwood and plywood imposed by Malaysia and other South East Asia exporters reduced domestic prices of that particular product in those countries, leading to losses in producer surplus. Indonesia imposed substantial taxes on sawnwood in an effort to shift processing activities to plywood. A recent study by Barbier et al. (1995) indicated that imposition of this tax does not appear to instigate a major shift of processing capacity to plywood. Only at extremely high rates of taxation does this occur even slightly. A prohibitive sawnwood export tax appears to be a high cost strategy for shifting processing capacity to plywood production and export for the following reason. The sawnwood export tax appears to have the effect of reducing export demand for Indonesian sawnwood, thus lowering the export price received and the quantity exported. The price effects appear to be outweighted by quantity effect. Although some sawnwood production is diverted to domestic consumption , it is not sufficient to overcome the fall in export demand. Thus, overall, sawnwood production falls. The greater the tax, the more severe the impacts on Indonesia's sawnwood markets. The strategy also does not appear to be an effective approach for reducing timber-related deforestation.

Policies that increase taxes on log exports to protect domestic industrial wood processors often lead to production inefficiencies, low log recovery rates, and wasteful harvesting (see section 3.3). In Indonesia, the *ad valorem* export tax on logs was doubled from 10% to 20% in 1978, while most sawnwood and all plywood were exempted. Beginning in 1980, controls on the export of logs were progressively enforced, until an outright ban was introduced in 1985. The consequence has been the creation of inefficient processing operations and expended capacity, with consequences for the rate of timber extraction and forest management (Barbier et al., 1995; Manarung and Boungiorno, 1997).

The efficiency argument has come under attack from the development point view (Varangis, 1993; Goodland and Daly, 1996). The goal of economic development seems to be better served by assisting developing countries to process more of their raw materials, rather than less. In addition, poverty alleviation (e.g. through increasing employment and value added) and improved efficiency are more directly achieved by technology transfer and training, rather than discouraging processing. Economic development should promote conditions under which value-added is maximised. Encouraging the export of raw materials, rather than value added products, seems to be contrary to development objectives. Relying on the foreign demand to keep the price up for allocative efficiency, when the same result could benefit the national treasury by charging or raising stumpage fees, seems to be problematic in forest sector. Stumpage fees raise input prices and reduce logging. Export demand raises prices and increases logging.

Domestic processing of natural resources has long been a possible development strategy for primary product exporters (Takeuchi, 1991). Value added is increased, thus increasing export earnings. One economic issue is whether the loss of log export earning is compensated by increases in processed wood export, because infant industry promotion takes at least a decade before becoming internationally competitive (Goodland and Daly, 1996). According to Goodland and Daly, the Indonesian case is not yet conclusive, for Indonesia, which phased in its log export ban during 1980-1985, it seems likely that processed export earnings began to exceed log export earnings forgone by 1986 (Lindsay,1989), and in the long run the present value of forgone log export earnings will be outweighted by the present value of the addition to processed timber export revenue.

Manarung and Boungiorno (1997) argue that the reduction in stumpage value has a negative effect on wood utilisation and long term conservation, though in the short-term the policy has decreased the cut from Indonesian forests by almost 20 percent. Their findings suggest that Indonesia might have been better off by allowing the export of logs, even if it had caused plywood and sawnwood production to expand more slowly. Without the log export ban, wood processing industries would still have been economically profitable and would have grown, without proliferation of inefficient mills.

Manarung and Boungiorno (1997) also argue that, the Indonesian government should consider taking steps to increase the domestic price of logs. A higher domestic price would induce the owners of the wood industries to use logs more efficiently so that the waste at the mills and the forest would decrease. A higher log price would also reduce demand for log. This would, in turn, reduce the forest harvest and help to reduce deforestation and also help to achieve a sustainable forest management of the Indonesian forest.

Although the switch to value added processing of timber initially slowed down the rate of timber extraction, the inefficiencies and rapidly expanding capacity of domestic processing may have actually increased the rate of deforestation over the medium and long term. For example, by the early 1980s, the major operational inefficiencies in domestic processing due to high rates of effective protection in Indonesia led to low conversion rates in Indonesia. As a result, for every cubic metre of Indonesian plywood produced, 15 percent more trees had to be cut relative to plymills in Asia that would have processed Indonesian log exports. Thus, not only did the protection given to Indonesian mills increase rather than reduce the log demand, but the gross operational inefficiencies also ensured that millions more logs may have been harvested than if a more efficient policy to boost domestic processing capabilities than forced industrialisation through export taxes and bans had been implemented.

A ban on log exports is equivalent to a prohibitive export tax - it reduces price and reduces deforestation. Gillis (1988a,1988b) however, has argued that log export restrictions in Indonesia, Malaysia, the Ivory Coast, Liberia and Ghana actually increase deforestation. The argument offered is partly economic and partly political. First, an export ban causes timber to be processed in the developing country's domestic mills which tend to be 'wasteful' - they use more timber to produce a given output of wood products than foreign mills. Second, once domestic mills are established, the host government is said to maintain the timber harvest at whatever level is needed, regardless of cost benefits, to keep the mills running and mill workers employed.

3.5. Trade and deforestation

Deforestation is a widely used term; its definition has not been agreed upon and it is used by different people to mean different things, or with different meanings in different contexts. Some have defined deforestation as a complete destruction of forest cover, due to land clearing for cattle ranching, agriculture or other development purposes such as road construction and the destruction should be the permanent conversion of forest land to non forest use (FAO, 1981; Lanly, 1982; Reitbergen, 1993; Faminow, 1998). This is the most restricted definition of deforestation. Alternatively, others such as Myers(1984, 1990) and Johnson (1991) define deforestation to include forest alteration, modification of forest structure and composition that impoverishes the resource base without completely clearing the forest. Forest alteration, or 'degradation' is less drastic than complete deforestation, because the land returns to continuous tree cover and ecological functions more or less recover. Another definition by environmentalist, ecologists and conservation agencies such as WWF, IUCN and World Conservation Monitering Centre (Sayer et al., 1992) consider the impact of forest disturbances that degrading the forest ecosystems through loss of biomass and ecosystem services as deforestation. Thus, the problems of definition and measurement have led to disagreement about the magnitude of deforestation. For example Mayer's survey (Mayer, 1990) gives higher estimates of forest loss than the survey of FAO (1981), which only recognises total clearance as forest loss.

There are two types of causes of deforestation; direct causes and the underlying causes. The direct or immediate causes of deforestation are agricultural expansion, overgrazing, fuelwood gathering, commercial logging, and infrastructure and industrial development. These immediate causes are driven by other causes such as population growth, rural poverty, state of economy and market and policy failures which are often called underlying causes of deforestation. The causes of deforestation, whether direct causes or underlying causes, have been widely studied, some of the studies and factor use for investigation are outlined in Chapter 4.

The main focus of study in deforestation has been on tropical deforestation. The reason is very obvious; tropical deforestation is by many considered to be among the most serious examples of ecological disruption in our world. According to the most recent estimates, 0.8% of tropical forests are deforested each year. This amounts to an area of 14 million hectares a year, which by way of illustration, is twice the area of Ireland. According to the World Commission on Environment and Development (WCED, 1988), a further area of 10 million hectares is grossly disrupted annually. Hence, if deforestation continues at that rate, large portions of tropical forests will be severely damaged or eliminated within a few decades.

Tropical deforestation may cause a number of environmental problems. Some of them are local problems, such as soil erosion, siltation of river and lakes, and more irregular patterns of floods and droughts. Some, such as biodiversity and carbon emissions affect the global community. Tropical moist forests constitute an enormous reservoir of biodiversity and genetic material. These forests, which cover only 7% of the land surface on earth, contain between 50% and 90% of species (WCED,1988). Some of these species will probably become important resources for humans in the future, for instance in the manufacturing of medicines. A great share of these benefits is likely to accrue to people outside the tropics. This makes the preservation of biodiversity an international concern.

Considerable effort has been undertaken in order to identify the causes of deforestation. The Brundtland Commission pointed to the international trade in tropical timber as one of the causes of tropical deforestation (WCED, 1988:68). Proposals have therefore been put forward in several countries to use timber trade restrictions as a means of forest preservation: local government restrictions on the use of tropical timber have been implemented in some countries (for example Germany, Netherlands and Austria).

The idea behind the use of timber trade restriction is simple: by reducing the profitability of tropical forestry, logging will be reduced, and the rate of deforestation will slow down. This argument has been challenged by some people. (see e.g. Vincent,1990; Swanson,1993; Schulz, 1993; Barbier and Rauscher, 1994). According to them the above is false because it ignores that forest land has alternative uses. To make forestry less profitable may in fact accelerate the rate of deforestation by promoting the conversion of forest land to agricultural or industrial uses

Secondly, the argument might be correct if there were substantial trade in tropical timber, but if only a small share of tropical production is exported, trade restriction will therefore not be effective (ITTO, 1993). Finally, although trade provisions may have some desirable effects, they are clearly an inefficient means of environmental protection in this context, because the environmental problems at issue are caused by timber extraction, and not by timber trade as such (Maestad, 1995).

The latter objection is a general, and a valid, criticism against the use of trade policy for environmental purposes. Trade policy is not a first best instrument for environmental regulation unless trade is the direct source of environmental degradation. However, in the case of transborder environmental problems, it is far from obvious that first best policies will ever be implemented. The use of trade measures by the victim countries may be a second best policy alternative (Markusen, 1975; Rauscher, 1991 and Maestad, 1995).

3.6. Alternative Policies to Forest Management

In the last section we discussed the possibilities of forest management through market regulation- restriction on timber and timber products market. In an earlier section, 3.1, it was mentioned that policy makers could also regulate the forest management by introducing the policy directly at forest level. Most of the forests in developing and developed countries are nominally owned by governments and most governments use the royalty, assessed on either a per unit or an ad valorem basis, as the form of payment on timber harvesting contracts. It has been debated whether the implementation of such a policy would increase or reduce deforestation. Deacon (1993) argued that a royalty levied on the volume of timber harvested is effectively a tax on timber harvest. It reduces the mill value of each stem and tends to reduce the number of stems harvested. If the demand for logs is highly elastic, the royalty has little effect on the log price the buyer pays, but lowers the price the harvester receives by roughly the amount of the royalty. The reduction in deforestation caused by the royalty is greatest in this case. Alternatively, if demand is perfectly inelastic, the royalty is passed on to the buyer, leaving unchanged the timber price net of royalty, the harvesting decision, and the extent of deforestation.

Several observers have argued that royalties increase deforestation, contrary to the argument above. Barbier et al. (1991, 1995) claim this is true in Indonesia, Boado (1988) concurs for the Philippines, and Gillis (1988a, 1988b) reaches the same conclusion for Indonesia, Malaysia and Liberia. Their argument centres around the fact that a royalty causes high grading, that is, it eliminates the incentive to remove some stems that would otherwise be harvested. Leaving behind low grade timber increases the area disturbed per unit of timber harvested. Some who argue that royalties cause deforestation (Hyde and Sedjo, 1992 and Vincent, 1990) also claim that such deforestation could be avoided if the royalty were restructured to collect a fraction of the mill value of timber less all costs of harvest.

3.7. Environmental Kuznets Curve

Environmental Kuznets Curve or EKC is increasingly used as a shorthand term to describe the pattern whereby environmental conditions first deteriorate but then improve as development proceeds. According to this notion, environmental trends display an inverted U-shaped pattern when plotted against per capita income. This notion follows Kuznets (1955), who hypothesised that inequality in per capita income initially increases as economic growth proceeds, reaches a peak, and then declines. The transfer of such a notion to the environmental field involves the substitution of some measure of environmental conditions for income inequality. A simple schematic model of an environmental Kuznets curve is shown in Figure 3.3; the horizontal axis represents per capita income, while an indicator of environmental degradation is shown on the vertical axis.

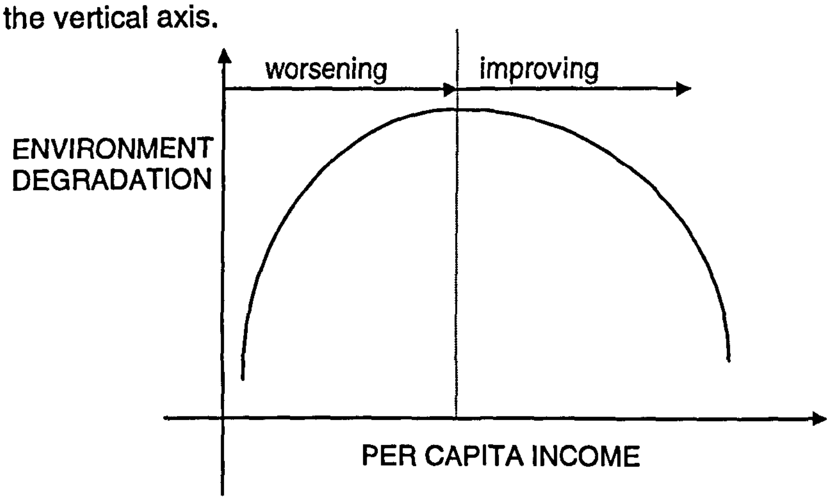


Figure 3.3 Environmental Kuznets Curve.

The notion of a Kuznets-type relationship between 'development' variables and environmental conditions began to attract attention in the early 1990s. Beckerman (1992) contended that while economic growth usually leads to environmental deterioration in its early stages, in the longer term environmental conditions improve as development proceeds. An optimistic stance is also adopted by Easterbrook (1995), who argues that the worst of pollution is now over in the West, and that further environmental improvement may be expected in the future.

Much of the initial work of EKC focused on air pollution emissions. Grossman and Krueger (1995) concluded that for four indicators (relating to air and river quality), economic growth were accompanied by an initial phase of deterioration, followed by a subsequent phase of improvement. They found that the position of the turning points differed for different pollutants, but that in most cases they arrived before a country reached a per capita income of US$8000. Selden and Song (1994) in their study concluded that four major air pollutants exhibited inverted-U relationships with per capita GDP. They proceeded to caution, however, that global emissions would continue to increase over the next few decades, even if a long-term decrease is likely. More recently Roberts and Grimes (1997) confirmed that carbon dioxide emissions per unit GDP have followed an inverted-U trend over the last three decades.

Most of the limited work that has been undertaken in the forest sector has focused on tropical deforestation. Two prominent papers that have investigated this relationship are those Cropper and Griffiths (1994) and Shafik (1994). Cropper and Griffiths (1994) tested a model of a convex upwards (quadratic) relationship between deforestation and per capita GDP for tropical countries experiencing deforestation. They found that there was some evidence for a 'hump-shaped' relationship between per capita income and deforestation in Africa and Latin America (with turning points around US$5000), but not for Asian countries. For Africa, they also found that the turning point is displaced upwards by rural population density. In other words, the turning point is at a higher income level in densely populated countries than in those with sparser populations. They are careful to add a technical/statistical note of caution: most of their data points lie to the left of the peak, and therefore they suggest that it might be more accurate to say that rates of deforestation level off as income increases. Some other work is even less conclusive, Shafik (1994) found that deforestation exhibits a week inverted-U relationship with per capita income but that per capita income has an insignificant effect on deforestation rate.

Recent papers on EKC in deforestation are from Koop and Tole (1999) and Mather et al. (1999). Both of these studies confirm the existence of a Kuznets relationship between deforestation and per capita income in a simple pool regression model. However, instead of using only a simple regression model, Koop and Tole extended their analysis using fixed effects, random effects and random coefficients models. Their results indicate that a significant environmental Kuznets curve exists in a simple pooled regression model but it is gradually lost when the specification is changed. The results show less regularity both in the basic model (per capita income and (per capita income)^2 as independent variables) and in the extended model (change in per capita income, population density and change in population as added explanatory variables).

Mather et al. (1999) raise an issue about the application of Kuznetsian notions to forest trends. Kuznets curves of air pollution, for example by sulphur dioxide, reflect a deterioration, followed by improvement. If applied to deforestation, however, they only indicate changing rates of degradation (assuming that deforestation is regarded as degradation), and not of environmental 'improvement'. If the scope is broadened beyond deforestation to encompass wider change in forest area (including reforestation as well as deforestation), the evidence for Kuznets-type curves becomes more substantial. If annual deforestation rates are taken as an indicator of environmental change, then their trend against income would resemble an inverted U if Kuznetsian notions are valid. A corollary is that a plot of forest area (as opposed to deforestation rates) would resemble a U shape. Thus, both forms of curve can be regarded as indicating Kuznetsian relationships. Some attention has been focused on the fact that forest trends through time have U-shaped characteristics in many developed countries, with the turning point at the base of the U representing a major forest transition (Mather, 1992; Grainger, 1995). Income has, of course, also increased strongly in these countries, and thus by implication a Kuznetsian relationship may exist.

Despite these examples, evidence for the general and widespread existence of EKCs remains limited. In a recent and thorough review, Ekins (1997) concludes that EKCs are less convincing for some environment indicators, for example EKCs of some air pollutants are less convincing compared with other environmental elements. The existence of EKCs relating to deforestation are also less convincing, the results from most of the existing studies were insignificant and not consistent. Thus as a generally applicable notion, the EKC hypothesis can be deemed invalid. Ekin (1997) and Stern et al. (1996) caution that if a Kuznetsian relationship exists, several decades would elapse before turning points were achieved, and extensive environmental damage would occur in the meantime.

Chapter 4

FOREST PRODUCT MODEL AND DEFORESTATION FOR MALAYSIA

This chapter introduces a model of the forest product sector for Malaysia and explains the reason for adopting it. The chapter comprises a section on the general overview of the model and a section on modelling the supply and demand relationship of the model. The modelling section is divided into sub-sections that derive specific demand relationships for each product. The main purpose of the model is to examine the demand and supply of the raw material and intermediate product sectors for major hardwood products in Malaysia. The model differs from previous studies (Kumar 1979, 1986; Vincent 1989, 1992) in two respects. It considers explicitly the competition between rubberwood and hardwood and secondly it models explicitly the natural forest production and rubberwood production. This chapter also highlights deforestation and forest cover relationships that link to the forest product sector.

4.1. Overview of the Model

The model is divided into three main sector products: raw material products sector, intermediate products sector and final processed products sector. The raw material products include hardwood logs, rubberwood and plantation logs. The intermediate wood products are sawnwood, sawn rubberwood, plywood and veneer. The processed wood products are building materials and furniture. These products sectors are shown in Table 4.1.

Table 4.1 Malaysia Forest Products Sector

	Sectors		
	Raw material Products (1)	Intermediate Wood Products (2)	Processed Wood Products (3)
Products	Hardwood (h) Rubberwood (r) Plantation (p)	Sawnwood (s) Sawn rubberwood (sr) Plantation sawnwood (sp) Plywood (pl) Veneer (v)	Building materials Furniture & Joinery Boxes, crates & pallet.

The model developed in this framework will focus on developing a supply and demand relationship for the raw material and intermediate wood products sectors only. Sector 3 is therefore treated as a final goods sector, which influences the demand for intermediate wood products through domestic consumption by the furniture and construction industry. Thus each product in sector 1 and 2 has the following relationship

$$Q^S_{i1} = Q_{i1} + M_{i1} = C_{i2} + X_{i1} = Q^D_{i1} \quad (4.1)$$

$$Q^S_{i2} = Q_{i2} + M_{i2} = C_{i3} + X_{i2} = Q^D_{i2} \quad (4.2)$$

Q^D_{ij} and Q^S_{ij} are the aggregate demand and supply for each product in the two sectors. Q_{ij}, M_{ij} and X_{ij} are the domestic production, imports and exports respectively of each product *i*, in sector *j*. C_{i2} is the domestic consumption of the i^{th} raw material product in the intermediate good sector, whereas C_{i3} is the domestic consumption of the i^{th} intermediate product in the processed sector. The relationships that link together across product and sector could be described by the following diagram (Figure 4.1).

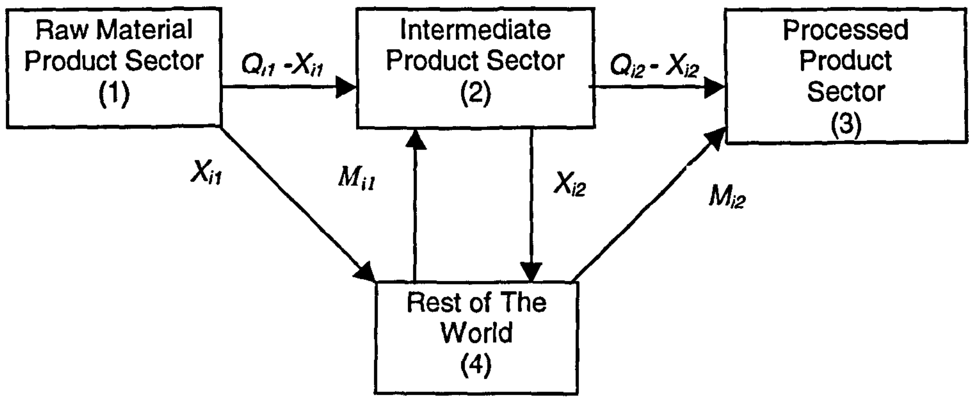


Figure 4.1 Malaysia Forest Products - Sectorial Relationships

The products were selected for each sector based upon their relative importance and their significance for the analysis of this study. This undoubtedly involves some bias in estimates, but given the relatively small size of each product, such bias should be small. In sector 1, only hardwood from the natural forest and rubberwood are chosen. Plantation logs are excluded because the raw material contribution from plantation forest for the proposed period of analysis is very small. Plantation logs are expected to give only a substantial contribution starting after the year 2000 (Hasshim, 1997). Secondly, where the plantation sectors have contributed raw material to the forest-based industries, it is mainly used as an input in the paper products industries and has no significant effect on the current use of hardwood and rubberwood.

Malaysia does import logs, sawntimber, plywood and veneer; however, the amount is very small. This study therefore assumes that the import of raw material products into Malaysia (M_{i1}) is zero. Rubberwood logs need to be processed immediately into intermediate products such as sawn rubberwood. This is because rubberwood logs are susceptible to fungus and insect attack that will reduce their quality. Therefore no rubberwood logs are exported, instead all rubberwood logs are processed domestically.

Consequently, allowing for these assumptions the equation for the product balance relationship for raw materials products becomes:

$$Q^S_{h1} = Q_{h1} = C_{h2} + X_{h1} = Q^D_{h1} \quad (4.3)$$

$$Q^S_{r1} = Q_{r1} = C_{r2} = Q^D_{r1} \quad (4.4)$$

Equation 4.3 implies that production of hardwood (h) from the logging sector is equal to consumption of hardwood in the processes sector plus export. Equation 4.4 implies that rubberwood logs produced are all domestically consumed in processed sector.

In the intermediate wood products, most of the hardwoods are used in the production of sawnwood, plywood and veneer which constitutes an amount more than 70 percent of the total production. The remainder are used in making other wood products such as chipboard and also directly used for making bridges or poles. On the other hand, rubberwood is mostly processed into sawn rubberwood, only a small portion being used for making wood chips and for the inner layer of plywoods. Sawnwood, sawn rubberwood, plywood and veneer are consumed locally as well as exported. Thus, the product balance relationships of intermediate products are:

$$Q^S_{sh2} = Q_{sh2} = C_{sh3} + X_{sh2} = Q^D_{sh2} \quad (4.5)$$

$$Q^S_{sr2} = Q_{sr2} = C_{sr3} + X_{sr2} = Q^D_{sr2} \quad (4.6)$$

$$Q^S_{pl2} = Q_{pl2} = C_{pl3} + X_{pl2} = Q^D_{pl2} \quad (4.7)$$

$$Q^S_{v2} = Q_{v2} = C_{v3} + X_{v2} = Q^D_{v2} \quad (4.8)$$

4.2. Modelling the Demand and Supply Relationship.

This section describes and derives the supply and demand relationships for each product in the model. Equations (4.3) - (4.8) show that there are a total of 17 supply and demand relationships needed to analyse the demand and supply of forest products for Malaysia. The supply relationships are the production of raw material products (Q_{h1} and Q_{r1}) and the production of intermediate wood products

(Q_{sh2}, Q_{sr2}, Q_{pl2} and Q_{v2}). The demand relationships are domestic demand for raw material products (C_{h2} *and* C_{r2}), domestic demand for intermediate wood products (C_{sh3}, C_{sr3}, C_{pl3}, and C_{v3}), and export demand for raw material products and intermediate wood products (X_{h1}, X_{sh2}, X_{sr2}, X_{pl2} and X_{v2}). The specification of each supply and demand relationship is developed in the following section.

4.2.1. Supply Relationships

Hardwood and rubberwood are both natural resources. Modelling the supply relationships of these raw material products depend upon their type of natural resource, either renewable or non-renewable. According to their physical properties, forest and rubberwood trees are renewable resources. However by a relevant adjustment process they are either renewable or non-renewable resources. According to Sweeney (1993), renewable resources adjusted more rapidly so that they are self renewing within the time important for economic decision making. On the other hand if the adjustment speed is so slow that we can think of them as being available once and only once during the available time period, then the resource is non-renewable.

As mentioned earlier, in many tropical countries, forests are government owned. The government allocates the forest land as a concession to a company for logging. However, the concession agreements, the rules and regulations imposed by the government to the concessionaires, provide extremely weak incentives to adopt a long run perspective on their logging activities. The duration of timber concessions is often very short. Poore et al. (1989) found that concessions in Asia were issued for periods of 21 to 25 years, while the minimum realistic felling cycle is 30-35 years and the rotation is 60-70 years. With such a short time horizon, the logging companies cannot be expected to pay much attention to the fact that the forest is a growing resource. Even if their logging operation could be allocated over time within the period of concession, when the trees are used up, it is for such a long time that the possibility of their eventual renewal has no current economic significance to the current owner, and even if the stock is available, further use may not be possible due to concession period restrictions. In such circumstances it is more appropriate to treat the forest harvest problem as a non-renewable resource problem.

In contrast to forest ownership, all rubber plantations in Malaysia are privately owned, either by individuals or by firms. The owners have the option to choose to replant or otherwise, depending upon the opportunities available to them. The rubber trees are cut for replanting at an average of 27 years, that is, when rubber production is no longer economic. This process ensures the continuous availability of rubber and rubberwood from the rubber plantation. Therefore, the rubberwood supply in this study is treated as a renewable resource.

4.2.1.1. Rubberwood Supply

Rubber is the main produce and the primary objective of the rubber plantations. Before 1980, rubberwood logs, which were only available when the rubber trees were cut down during replanting, had not much market value except for fuelwood (see Chapter 2). Thus, before 1980, rubberwood plantations were managed either as a single plantation crop or multiple rotation, depending on the possibility for replacement with palm oil plantation, which gives greater economic return. However, the development of rubberwood industries has changed the situation. A study by the Shahwahid et al. (1995) has shown that at the current market price (RM60/m^3) of rubberwood, the economic return from rubber plantation is better than palm oil plantation. In another development, research by the Forest Research Institute of Malaysia (FRIM) has shown that rubberwood of the younger age of 3-14 years can be used for the manufacture of furniture and other wood products. The use of rubber trees as young as 3 years was found to be suitable for the manufacture of MDF as well. Therefore, rubber plantations with high tree densities could be established on a short rotation basis of 3-5 years to supply to such mills. This development established one of the possibilities in managing the rubber plantation which are discussed in this section.

Considering a traditional decision on rubber replanting, which depends solely on profit maximisation of rubber production, then the revenue function of rubber plantation could be written as:

$$R = \int_{t=0}^{T} \{p^a g(t) - w\} e^{-rt} dt - c \qquad (4.9)$$

where *R* is the value of a rubber plantation, *g(t)* is the volume of rubber in period *t*, *w* is the cost of rubber production in year *t*, *r* is an interest rate and *c* is the cost of planting.

When the rubberwood and rubber of the rubber tree standing stocks are valued, then the owner of the rubber plantation has to respond to the value of rubber as well as rubberwood in choosing the time sequence of a possible replanting programme. The plantation owner now has a set of production possibilities to choose. With multiple objectives, the revenue function for rubber plantation could be specified according to the following formulation:

$$R = \int_{t=0}^{T} \{p^a g(t) - w\} e^{-rt} dt + p^b f(T) e^{-rt} - c \qquad (4.10)$$

where p^b is the rubberwood price, *f(T)* is the quantity of rubberwood at the end of the rotation period (*T*).

Suppose replanting is possible, that is, the return from rubber plantation is more favourable than the return from other commodities or other land use. This offers the potential for the rubber plantation to be managed over an infinite time horizon. Then the return from the rubber plantation could be written as follows:

$$R_\infty = R_1 + e^{-rT} R_2 + e^{-r2T} R_3 + \ldots\ldots. \qquad (4.11)$$

The problem facing the rubber plantation owner is to choose the rotation length, *T*, to maximise (4.11). Equation 4.11 can be simplified as:

$$J = \max_T 1/(1 - e^{-rt}) \{ \int_{t=0}^{T} \{p^a g(t) - w\} e^{-rt} dt + p^b f(T) e^{-rt} - c\} \qquad (4.12)$$

where J can be interpreted as the value of rubber plantation site when the optimal path is followed. Differentiating and setting equal to zero yields:

$$p^b f'(T) - rp^b f(T) + p^a g(T) - w - rJ = 0 \quad (4.13)$$

Equation (4.13) implies that the aggregate supply function of rubberwood , Q_{r1}, is:

$$Q_{r1} = Q_{r1}\,(p^b, w, r, p^a) \quad (4.14)$$

Supposing the relationship is linear, then 4.14 will be:

$$Q_{r1} = u1 + u1^* p^b + u2^* p^a + u3^* w + u4^* r$$

$$\partial Q_{r1}/\partial p^b > 0 \quad \partial Q_{r1}/\partial p^a < 0 \quad \partial Q_{r1}/\partial w > 0 \quad \partial Q_{r1}/\partial r < 0$$

4.2.1.2. Hardwood Supply

The harvest problem for the forest concessionaires in Malaysia could be formulated under two situations: first, the situation where the total harvest cost is independent of the remaining stock of the forest; secondly, the situation where the total harvest costs depend upon remaining stock. The first case could be applicable to the concessionaires of a flat lowland area. The second case could apply to the concessionaires where the harvest is moving from the flat land area to the hillside area. In this case, the total cost does not only depend on the total harvest but is also based upon the physical difficulties of harvesting the remaining stock[1]. This section will focus only on the second case, as it is more relevant to the current situation.

[1] The movement of concession area from flat to hill side increases not only in private cost but also the environmental cost. This is the main reason why the forest harvest system has been changed from the Malaysian Uniform System to the Selective Management System (see section 2.1.2).

Suppose the objective function of concession holders is to maximise the present value of harvest of available forest stock within a given concession area. The harvest problem could be written as:

$$Max\Pi = \sum_{t=1}^{T}\{p^h h_t - C_t(h_t, S_{t-1})\} \tag{4.15}$$

Subject to : $S_t = S_{t-1} - h_t$ for all t

$S_T \geq 0$

$h_t \geq 0$

where p^h is the price of hardwood, h_t is the volume of stock harvested in time t, $C_t(h_t)$ is harvesting cost and S_t is the level of forest stock at time t. From a standard Lagrangean function, denoting the Lagrangean by L, then the problem (4.15) could be converted to the following unconstrained optimisation problem:

$$MaxL = \sum_{t=1}^{T}\{p^h h_t - C_t(h_t, S_{t-1})\}\rho^t - \sum_{t=1}^{T}\{S_t - S_{t-1} - h_t\}\lambda_t + \mu S_t \tag{4.16}$$

where ρ^t is the discount factor, λ is the shadow price of remaining stock and μ is the shadow price of stock at the end of concession period, S_T. Suppose we could write λ_t as $\phi_t\rho^t$, where ϕ is simply the current value of the shadow price of remaining forest stock S_t, then differentiating L with respect to h_t and S_t, would give the first order necessary conditions as:

$$\partial L / \partial h_t = \{p^h - dC_t/dh_t\}\rho^t - \phi\rho^t \tag{4.17}$$

$$\partial L / \partial h_t = 0 \text{ if } h_t > 0 \text{ and } \partial L / \partial h_t < 0 \text{ if } h_t = 0$$

$$\partial L / \partial S_t = -\partial Ct/\partial S_{t-1}\, \rho^t - \phi_{t-1}\rho^{t-1} + \phi_t\rho^t = 0 \qquad \text{for } t<T \tag{4.18}$$

$$\partial L / \partial S_T = -\phi_T\rho^T + \mu = 0 \tag{4.19}$$

$$\mu S_T = 0 \tag{4.20}$$

The above set of equations provides the fundamental first order necessary condition for optimal harvest by the concessionaires as:

$$p^h = dC_t/dh_t - \phi_t \quad \text{if} \quad h_t > 0 \tag{4.21}$$

$$< dC_t/dh_t - \phi_t \quad \text{if} \quad h_t = 0$$

$$\phi_t = \phi_{t-1}/\rho + \partial C_t/\partial S_{t-1} \qquad \text{for } t<T \tag{4.22}$$

$$\phi_T S_T = 0; \qquad \phi_T \geq 0 \qquad S_T \geq 0 \tag{4.23}$$

Equations (4.21), (4.22) and (4.23) collectively define the time paths of the current value of opportunity cost, harvesting, and remaining stock. Equation (4.21) determines harvesting, given ϕ_t. Equation (4.22) is a difference equation governing the evaluation of S_t and of ϕ_t, respectively. Equation (4.23) provides one boundary condition at the final concession period, while the known value of S_0 provides the boundary condition for stock at the initial time. Given $t = T-1$ and the boundary condition $\phi_T = 0$, then the general solution to equation 4.22 is:

$$\phi_t = -\sum_{\tau=t+1}^{T} (\partial C_t / \partial S_{\tau-1}) \rho^{\tau-t}$$

where τ is a time that stock reduction causes a cost change of $-\partial C_\tau / \partial S_{\tau-1}$. This relationship shows that the opportunity cost at time t is simply the present value, discounted to time t, of the future incremental costs accruing as a result of harvesting one more unit of log from the forest (Sweeney, 1993).

One of the issues concerning the forest concessions in Malaysia is the period of concession. The period of concession varies from one year to more than 25 years. These periods are considered too short to interest concessionaires in the maintenance and regeneration of the forest resources. Even for those who have longer concession periods, their harvesting area is controlled by the government.

Whatever the concession area or period, the concessionaires in Malaysia are given a fixed area to harvest per year, either determined by the government or based on application by the concessionaires. The concessionaires have to harvest that particular area within the specified year. Under this condition, we could assume that the opportunity cost of not harvesting or delaying the harvest ($\rho\phi$) is zero. Thus, equation (4.21) becomes:

$$p^h = dC/dh \qquad (4.24)$$

Equation (4.24) gives the harvest as a function of log price and the cost of harvesting subject to concession agreement constraint, such as area (A). Supposing the cost of harvesting could be represented by the cost of labour, w^h, then the following relationship will apply to the aggregate supply of hardwood in Malaysia:

$$Q_{h1} = Q_{h1}(p^h, w^h, A) \qquad (4.25)$$

$$\partial Q_{h1} / \partial p^h > 0 \qquad \partial Q_{h1} / \partial w^h < 0 \qquad \partial Q_{h1} / \partial A > 0$$

4.2.1.3. Supply of intermediate wood products

The fixed proportion structure of log demand suggests a particular specification for the supply equation for sawnwood, plywood and veneer. Following Vincent (1989) the intermediate wood products could be derived as follows.

Assume that a firm manufactures sawnwood or plywood using only log (h), labour (l), and capital (k), and that the firm has a fixed supply of capital. Let p^h be the price of logs, p^s is the price of sawnwood, w^s is wage in sawnwood sector, and r is the cost of capital. Then we can write the firm profit maximisation problem as:

$$\underset{l,h,k}{Max.} \quad \pi = \quad p^s{*}q^s - p^h{*}h - w^s{*}l - r{*}k \qquad (4.26)$$

$$s.t.: q^s = f(h,l,k)$$
$$h = c{*}q^s$$
$$k = \bar{k}$$

where c is the log demand coefficient, that is the quantity of log required to produce a unit of sawnwood. The c value would reflect the efficiency of the sawmill . The smaller the value of c, the more efficient the sawmill, because it requires less log input to produce a unit of sawnwood.

Assume that q^s can be solved as a function of l and k by substituting the second and the third constraints into the first:

$$q^s = g(l,k) \qquad (4.27)$$

If we substitute this expression and constraints into the profit equation (4.26), the firm's problem is reduced to the selection of l:

$$\underset{l}{Max.} \quad \pi = p^s{*}g(l,k) - p^h{*}c{*}g(l,k) - w^s{*}l - r{*}k \qquad (4.28)$$

It follows that the profit maximising condition is:

$$\partial\pi/\partial l = g_l = w^s / (p^s - c^*p^h) \quad (4.29)$$

This result implies that labour demand is a function of net prices divided by the wage rate:

$$l = l[(p^s - c^*p^h)/ w^s] \quad (4.30)$$

Therefore by the equation 4.27, the supply function is:

$$q^s = g ((p^s - c^*p^h)/ w^s, k) \quad (4.31)$$

Suppose the capital is determined by the level of sawnwood processing capacity (*K*), which has expanded rapidly in Malaysia. Suppose equation (4.31) applies to other intermediate wood products, then the aggregate supply of intermediate wood products is:

$$Q_{i2} = Q_{i2} ((p^i - c_i{}^*p^h)/ w^i, K) \quad (4.32)$$

Suppose the relationship is linear then:

$$Q_{sh2} = a1 + a2^*(p^{sh} - c_{sh}{}^*p^h)/ w^{sh} + a3^*K^{sh} \quad (4.33)$$

$$Q_{sr2} = f1 + f2^*(p^{sr} - c_{sr}{}^*p^r)/w^{sr} + \phi 3^*K^{sr} \quad (4.34)$$

$$Q_{pl2} = \kappa_1 + \kappa_2{}^*(p^{pl} - c_{pl}{}^*p^h)/w^l + \kappa_3{}^*K^{pl} \quad (4.35)$$

$$Q_{v2} = \xi 1 + \xi 2^*(p^v - c_v{}^*p^h)/w^v + \xi 3^*K^v \quad (4.36)$$

4.2.2. Demand Relationships

A vital aspect of demand for raw material products and intermediate processed products is that they are both derived demands. The demand for raw material products is derived from the demand for intermediate products, and the demand for intermediate products is derived from the demand for the final processed product.

4.2.2.1. Domestic demand for intermediate wood products

First consider the demand for intermediate wood products. This demand can be divided into two types. The first case applies to the demand for intermediate wood product used in the processed wood products, which has no input substitution.

This case refers to the demand for plywood and veneer used in the production of building raw materials and furniture.

Let x be the aggregate output of a processed wood product industry, that uses an intermediate wood input, z_1, that has no wood or non-wood substitute. However another variable input z_2, is also used in producing x. Denoting p^1 and p^2 as the respective prices of the two inputs, the industry's problem is to minimise the costs, C, of producing x through optimal choice of z_1 and z_2.

Since the choice of z_1 and z_2 determines x are the only two independent decision variables; the firm's problem therefore is:

$$\min C = p^1 z_1 + p^2 z_2$$

$$\text{subject to } x = x(z_1, z_2)$$

The relevant Lagrangean equation is:

$$L = C + \lambda(x - x(z_1, z_2)) \qquad (4.37)$$

where λ is the Lagrangean multiplier.

First-order conditions for cost minimisation are:

$$\lambda\,(\partial x/\partial z_1) = p^1\,, \qquad (4.38)$$

$$\lambda\,(\partial x/\partial z_2) = p^2\,, \text{ and} \qquad (4.39)$$

$$x(z_1, z_2) = x \qquad (4.40)$$

From (4.38) and (4.39) it follows that:

$$(\partial x/\partial z_1)/p^1 = (\partial x/\partial z_2)/p^2 \qquad (4.41)$$

Solving (4.38) - (4.40) yields the optimal input quantities, z_i as a function of input prices and output level:

$$z_1 = z_1(p^1, p^2, x). \qquad (4.42)$$

Following Kumar (1979 and 1986), it is assumed that in Malaysia the aggregate demand for furniture and building materials products is directly related to the expansion of domestic housing capacity. In addition, furniture products in Malaysia are traded goods, and thus output in the industry will be affected by furniture export prices. Thus, denoting y as some indicator of housing capacity and p^f the export furniture price, then the above relationship can be modified to reflect the aggregate derived demand for each intermediate wood product, z_1:

$$z_1 = z_1(p^1,p^2,x(y,p^f)) \qquad (4.43)$$

The second case in the demand for intermediate wood products by the processed wood products sector is the case in which the intermediate wood product has wood and non-wood substitutes. For example sawnwood is substituted by sawn rubberwood in furniture production, bricks and cement are non-wood substitutes for sawnwood in the building material industry.

Thus, equation (4.43) can incorporate these factors. Let us assume that z_3 is a wood substitute, and that z_4 is one or more non-wood substitutes for the intermediate input z_1. Consequently, the above assumption and the new cost minimisation problem yield the following derived input demand relationship:

$$z_1 = z_1\,(p^1,p^2,p^3,p^4,x(y,p^f)), \quad i = 1,\ldots 4 \qquad (4.44)$$

Thus the aggregate domestic demand for intermediate processed wood products of 4.43 and 4.44 could be written generally as:

$$z_i \equiv C_{i2} = C_{i2}\,(p^i,p^j,\, w^j,\, x(y,p^f)) \quad i,j = \text{plywood, veneer, sawnwood, sawn rubberwood for } i \neq j$$

$$\partial\, C_{i2}/\partial p^i < 0 \quad \partial\, C_{i2}/\partial p^j > 0 \qquad \partial\, C_{i2}/\partial w^j < 0$$

Suppose the relationship is linear, then the demands for plywood, veneer, sawnwood and sawn rubberwood are:

$$C_{pl3} = e1 + e2^*p^{pl} + e3^*w^j + e4^*y + e5^*p^f. \qquad (4.45)$$

$$C_{v3} = h1 + h2^*p^v + h3^*w^j + h4^*y + h5^*p^f. \qquad (4.46)$$

$$C_{sh3} = \varphi 1 + \varphi 2^*p^s + \varphi 3^*w^j + \varphi c4^*p^{sr} + \varphi 5^*y + \varphi 6^*p^f \qquad (4.47)$$

$$C_{sr3} = \mu 1 + \mu 2^*p^s + \mu 3^*w^j + \mu 4^*p^{sr} + \mu 5^*y + \mu 6^*p^f \qquad (4.48)$$

4.2.2.2. Domestic Demand for Hardwood and Rubberwood

The demand for hardwood and rubberwood is the total hardwood and rubberwood required for the production of respective intermediate products. Using the log requirement relationship in equation 4.26, then the total hardwood and rubberwood requirement in Malaysia is:

$$C_{h2} = c_{sh}Q_{sh2} + c_{pl}Q_{pl2} + c_vQ_{v2} + DL \quad (4.49)$$

$$C_{r2} = c_{sr}Q_{sr2} + DR \quad (4.50)$$

Where c_{sh}, c_{pl}, c_v and c_{sr} are the log required to produce one unit of each respective product. *DL* and *DR* are residual demand for hardwood and rubberwood logs.

4.2.2.3. Export Demand

Let X_i be the amount of Malaysian wood product i used by an importing country, W_i be the amount of product i used in a particular country during the same period originating from the rest of the world, and Z the amount of all other commodities either wood products other than i or non-wood products used in combination with product i to produce a particular output, Y. Assume that the relationship between output Y and input X, W and Z can be described as:

$$Y = Y(X,W,Z) \quad (4.51)$$

and the associated cost function is:

$$C = p^{ix} * X_i + p^{iw} * W_i + p^z * Z \quad (4.52)$$

where C is the total cost of producing Y while p^x, p^w and p^z are respectively the price of Malaysian forest products of interest in a particular country, the price of the same product originating from other countries, and the price of all other inputs used in producing Y.

Suppose the producers in the importing country choose the input mix which minimises cost, subject to the production relationship (4.51). By the same procedure as the domestic demand, it leads to a factor demand for Malaysian forest products of the form:

$$X_i = X_i(p^{ix},p^{iw},p^{iz},Y) \quad (4.53)$$

$$\partial X_i/\partial p^{ix} < 0 \quad \partial X_i/\partial p^{iw} > 0 \quad \partial X_i/\partial p^{iz} < 0 \quad \partial X_i/\partial Y > 0$$

This form of relationship has been widely used in literature to analyse the export demand relationship of forest products (Kumar, 1979; Chou and Boungiorno, 1983; Cengel and McKillop, 1990; Vincent, 1989; Barbier et al., 1995; and

Manarung and Boungiorno, 1997). Due to data difficulties, most studies used the following specification

$$X_i = X_i(p^{ix}, p^{iw}, I^{xj}) \quad (4.54)$$

where I^{xj} is some form of index, such as industrial production index or per capita income of importing country j of product i.

4.3. Deforestation Relationship

This section provides a deforestation relationship link to the Forest Sector Model. The purpose of this linkage is to investigate the effect of forest sector policy, by the means of timber production on deforestation in Malaysia. Many empirical analyses have been conducted to test the influence of the intermediate causes and underlying causes of deforestation (see Chapter 3). A major difficulty in the development of empirical models stems from the fact that tropical deforestation is a diverse phenomenon. There is a high geographic variability in the forest type, the physical environments, the socio-economic activities and the cultural contexts associated with deforestation. Different model designs will therefore be required for different deforestation processes (Lambin, 1994). Thus, wide ranges of variables have been used in studies to determine the cause of deforestation. Table 4.2 gives a summary of some of the variables used in studies of deforestation.

Table 4.2 Variables Used in Deforestation Studies

Variables	Studies
Agriculture prices	Ruben et al.(1994), Angelsen (1999), Monela (1995), Barbier and Burgess (1996), Deininger and Minten (1999), Elnagheeb and Bromley (1994), Angelsen et al. (1998), Panayotou and Sungsuwan (1994) .
Fertilizer prices	Monela (1995), Holden (1997), Mwanawina and Sankhayan (1996), Barbier and Burgess (1996).
Other agricultural inputs (seeds pesticides, and hand tools)	Ruben et al. (1994), Ozorio de Almeida et al. (1995), Monela (1995).
Credit availibilty	Ozorio de Almeida et al. (1995), Barbier and Burgess (1996), Andersen (1997), Pfaff (1997).
Wages and Off farm employment	Holden (1993), Ruben et al. (1994), Bluffstone (1995), Godoy et al.(1996, 1997), Pichon (1997).
Population density	Andersen (1996), Pfaff (1997), Southgate et al. (1991), Barbier and Burgess (1996), Kummer and Sham (1994), Katila (1995); Cropper et al. (1997).
Population growth	Kimsey (1991), Rock (1996). Burgess (1991), Inman (1993) Cropper and Griffiths (1994) and Palo (1994).
Timber prices	Capistrano (1990), Gullison and Losos (1993), von Amsberg (1994), Barbier et al.(1995), Maestad (1995), Southgate (1990), Deininger and Minten (1999).
Per capita income	Capistrano (1990), Burgess (1993), Krutilla et al. (1995), Barbier and Burgess (1996), Mainardi (1996), Mather (1992), Grainger (1995) ,Panayotou (1993), Cropper and Griffiths (1994), Rock (1996).
External debt	Burgess (1991), Kahn and McDonald (1994), Mainardi (1996), Kant and Redantz (1997),Capistrano (1990), Kimsey (1991), Inman (1993).

Source: Angelson and Kaimowitz (1999).

In this thesis, deforestation is investigated using two types of relationship. The first relationship is between the deforestation rate (DFRATE) and explanatory variables; timber production (MHQ), agriculture productivity (AGR), harvest intensity (INT) and rural population density(RUI). The relationship is:

$$DFRATE \equiv (F_{t-1} - F_t)/F_{t-1} = a_1 + b_1{*}MHQ_t + c_1{*}AGP_t + d_1{*}INT_t + e_1{*}RUI + u_t \quad (4.55)$$

$$\partial(DFRATE)/\partial(MHQ_t) > 0 \qquad \partial(DFRATE)/\partial(AGP_t) < 0$$

$$\partial(DFRATE)/\partial(INT) < 0 \qquad \partial(DFRATE)/\partial(RUI) > 0$$

The above conditions imply that an increase in timber harvest would increase deforestation. Increases in agriculture productivity would reduce deforestation, because increased productivity would reduce the pressure on the government to open new forest land for other alternative use. The above conditions also imply that increases in harvest intensity would reduce deforestation. This is because the extra income collected by the government from each area of concession would also reduce the pressure on the government to give out more concessions for harvest, thus putting less pressure on the government to open new forest land. As discussed in Chapter 3, population pressure is emphasised as an underlying cause of deforestation. Increase in population would increase the demand for arable land, encouraging the conversion of forests to agriculture. Since it is people living in rural areas who turn to agriculture as a means of livelihood, one would expect the forest cover to decrease with an increase in rural population density. Forest cover would also decline due to increased demand for wood, both for timber and for fuelwood.

The second relationship is relating deforestation, $(F_{t-1} - F_t)/F_{t-1}$, to the annual change in explanatory variables of MHQ, AGP, INT and RUI. The reason for the second relationship is that, the forest change may not follow the time trend. Thus the relationship is:

$$DFRATE \equiv (F_{t-1} - F_t)/F_{t-1} = a_1 + b_1{*}CMHQ + c_1{*}CAGP + d_1{*}CINT + e_1{*}CRUI + u_t \quad (4.56)$$

$$\partial (DFRATE)/\partial(CMHQ) > 0 \qquad \partial (DFRATE)/\partial(CAGP) < 0$$

$$\partial (DFRATE)/\partial (CINT) < 0 \qquad \partial (DFRATE)/\partial(CRUI) > 0$$

We would expect the change in explanatory variables to give the same direction of effect on deforestation as given in the first relationship.

To investigate the relationship between deforestation and per capita income (Environmental Kuznets Curve), per capita income (PERCAP) is added to deforestation relationship of equation 5.55. Thus, a new relationship is:

$$DFRATE \equiv (F_{t-1} - F_t)/F_{t-1} = a_2 + b_2{*}MHQ_t + c_2{*}AGP_t + d_2{*}INTt + e_2{*}RUI + f_2{*}\, PERCAP + g_2\,(PERCAP)^2 + v_t \quad (4.57)$$

$$\partial (DFRATE)/\partial (PERCAP) > 0 \qquad \partial (DFRATE)/\partial(PERCAP)^2 < 0$$

4.4. Current Forest Cover

The factors affecting the current level of deforestation, (Ft-1 - Ft)/Ft-1, may also influence the current amount of forest cover, F_t. That is, an expansion in timber production in the current year may affect the current forest area. Thus, a third relationship between the forests and the key explanatory variables of intent in this thesis is:

$$F_t = a + b{*}MHQ_t + c{*}AGP_t + d{*}INT_t + e{*}RUI_t + u_t \quad (4.58)$$

$$\partial (F_t)/\partial (MHQ_t) < 0 \qquad \partial (F_t)/\partial (AGP_t) > 0$$

$$\partial (F_t)/\partial (INT) > 0 \qquad \partial (F_t) = \partial(RUI) < 0$$

Thus, we would expect the explanatory variables to have the same effect on the current forest cover level as on the deforestation rate.

4.5. Summary and Conclusions

This chapter has discussed the demand and supply relationships for the Malaysia forest products. The demand and supply model presented in this study expands the existing model in two ways. First it includes the supply and demand of rubberwood products as a domestic substitute wood supply to natural log and secondly, it models explicitly the natural forest production and rubberwood production. The demand-supply system consists of 17 equations, 11 of which are demand relationships and 6 supply relationships.

This model is a partial equilibrium model of the production, consumption and trade of forest and rubberwood sector. It does not include the whole range of products available in the forest sector. The model includes only four products in the forest sector and two products in the rubberwood sector. The products in the forest sector are sawlog, sawnwood, plywood and veneer. These are the most important products from both the production and export points of view, comprising more than 70% of the total value of output in the sector. The products in the rubberwood sector are rubberwood logs and sawn rubberwood.

This chapter also discussed the deforestation and forest cover relationship and how it links to forest product model.

Malaysian forest is heterogeneous in type and species (see Chapter 2 and 7). Within each logging field for any type of Malaysian forest there are a large number of different tree species and corresponding differences in the tree quality. Due to the heterogeneity of tree species, the analysis of demand and supply by aggregation does not totally reflect the harvest situation, particularly the substitution effect among species. Therefore, an ideal model for the Malaysian Forest sector should take account of the interaction between species not only within Malaysia but also from other tropical countries. Unfortunately, it was not possible to build such a model, due to lack of data for each species.

Chapter 5

STATISTICAL ANALYSIS

The models which were used in this thesis to estimate the supply and demand of the five major sectors: three forest sectors and two rubberwood sectors, the deforestation and forest cover for Malaysia have been developed and described in chapter 4. This chapter provides estimated relationships of this model. The estimation procedure is discussed and the estimated results evaluated in section 5.2. In section 5.2, the notion of an environmental Kuznets curve related to deforestation is also estimated and discussed. This chapter begins with a discussion of the data used for analysis, describes the sources and the nature of the data used in the study and explains some relevant computations

5.1. The Data

Annual data were used to estimate the supply and demand system developed in the previous chapter. The data were collected from various published sources, including existing studies of Malaysia's timber trade (Kumar, 1978 and Vincent, 1989) and FAO forest statistics. An important feature of all the forest product data is the level of aggregation. In all cases, figures for Malaysia data are aggregated over categories, species and grades of wood and products. Log production, consumption and exports are aggregated over three categories of hardwood; heavy hardwood, medium hardwood and light hardwood and softwood. Each category of hardwood consists of at least 5 major species, as reported in official timber statistics supplied by the Malaysian Timber Industry Board, Forestry Department of Peninsular Malaysia, Forestry Department of Sabah, Forestry Department of Sarawak and Ministry of Primary Industry.

Data for royalties are the aggregation of various rates for different species and states. All eleven states in Malaysia impose different rates of royalty. The rate also varies according to species. The average royalty rate was computed as total royalty collected divided by the total log production.

Official figures for home consumption for all forest products were not available; therefore the apparent consumption was used instead. The apparent consumption was calculated by deducting exports from production and adding imports. This method is crude, as it does not take into account stocks, which certainly influence the decision taken by the market agent; the buyer and supplier as it would influence the price of the product. This method is generally used in commodity studies such as those the timber trade (Kumar, 1979; Vincent, 1989 and Barbier et al., 1995).

For prices, in all cases, Malaysian unit values (Malaysian Ringgit) have been used. All prices are average prices. Where the published prices are not available, the price was computed by dividing the total value of export (FOB-value) by the total volume of export. The domestic prices of all Malaysian forest products are assumed to be equal to total average export prices minus the value of tax imposed per unit of particular wood products.

The following data were also calculated for the analysis:

i. Agricultural productivity is calculated by dividing total agriculture production by the total agriculture area. Agriculture production is only confined to the principal crops[1].
ii. Salaries in the processing sectors, sawnwood and plywood are the total wages paid in the particular sector divided by total employment.
iii. The value added is calculated by dividing total value added by the total production.

Variables used for analysis in the following section, together with their definition and unit of measurement are listed in Table 5.1.

---

[1] Rice, cassava, bananas, cocoa beans, coffee, tea, tobacco, coconuts, palm oil, pineapples and rubber.

Table 5.1. Variables Used in Estimation of log, sawnwood, plywood, rubberwood, sawn rubberwood, deforestation and forest cover relationship.

	Dependent Variables
MHC	Apparent domestic log consumption ('000 m^3)
MFOREST	Malaysia forest area
MHQ	Log production ('000 m^3)
MHX	Log export ('000 m^3)
MPVQ	Plywood and veneer production ('000 m^3)
MPVC	Apparent domestic plywood/veneer consumption ('000 m^3)
RWD	Total rubberwood demand ('000 m^3)
RWQ	Total rubberwood production ('000 m^3)
SRC	Apparent sawn rubberwood consumption ('000 m^3)
SRQ	Sawn rubberwood production ('000 m^3)
SRX	Sawn rubberwood export ('000 m^3)
SWC	Apparent domestic sawnwood consumption ('000 m^3)
SWQ	Sawnwood production ('000 m^3)
SWX	Sawnwood Export ('000 m^3)
	Independent Variables
AGP	Agricultural productivity (tons/ha)
CAGP	Change in agricultural productivity
CINT	Change in rural population intensity
CONSTRUC	Total construction expenditure in Malaysia, in Malaysia Ringgit.
D90	Dummy variable for structural change, 1991-1994=1
DFRATE	Deforestation rate, define as ($MFOREST_{t-1}$ - $MFOREST_t$)/ $MFOREST_{t-1}$
EXR	Malaysian Ringgit exchange rate to US dollar
INT	Harvest intensity, measure in m^3 per hectare of harvest
KPC	South Korea per capita income
LEXBAN	Dummy variable for total ban on log export by Peninsular Malaysia, 1985-1994=1
MFOREST	Malaysia forest area
MHP	Average export price of log measure in Malaysia Ringgit per m^3
MPVP	Average export price of plywood and veneer in Malaysia Ringgit per m^3
MRLP	Average price of rubberwood logs in Malaysia.
OECDPC	Per capita income of OECD
PERCAP	Malaysia per capita income
PLUAN	Average price of Luan plywood in US dollars.
PLYMILL	Number of plywood/veneer mill in Malaysia
PVSAL	Average salary in Plywood/Veneer sector
PVTAX	Average export tax of plywood and veneer in Malaysia Ringgit per m^3
r	interest rate in Malaysia
RUBP	Average rubber price in Malaysia.
RUI	Rural population density
SAWMILL	No of sawmills in Malaysia
SAWSAL	Average salary in sawnwood sector
SRP	Average price of sawn rubberwood in Malaysia Ringgit per m^3
SRT	Sawn rubberwood tax in Malaysia Ringgit per m^3
STAX	Average sawnwood tax in Malaysia Ringgit per m^3
SWC	Domestic sawnwood consumption.
SWP	Average export price of sawnwood in Malaysia Ringgit per m^3
SWPNC	Average price of non-coniferous sawnwood in US dollar.
TPNC	Average price of non-coniferous logs from temperate region in US dollars.
VADI	Average value added per unit cost in wood downstream industries.

5.2. Estimation

The relationships in each sector were estimated by the two stage least square (2SLS) estimation technique. The 2SLS estimations were done on a single equation basis, due to differences in the period for which data were available. Multiple linear regression functions were used for estimations, based on the general model developed in Chapter 4. In the case of the plywood sector[2] only, based on data observation, the 'piecewise -linear' regression function was used. The relationships and estimation results for each sector are as follows

5.2.1. Log Sector

Table 5.2 presents the regression results for the log sector. The coefficient for hardwood price and the area harvest for hardwood supply gives the expected economic sign and is significant the 1 percent level. The positive relationship indicates that an increase in the average net price of log would give an incentive to the concessionaires to extract more timber from the concession area. Thus, an increased payment to the government would reduce the harvest. The area harvest is also highly significant, which implies that if the government were to increase the concession area, more timber would be harvested from the forest.

The export relationships result shows a good correlation between export and the explanatory variables. All variables give the expected sign and are significant at the 1 percent level. Malaysian export is inversely related to its own price and positively related to the price of non-conifer logs from temperate regions. This shows that Malaysian timber is substituted in the export market. Thus, a competitive price is important for Malaysian logs in the export market.

The main importers of Malaysian logs are OECD countries, where Japan is the biggest importer (see Chapter 2). The results also show that the performance of OECD is an

[2] Plywood in this analysis includes veneer. Separate analysis of plywood and veneer is not possible because no separate data is available on log conversion rate of these products. Plywood and veneer are produced within the same mills.

important factor determining the export demand for Malaysian logs. Increase in the per capita income of OECD would increase the demand for Malaysian logs.

Table 5.2 Estimated Relationship of Log Sector.

MHQ = -11542.78 + 106.63 (MHP - ROY) + 43.56 MARLOG
(-2.286)** (5.446*** (6.837)***
R^2 (Adj) = 0.71876 DW= 0.941 F=31.668*** PERIOD= 1970 -1994

MHX = -68677.71 - 365.53 MHP/EXR + 199.95 TPNC + 5.96 OECDPC - 7935.48 LEXBAN
(-3.371) (-4.128) (6.100) (3.393) (-1.934)
R^2 (Adj) = 0.73580 DW= 1.315 F=17.714*** PERIOD = 1970 -1994

Identity
MHC = SWQ * c_{sh} + MPVQ * c_{pl} + LD
MHQ = MHX + MHC
where,
SWQ * c_{sh} = Log requirement for production of sawnwood (SWQ) where c_{sh} is a conversion rate that is the log require to produce a unit of sawnwood;
MPVQ * c_{pl} = log requirement for production of plywood and veneer (MPVQ) where c_{pl} is a conversion rate that is the log required to produce a unit of plywood; and
LD is = Log requirement in other industries.

Notes: The numbers in parentheses are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

The total export ban imposed by Peninsular Malaysia on log export has reduced total log export from Malaysia. The dummy variable used to represent the period of the export ban starting from 1985 gave the expected result, significant at the one percent level. The total export ban from Peninsular Malaysia, however, shifts the export to East Malaysia. Thus the total reduction from Malaysia is less than the total export of Peninsular Malaysia before the export ban (see Chapter 2).

5.2.2. Sawnwood Sector

Table 5.3 gives the regression results for the sawnwood sector. Sawnwood production has a positive relationship with the profit factor. An increase in the profit factor would increase sawnwood production. Changes in profit factor are not only due to endogenous changes, price of sawnwood and price of log, but also due to change in exogenous factors, the recovery rate and salary.

Production capacity is another important factor determining production. It was previously reported that the Malaysian sawnwood sector is over capacity (Shahwahid, 1994). However, this result shows that an increase in capacity due to an increase in the number of sawmills has contributed to an increase in production. The Malaysian government has imposed a new policy to restrict the issue of new licences, with the objective of improving capacity utilisation from the existing mills and eliminating inefficient production from new mills.

Sawnwood exports depend on the performance of importing countries. The relationship shows that an increase in OECD per capita income would increase the demand for Malaysian sawnwood. The price of Malaysian sawnwood relative to the price of sawn hardwood from temperate regions is another important variable explaining the export demand for Malaysian sawnwood. The coefficient of relative price is negative, indicating that Malaysian sawnwood is substituted by other sawnwood producers. Thus, a competitive price is necessary to keep Malaysian sawnwood in the international market.

Table 5.3 Estimated Relationship of Sawnwood Sector

SWQ =	-1231.73	+ 58282.166 ((SWP-STAX) - c_{sh}*MHP))/SAWSAL		+ 6.884 SAWMILL
	(-0.657)	(1.823)*		(4.088)***
R^2 (Adj) =	0.38818	DW = 0.92	F=7.212	Period = 1970 - 1994
SWX =	-1432.660	- 2969.176 (SWP/ EXR* SWPNC)	+ 0.467 OECDPC	
	(-.684)	(-2.220)**	(5.929)***	
R^2 (Adj) =	0.79090	DW=1.45	F= 41.67	Period = 1970 - 1994
SWC =	2173.988	- 1.635(SWP-STAX)	- 1153.634 VADI	+ 0.885 CONSTRUC
	(5.372)***	(-1.306)	(-1.530)	(3.774)***
R^2 (Adj) =	0.67663	DW = 1.614	F = 20.92	Period = 1970 - 1994

Notes: The numbers in parentheses are t-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

All explanatory variables in domestic consumption relationships give the expected sign except the coefficient for value added. Construction expenditure is the variable that last explains domestic consumption behaviour. The coefficient of construction expenditure is positive and significant at the one percent level. More than 55 per cent of domestic consumption of sawnwood is from the construction sector. Thus, an increase in construction activities would lead to a significant increase in sawnwood demand in Malaysia.

The domestic price of sawnwood is negatively related to domestic demand. Value added of downstream industries is negatively related to the sawnwood consumption. This relationship was expected to be positive, because it was expected that increase in profit in wood downstream industries would cause the producers in downstream industries to increase production and thus more sawnwood would be demanded. However, the negative sign might reflect the efficient use of raw material, where less material is needed to produce one unit of downstream products.

To investigate the effect of sawn rubberwood on sawnwood demand, the sawn rubberwood price was added as another explanatory variable in the export demand and domestic demand relationship of sawnwood. In both regression results, the domestic and export demand, the estimated coefficient of sawn rubberwood price is not a good estimator of the relationships. The relative price in the export demand gives the wrong sign and is not significant. The coefficient for sawn rubberwood price in domestic consumption is negative, indicating the existence of complementary products to sawnwood; the sign is not consistent with the results in the sawn rubberwood markets, where sawnwood is a substitute product. The results of the analysis are shown in Table 5.4.

Table 5.4. Estimated Relationship of Export and Domestic Consumption with Sawn Rubberwood Price as another Explanatory Variable.

SWX = -1551.82 - 2854.2(SWP/ EXR* SWPNC) + 272.21 (SRP/ EXR* SWPNC)
(-0.345) (-1.643)* (0.674)
+ 0.444 OECDPC
(2.433)**
R^2 (Adj) = 0.75129 DW= 1.75 F= 4.38** PERIOD = 1979 - 1994

SWC = 2274.221 - 1.19 (SWP-STAX) - 0.815 (SRP-SRT) - 1434.896 VADI
(3.910)*** (-1.029) (-0.516) (-1.689)*
+ 868.13 CONSTRUC
(3.639)***
R^2 (Adj) = 0.60195 DW= 1.14 F= 4.52** PERIOD = 1979 - 1994.

Notes: The numbers in parentheses are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

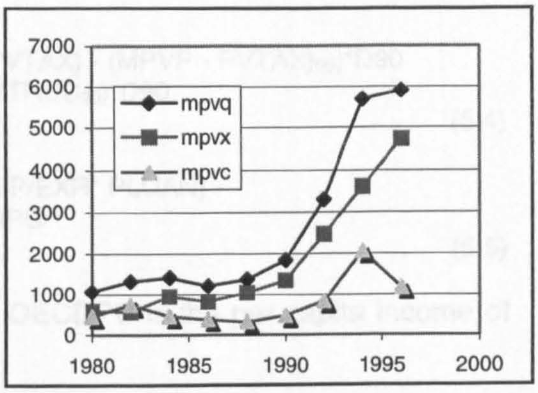
Interestingly, OECDPC and construction coefficients consistently give the right sign and are significant in explaining the export and domestic consumption behaviour of sawnwood. This seems to indicate that, *ceteris paribus*, the OECD and construction are the important factors influencing export demand and domestic demand.

5.2.3. Plywood sector.

The production, export and consumption trend of Malaysia plywood is presented graphically in Figure 5.1. By examining the trend of production, export and consumption, it shows that the relationship can be divided into two segments.. The first segment is prior to the year 1990. The second segment started with the year 1990. The slope of the second segment is steeper than that of the first segment. The change in slope occurred when Peninsular Malaysia imposed export tax on sawnwood in late 1990 and is also influenced by the heavy investment in this sector by Sabah and Sarawak from the year 1990.

Figure 5.1 Production, Export and Consumption of Plywood, 1980 - 1996.

Year	Production (mpvq)	Export (mpvx)	Consumption (mpvc)
1980	1076.00	600.60	475.40
1982	1336.00	578.20	757.80
1984	1425.00	956.00	469.00
1986	1226.00	827.30	398.70
1988	1375.00	1044.10	330.90
1990	1843.00	1349.20	493.80
1992	3300.00	2468.54	831.46
1994	5680.00	3616.60	2063.40
1996	5900.00	4717.70	1182.30



To capture the effect for both segments, a 'piecewise-linear' regression function is used to approximate the relationship between production, export and consumption of plywood, with their respective explanatory variables.

Following Gujarati(1995), the 'piecewise-linear' regression function for plywood production is:

$$\begin{aligned} MPVQ = {} & k1 + k2 \text{*}((MPVP - PVTAX) - c_{pl}\text{*}MHP)/PVSAL \\ & + k3\{((MPVP - PVTAX) - c_{pl}\text{*}MHP)/PVSAL - (((MPVP - PVTAX) - c_{pl}\text{*}MHP)/PVSAL)_{90}\}\text{*}D90 \\ & + k4\text{*} PLYMILL + k5\text{*} (PLYMILL - PLYMILL_{90})\text{*}D90. \end{aligned} \quad (5.1)$$

The first and the third variables on the right hand side of equation 5.1 explain the production of plywood if there were no changes in the slope of coefficients. The second and the fourth variables are to explain if there is a change in the slope of coefficient. If there are no slope changes in the explanatory variables, the function reduces to:

$$MPVQ = k1 + k2 \text{*}((MPVP - PVTAX) - c_{pl}\text{*}MHP)/PVSAL + k4\text{*} PLYMILL \quad (5.2)$$

However, if there are slope changes in both variables then the true relationship of the plywood production function is as in equation 5.1. Re-arranging this equation would give the following relationship:

$$\begin{aligned} MPVQ = {} & k1 - k3((MPVP - PVTAX) - c_{pl}\text{*}MHP)/PVSAL)_{90} - k5\text{*} PLYMILL_{90} \\ & + (k2+k3)\text{*}((MPVP - PVTAX) - c_{pl}\text{*}MHP)/PVSAL + (k4+k5)\text{*} PLYMILL \end{aligned} \quad (5.3)$$

The first three terms on the right hand side are the new intercept, (k2+k3) is the new slope of the profit factor and (k4+k5) is the new slope of plymill.

Similarly a 'piecewise-linear' regression function for consumption and export would be specified as follows:

$$MPVC = e1 + e2^{*} (MPVP - PVTAX) + e3\{(MPVP - PVTAX) - (MPVP - PVTAX)_{90}\}^{*}D90 + e4^{*}CONSTRUC + e5(CONSTRUC - CONSTRUC_{90})^{*}D90 + e6^{*} VADI + e7 (VADI - VADI_{90})^{*}D90 \quad (5.4)$$

$$MPVX = d1 + d2^{*} (MPVP/EXR^{*} PLUAN) + d3^{*} \{ (MPVP/EXR^{*} PLUAN) - (MPVP/EXR^{*}PLUAN)_{90}\}^{*}D90 + d4^{*} OECDPC + d5^{*} (OECDPC - OECDPC_{90})^{*}D90 \quad (5.5)$$

where PLUAN is the price of luan plywood and OECDPC is the per capita income of OECD countries.

Two estimations were made of plywood sector relationship. The first estimation was made for the data from 1970 to 1990 using the multiple regression function. The second estimation was made for the data from 1970 to 1994 using the 'piecewise-linear' regression function.

The regression results for the period 1970 to 1990 are presented in Table 5.5. The results give the right sign for all explanatory variables, except for value added in domestic consumption. The profit factor appears to be a good estimator to plywood production. The profit factor gives a positive significant relationship. Given the price of log and salary in the plywood sector, this result might indicate the importance of efficiency in the production of plywood. The number of mills as a proxy for capacity of production is highly significant and the best variable in explaining the relationship. Increase in the number of mills would increase production. Under the current situation, where the Malaysian plywood industry has excess production capacity, the approval of a new licence would create more competition for logs .

Table 5.5 Estimated Relationship of Plywood Sector, 1970-1990

$$MPVQ = \underset{(-5.260)^{***}}{-898.3} + \underset{(1.501)^{**}}{4329.54}*((MPVP - PVTAX) - c_{pl}*MHP)/PVSAL + \underset{(18.967)^{***}}{36.74}\ PLYMILL$$

R^2 (Adj) = 0.93802 DW =1.092 F=159.62*** Period = 1970-1990

$$MPVC = \underset{(1.934)^{**}}{257.69} - \underset{(-1.170)}{0.299}\ MPVP + \underset{(4.920)^{***}}{0.255}\ CONSTRUC - \underset{(-2.049)^{**}}{434.13}\ VADI$$

R^2(Adj) = 0.65083 DW = 1.138 F= 19.92 Period = 1970-1990

$$MPVX = \underset{(-2.030)^{**}}{-1021.25} - \underset{(-1.465)^{*}}{555.88}*(MPVP/EXR*PLUAN) + \underset{(8.110)^{***}}{0.147}\ OECDPC$$

R^2 (Adj) = 0.83654 DW=1.326 F= 24.52*** Period = 1970-1990

Notes: The numbers in parentheses are t-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

For plywood export, it seems that the OECD per capita income is the factor that best explains the variation. Thus, export is dependent on the income performance of the importing countries. An increase in per capita income in OECD would increase the demand for Malaysian plywood. The relative price of Malaysian plywood against the world price of luan plywood gives a negative coefficient. This implies that Malaysian plywood is a substitute for other plywood produced by other exporting countries. Thus, the relative price is very important if Malaysian producers want to expand and increase their market share.

The result also indicates that the construction expenditure is the best explanatory variable for the domestic demand relationship for plywood. The variable gives the right sign and is significant at the 1 percent level.

The regression results, using 'Piecewise Function', for the period 1970 to 1994 are presented in Table 5.6. The number of plymills gives a similar result as in the previous estimation; it is the most influential variable explaining plywood production variations. The variable gives the expected sign, positive, and is highly significant. The result also indicates that the slope coefficient of plywood changed after the year 1990. That is, more plywood is produced per unit of plymill. This change could be a shift of production from sawntimber to plywood. Historical figures show that the total production of sawntimber in Malaysia decreased from 9.15 million m^3 in 1990 to 8.25 million m^3 in

1994. In contrast, the total plywood production increased from 1.49 million m^3 in 1990 to 3.56 million m^3 in 1994.

The profit factor coefficient gives the wrong sign; however, the second term of the profit factor gives the correct sign and is highly significant, which indicates that there is a change in the slope of coefficient. The overall effect of the profit factor on plywood production for the period after 1990 is positive.

Table 5.6 Estimation Results for Plywood Sector, 'Piecewise Function', 1970-1994.

$$
\begin{aligned}
MPVQ = {} & \underset{(0.636)}{178.759} - \underset{(-1.282)}{2301.51}*((MPVP - PVTAX) - c_{pl}*MHP)/PVSAL \\
& + \underset{(3.119)^{***}}{39117.8}*\{((MPVP - PVTAX) - c_{pl}*MHP)/PVSAL - (((MPVP - PVTAX) - c_{pl}*MHP)/PVSAL)_{90}\}*D90 \\
& + \underset{(7.381)^{*}}{21.90}*PLYMILL + \underset{(5.257)^{***}}{28.02}*(PLYMILL - PLYMILL_{90})*D90 \\
& R^2=0.9859 \qquad DW=0.815 \qquad F=422.99^{***}
\end{aligned}
$$

$$
\begin{aligned}
MPVC = {} & \underset{(2.167)}{261.32} - \underset{(-1.369)}{0.303}*(MPVP - PVTAX) + \underset{(4.738)^{***}}{2.849}\{(MPVP - PVTAX) - (MPVP - PVTAX)90\}*D90 \\
& + \underset{(5.161)^{***}}{0.254}*CONSTRUC + \underset{(1.828)^{**}}{0.225}(CONSTRUC - CONSTRUC_{90})*D90 \\
& - \underset{(-2.161)^{**}}{433.912}\,VADI + \underset{(0.976)}{2009.27}(VADI - VADI_{90})*D90 \\
& R^2 = 0.9537 \qquad DW=1.448 \qquad F=83.456^{***}
\end{aligned}
$$

$$
\begin{aligned}
MPVX = {} & \underset{(-6.753)^{***}}{-1776.65} + \underset{(4.186)^{***}}{11106.79}*(MPVP/EXR*PLUAN) \\
& + \underset{(-3.773)^{***}}{5290.316}*\{(MPVP/EXR*PLUAN) - (MPVP/EXR*PLUAN)_{90}\}*D90 \\
& + \underset{(9.498)^{***}}{0.167}\,OECDPC + \underset{(4.115)^{***}}{1.907}(OECD - OECD90)*D90 \\
& R^2= 0.9748 \qquad DW=1.813 \qquad F=125.39^{***}
\end{aligned}
$$

Notes: The numbers in parentheses are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

For plywood export, it seems that per capita income of OECD, again, is the most influential factor. The result indicates that an increase in per capita income in OECD would increase the demand for plywood from Malaysia. The second variable of OECD per capita income also gives the expected sign and is highly significant. The relative price of Malaysian plywood against world price of luan plywood gives the wrong sign in both terms, but the coefficient is highly significant. One possible explanation of this is a market expansion from Malaysia producers. Thus, a market shift from this expansion indicates a positive relationship to price.

In domestic consumption, as in the previous estimation, the result indicates that construction expenditure is the best variable explaining the relationship. The variable gives the right sign and is significant at the 1 percent level. This variable also shows a change in slope after the year 1990. As expected, the price variable is negatively related to domestic consumption, which is to say that an increase in price would reduce demand. These variables indicate a change in slope but the sign of the coefficient is positive, causing a positive net effect for the period after 1990. Value added consistently gives a negative relationship to consumption, as in other wood markets discussed earlier in this analysis. The coefficient of the variable is also highly significant, but the structural coefficient is not significant indicates that there is no structural change with respect to value added.

5.2.4. Rubberwood Sector

Table 5.7 shows the regression results of the rubberwood sector. The price of rubberwood coefficient is positive and significant at the 1 percent level. This shows that the rubber planters are responding positively to the price of rubberwood which implies that more rubberwood will be supplied to the market if there is an increase in the price of rubberwood. The coefficient of rubber price is negative. This negative coefficient could imply that if the rubber price were to increase, the rubber producers would delay their rubber replanting and continue the rubber production. However, this variable is not significant. The cost of replanting seems to be an important variable influencing the planters' decision to cut the rubber trees. Interest rate as a variable to represent the cost has a negative coefficient. The negative response to interest rate seems to indicate that an increase in cost would delay replanting of rubber trees. That is, it is more profitable for the rubber owner to continue rubber production, rather than cut the trees for rubberwood.

Table 5.7 Estimation results for rubberwood logs.

$$RWQ = 590 + 418.8\,MRLP - 642.82\,RUBP - 130.44\,R$$
(0.708) (2.624)** (-0.204) (-1.852)*

R^2 (Adj) = 0.4786 DW=1.318 F= 6.864*** PERIOD=1981 -1994.

$$RWD = 271.67 + 2.207SRQ$$
(1.157) (3.345)***

R^2 (Adj) = 0.4786 DW=1.318 F= 6.864*** PERIOD=1981 -1994.

Notes: The numbers in parentheses are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively

A possible explanation of the non-significance of rubber price is to do with the problem of marketing rubberwood, as reported by Sahwahid et al. (1993). The data on rubberwood are only based on reports by the millers, which means those who supply the market. A lot more could be left on the field because of location. Even if replanting takes place due to price change, to bring rubber log to the market is not feasible, because of the high cost involved.

On the demand side, the regression results in Table 5.7 show that the sawn rubberwood production is a good estimator in explaining the demand for rubberwood. The sawn rubberwood coefficient is positive and significant at 1 percent. The value of the coefficient is 2.7, which implies that for every m^3 production of sawn rubberwood, the sawn rubberwood producer would demand 2.7 m^3 of rubberwood. This sawn rubberwood production is at a recovery rate of around 37 percent. The recovery rate by this statistical method is within a range comparable to the findings based on the field survey. Shahwahid et al. (1993) reported that, on average, the sawmills in Peninsular Malaysia are able to convert up to 39 percent of green sawnwood[3], Lopez (1980) reported a recovery rate up to 46 percent and Gan et al. (1987) reported a recovery rate of 32 percent.

[3] Green sawn rubberwood means the actual volume of sawn rubberwood measured soon after the sawing process. This wood still need to be processed further and the volume may be reduced due to shrinkage during drying and removal of minor defects.

5.2.5. Sawn Rubberwood Sector

Table 5.8 shows the regression results for the sawn rubberwood sector. Sawn rubberwood, again, as in other production equations, has a positive relationship with the profit factor. Increase in the profit factor would increase sawn rubberwood production. Exogenous variables, conversion rate and salary, therefore, are important in influencing the sawn rubberwood production.

For domestic consumption, the domestic price coefficient is negative, indicating a normal downward slope of demand. The sawn rubberwood consumption would decrease if the price of sawn rubberwood increased. The coefficient for the price of sawnwood is positive, giving an indication that it is a substitute raw material for sawn rubberwood. More importantly, the sawnwood price is significant at the 1 percent level. However, this result is not consistent with the results estimated for the sawnwood sector, which makes sawn rubberwood and sawnwood complement any raw material products; the sawn rubberwood price is not significant in the sawnwood analysis.

Table 5.8 Estimation Relationship of Sawn Rubberwood Sector, 1983 - 1994.

SRQ = -6835.79	+ 938.96 ((SRP -SRT) - c_{sh}*MRLP)/SAWSAL		+ 9.92 SAWMILPM	
(-3.656)***	(1.472)		(4.018)***	
R^2 (Adj) = 0.6704	DW = 1.397	F=12.191***	PERIOD=1983-1994	
SRC = 1183396.11	- 1868.85(SRP-SRT)	+ 692.23 (SWP-SWT)	- 1275277.18 VADI	
(1.224)	(-1.486)	(4.673)***	(-1.382)	
R^2 (Adj) = 0.8651	DW = 1.992	F=24.514***	PERIOD = 1983-1994	
SRX = 72.33	- 192.16(SRP/EXR*SWPNC)	+ 108.66SWP/EXR*SWPNC	+ 181.25KPC90	
(0.464)	(2.280)**	(0.588)	(1.809)*	
R^2 (Adj) = 0.2072	DW=1.012	F=2.307	PERIOD = 1983-1994	

Notes: The numbers in parentheses are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

Sawn rubberwood is only a small portion of total sawnwood produced in Malaysia. Most of the production is in Peninsular Malaysia. The total production in 1994 is about 5 per cent of Malaysia sawnwood production or about 10 per cent of Peninsular Malaysia sawnwood production. The magnitude of change of sawn rubberwood consumption due to change in sawnwood price is far bigger than the magnitude of change of sawnwood due to changes in sawn rubberwood price, because the ability of natural hardwood species to substitute for sawn rubberwood is bigger than the ability of rubberwood to substitute natural hardwood species. This could explain why the results in the sawn rubberwood analysis are more favourable than the results in the sawnwood analysis, that is, sawnwood price gives the expected sign in sawn rubberwood consumption but sawn rubberwood price does not give the expected sign in sawnwood consumption function.

In the export market, South Korea per capita is the most significant variable explaining the export relationship. Sawn rubberwood price also gives the expected sign and is significant at the 5 per cent level. Sawnwood price gives the right sign but is not significant.

5.2.6. Deforestation

Two relationships were estimated to describe the change in forest cover in Malaysia. The first relationship is the relationship between deforestation and the key explanatory variables identified in section 4.3. The second is the relationship between deforestation and change in explanatory variables. The reason for performing these two different forms of estimation is to find which relationship best describes deforestation in Malaysia. The best relationships are used in policy simulation in Chapter 6. Table 5.9 shows the estimation results.

Table 5.9 Estimated Relationship of Deforestation for the Period 1970-1994.

$$DFRATE = \underset{(-.230)}{-0.0379} + \underset{(0.908)}{0.819 \times 10^{-6}} MHQ + \underset{(-1.161)}{1.322 \times 10^{-5}} AGP + \underset{(0.261)}{5.69 \times 10^{-5}} INT + \underset{(0.352)}{2.942} RUI$$

R^2 (Adj) = -0.66 D-W= 2.465 F=0.673

$$DFRATE = \underset{(1.727)^{*}}{0.0353} + \underset{(0.283)}{2.43 \times 10^{-7}} CMHQ + \underset{(2.738)^{***}}{3.370 \times 10^{-5}} CAGP - \underset{(0.333)}{1.831 \times 10^{-5}} INT - \underset{(0.993)}{72.34} RUI$$

R^2 (Adj) = 0.155 D-W=2.073 F = 1.966

Notes: The numbers in parentheses are *t*-statistics. One and three asterisks indicate significance at 10 and 1 percent level respectively.

The results show that only two of the explanatory variables, forest harvest (MHQ) and rural population density (RUI), in the first relationship give the expected sign, as described in section 4.3. Forest harvest and rural population density are both positive, which indicates that increase in these variables would increase deforestation, but these variables are not statistically significant. All explanatory variables poorly describe the deforestation relationship. This is indicated by the very poor coefficient of determination, negative R^2 (Adj), and very low and non-significant *F*-statistic value. In the second relationship, only forest harvest gives the expected sign but, again , is not significant.

In both relationships above, agriculture productivity shows a positive relationship with deforestation rate, which is to say, a positive change in agriculture productivity would increase deforestation rate. This explanatory variable is the best variable, in both relationships, for explaining deforestation in Malaysia. These results do not support the hypothesis in this thesis that increased agriculture productivity would reduce the pressure to open new forest area, thus reducing the rate of deforestation. However, it is important to note that this variable is the only variable that significantly describes the relationship at the 1 percent level. This result seems to agree with the studies by Barbier and Burgess (1996) for Mexico and Panayotou and Sungsawan (1994) for Thailand, which found that increase in agriculture income, which would undoubtedly result from increase in agricultural productivity or agricultural price, would cause forest to be cleared for agriculture.

5.2.7. Current Forest Cover

Because the above two deforestation rate regressions did not display high explanatory power, the third relationship between the current level of forest cover, F_t , and the independent variables, which was suggested in section 4.4, was also estimated. Table 5.10 shows the regression results.

Table 5.10 Current Forest Cover Relationship

MFOREST = 27792.558 -	0.0399 MHQ +	0.607 AGP +	3.011 INT -	$1.4 X10^5$ RUI	
	(7.096)***	(-1.860)*	(-2.242)**	(.582)	(-0.745)

R^2 (Adj) =0.919   D-W=2.14   F=60.738***

Notes: The numbers in parentheses are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

The result shows that all the variables give the expected sign, except for agricultural productivity. Increase in forest harvest, agriculture productivity and population intensity would reduce the forest cover but increase in harvest intensity would improve the forest cover. Only forest harvest and agriculture productivity are statistically significant at 10 and 5 percent respectively. The regression has high explanatory power with a R^2(Adj) of 0.919, and the value of the *F*-statistic of the relationship is significant at the 1 percent level. Based on the explanatory power of the above regression, and the significance of variables, the current forest cover relationship is selected for use in policy analysis in Chapter 6, in preference to the deforestation regressions of Table 5.8.

5.2.8. Environmental Kuznet Curve

Two equations were estimated to investigate the relationship between rate of deforestation and per capita income in Malaysia. The first equation is the basic relationship, that is, only per capita income is used as an explanatory variable. The second equation is the extended relationship, which includes the other variables that were used to determine the deforestation relationship in section 5.2.6. The results of the analysis were as in Table 5.11.

Table 5.11 Rate of deforestation and per capita income relationship.

Basic relationship

$$DFRATE = 0.0231 - 2.615 X 10\text{-}6 PERCAP_{90} - 4.192 X 10\text{-}11 (PERCAP_{90})^2$$
$$(0.396) \quad (0.101) \quad (0.015)$$

R^2 (Adj) = -0.057   D-W = 2.505   F=0.438

Extended relationship.

$$DFRATE = -0.318 + 4.495 X 10^{-7} MHQ + 3.33 X 10^{-5} AGP + 1.30 X 10^{-4} INT + 8.947 RUI$$
$$(-0.834) \quad (-0.301) \quad (-1.509) \quad (0.551) \quad (0.633)$$

$$+ 8.39 X 10^{-5} PERCAP_{90} - 6.538 X 10^{-9}(PERCAP_{90})^{2\cdot}$$
$$(1.075) \quad (-1.011)$$

R^2(Adj)=-0.121   D-W = 2.556   F=0.623

Notes: The numbers in parentheses are *t*-statistics.
$PERCAP_{90}$ = Per capita income in 1990 base year.

The results for the basic relationship do not suggest the existence of a Kuznets relationship between deforestation and per capita income. Although the extended relationship gives the right sign to indicate the existence of a Kuznets relationship, the variable is not statistically significant and the explanatory power is very poor, the R^2(Adj) being very small and negative. Similar to the results in section 5.2.6, agricultural productivity, again, is the best variable to describe deforestation in Malaysia.

5.3. Summary and Conclusion.

Most of the explanatory variables used in the Malaysian forest product model seem to give the right sign as expected and described in chapter 4, though some variables are less significant than others. However, some poor estimations are expected, because of the level of aggregation of data highly of data between three distinct producing regions in Malaysia, Peninsular Malaysia, Sabah and Sarawak. The price variable in the domestic consumption relationship, for example, is less significant than in the export and production relationships. This could be due to the fact that Peninsular Malaysia has a strong domestic demand compared to Sabah and Sarawak, which, would give a different domestic price structure. The average export price used in this analysis thus hides those differences.

The poor results on deforestation are also not surprising, due to the poor data on forest cover. Most of the annual data available are estimated data, since forest surveys are only done at intervals of 10 years. The data are also very poor at capturing important differences between types of forest. There are number of serious controversies concerning the data on forest cover (for a discussion, see Allen and Barnes 1985).

The ideal situation would be to analyse the demand and supply for each region separately. A complete set of data is, however, not available for this purpose. The other possible solution to this problem is to study only the more extensive and more reliable data available, that is the data for Peninsular Malaysia. This is a widely used approach to study of Malaysian forest policy, being adopted by, for example, Vincent (1989 and 1992), Shahwahid (1993) and Lokman (1978).

Generally, the statistical results produced in this chapter are good and sufficient to provide a good basis for policy simulation in the following chapter, Chapter 6.

Chapter 6

POLICY ANALYSIS

The model of the forest sector described in the last chapter consists of a set of equations which have been specified and estimated independently of each other. Taken one at a time, these equations are of limited use for forecasting and describing the behaviour of the Malaysia forest sector. In order to analyse the sector it is necessary to take into account the simultaneous interaction of supply and demand on the whole forest and rubberwood sector, i.e., to view the sector as a complete system. This is done by simulating the model as a whole, i.e., by solving as a simultaneous system the set of equations that comprises the model.

The objective of this chapter is to simulate and evaluate the effect of different policy instruments using this simultaneous system. The instruments used were trade policies and alternative policies. The trade policy instruments were export tax, export ban and import ban. The alternative policy instruments were royalty on forest harvest, wood utilisation efficiency, concession area, subsidies and exchange rate policy. All these alternative policy variables are exogenous in the model discussed in chapter 5.

The simulations were performed on the forest sector, rubberwood sector and forest-rubberwood sector. To simulate and evaluate the effect of different policy measures, the estimated model structure in chapter 5 was calibrated to a base year data set, which is assumed to represent a benchmark equilibrium of the Malaysian forest sector. This benchmark equilibrium serves an important purpose. Policy appraisal was done on the basis of pairwise comparison of simulated and benchmark equilibrium. By comparing the simulated and benchmark values of the endogenous variables in the model, we can determine how the sector behaves and provide measures for comparison. The year 1990 was selected as the base year for the calibration of the equations, that was prior to the implementation of a market restriction policy on timber products (see Chapter 1). However, for the rubberwood sector alone, calibration of the simulation equations was done for the base year 1994, after the implementation of a second tax policy on sawn rubberwood.

6.1 Forest Sector Simulation.

This section simulates the possible outcome of policy changes in the forest sector on the production, consumption, and export of forest products, and also its effect on deforestation. The following sections compare different policy scenarios to the base case, focusing particularly on the sawnwood export tax intervention, the imposition of an import ban, the use of revenue-raising import surcharges and the implementation of improved sustainable timber management practices. Table 6.1 compares the results of the base case scenario with the actual values of the key price and quantity variables for Malaysia in 1990. The model appears to be a reasonably good simulation of these variables.

Table 6.1 Forest Sector Simulation - Base Case, 1990.

Market Indicators	Base case 1990 values	Actual
Prices (RM/m^3)		
Sawlog	169	195
Sawntimber	714	616
Plywood	922	789
Quantities('000 m^3)		
Sawlog production	39723	39128
Sawnwood production	8069.	8492
Plywood production	1895	1843
Sawlog export	21178	20088
Sawnwood export	5239	5179
Plywood export	1420	1349
Sawlog consumption	22090	19039
Sawnwood consumption	2830	3313
Plywood consumption	475	494
Forest Cover ('000 ha)	23121	19418

6.1.1. Sawnwood Export Tax

Table 6.2 displays the results of imposing varying levels of sawnwood export taxes in the simulation model of Malaysia's forest sector. The results compare the changes in the key prices, quantities and forest cover to the 1990 base case scenario.

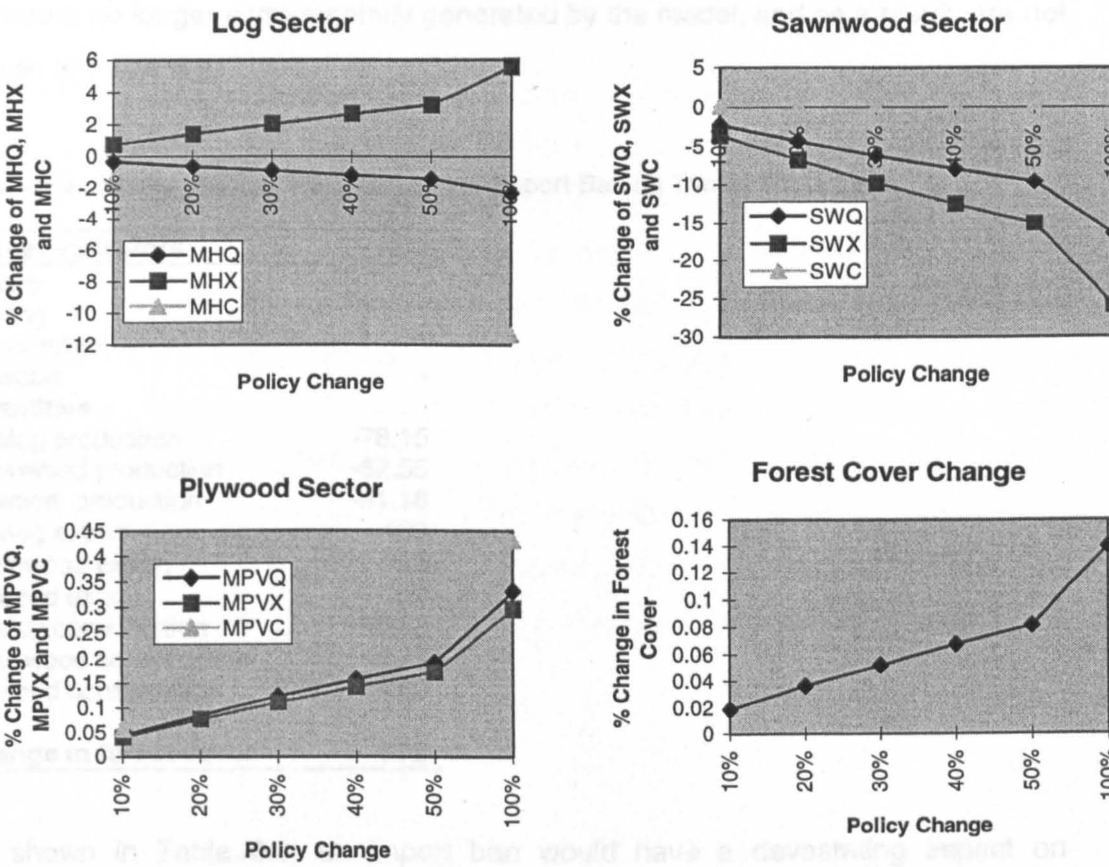
Table 6.2 Forest Sector Policy Scenario - Sawnwood Export Tax

Policies Market Indicators (%)	10%	20%	30%	40%	50%	100%
Prices						
Sawlog	-0.681	-1.313	-1.901	-2.449	-2.962	-5.097
Sawntimber	-3.732	-7.196	-10.419	-13.425	-16.237	-27.937
Plywood	-0.119	-0.229	-0.331	-0.427	-0.516	-0.889
Quantities						
Sawlog production	-0.310	-0.599	-0.867	-1.117	-1.351	-2.324
Sawnwood production	-2.199	-4.239	-6.137	-7.909	-9.565	-16.457
Plywood production	0.044	0.085	0.123	0.159	0.192	0.330
Sawlog export	0.745	1.436	2.079	2.679	3.240	5.575
Sawnwood export	-3.469	-6.689	-9.685	-12.481	-15.094	-25.971
Plywood export	0.040	0.076	0.111	0.143	0.173	0.297
Sawlog consumption	-1.515	-2.922	-4.231	-5.452	-6.593	-11.344
Sawnwood consumption	0.154	0.297	0.430	0.554	0.670	1.153
Plywood consumption	0.058	0.111	0.161	0.207	0.250	0.431
Change in forest cover(%)	0.018773	0.036196	0.052409	0.067533	0.081675	0.140533

In the model, the sawnwood export taxes appear to have the effect of reducing export demand for Malaysian sawnwood, thus lowering the export price received and the quantity exported. The greater the tax, the more severe are the impacts on Malaysia's sawnwood. With proposed taxes of 60-120 per m^3, actual government policy would be represented by the higher range of sawnwood export taxes shown in Table 6.2.

Significantly, the imposition of a tax on sawnwood exports does not appear to instigate a major shift of processing capacity to plywood - at least not in the one period duration of the simulation model. Only at extremely high rates of taxation does this occur even slightly, and it appears that increased domestic plywood consumption is the most noticeable effect.

Figure 6.1 Forest Sector Policy Scenario - Sawnwood Export Tax



6.1.2. Import Ban on Timber Products

Some environmental pressure groups in tropical timber importing countries have been urging their governments to ban the import of tropical timber, or at least imports of timber that is 'unsustainably' produced. Consumer led boycotts against tropical timber products have also been instigated. The presumption is that an import ban is the most effective way of ending timber -related deforestation in tropical forest countries. Despite the various economic and legal implications of such a move, as well as questions about its effectiveness, an import ban on tropical timber is a realistic probability in the near future.

Table 6.3 indicates the effects of a total import ban, compared to the base case scenario, in the timber trade-deforestation model of Malaysia. In order to simulate an import ban in the model, large price changes were used deliberately to constrain sawnwood and plywood export to zero. Timber product prices are therefore no longer endogenously generated by the model, and as a result, are not shown in Table 6.3.

Table 6.3 Forest Sector Policy Scenario - Import Ban on Timber Products.

Market Indicators	%
Prices	
Sawlog	-
Sawntimber	-
Plywood	-
Quantities	
Sawlog production	-78.15
Sawnwood production	-62.55
Plywood production	-51.18
Sawlog export	-100
Sawnwood export	-100
Plywood export	-100
Sawlog consumption	-60.72
Sawnwood consumption	6.76
Plywood consumption	8.69
Change in forest cover	4.70

As shown in Table 6.3, an import ban would have a devastating impact on Malaysia's forest industry in the short term. Although there would be significant diversion of plywood and sawnwood export to domestic consumption, this would be insufficient to compensate for the loss of exports. Net production in both processing industries would fall. Given its export orientation, the plywood industry would be particularly hurt, its output being reduced by over 51 per cent. Net production losses in the sawnwood industry would be closer to 63 per cent. The overall effect would be to lower domestic log demand in the short term by around 78 per cent.

The policy scenario, of course, assumes that the import ban is 100 per cent effective. It is unlikely that all importers of Malaysia's tropical timber products-many of which are also newly industrialising or producer countries with processing capacities- would go along with a western-imposed ban. In any case, one would expect that over the longer term, there would be some diversion of Malaysian plywood and sawnwood exports to either new import markets or existing markets that prove to be less stringent in applying the ban.

It is unlikely that the domestic market in Malaysia will generate the same demand for higher valued timber products as the international markets. Instead, domestic demand is likely to be strongest for high volume but lower valued wood products. As a consequence, it may be difficult for Malaysia to justify holding a large proportion of its tropical forests as permanent production forest, if the expected economic returns from sustainable management decline as a result of the ban. More of the resource may be shifted to conversion forests, and timber production will become residual to satisfying the growing demand for agricultural land. In short, without the timber trade providing increased value added in the form of external demand for higher valued products, there may be less reason for Malaysia to 'hold on' to these forests, as opposed to converting them to an alternative use, such as agriculture.

6.1.3. Log Export Ban

To provide a sufficient log supply to local processors, a total log export ban has been implemented by Peninsular Malaysia since 1985, followed by Sabah in 1993. Sarawak still continues to export sawn logs. However Sarawak also has a provision that provides a safeguard to local processors by insisting that a proportion of log must be sold to local processors. With low capacity utilisation of timber in sawnwood and plywood industries (see section 2.3), Sarawak will most likely impose a similar export ban on logs in the near future. Table 6.4 give the results of a possible total log export ban from Malaysia.

The results show that the immediate effect of the policy would be a big fall in log production because of the disappearance of the export market, that could not be absorbed by the domestic market. Domestic processing would benefit from this policy, as the logs would be easily available at a lower price. Thus, the domestic processors could offer sawnwood and plywood at lower prices and would be in a better position to compete in the foreign market. The results would be an increase in export of both sawnwood and plywood. Domestic consumers would also benefit from the lower price, and domestic consumption for both sawnwood and plywood increase. Therefore, a log export ban policy in a short term would increase the development of domestic processing industries. Because of a big reduction in log production, this policy also would improve the forest cover by 2.85 percent compared to the base year.

Table 6.4. Forest Sector Policy Scenario - Log Export Ban.

Market Indicators	%
Prices	
Sawlog	-
Sawntimber	-24.17
Plywood	-18.12
Quantities	
Sawlog production	-47.35
Sawnwood production	9.58
Plywood production	6.73
Sawlog export	-100
Sawnwood export	14.23
Plywood export	6.04
Sawlog consumption	7.65
Sawnwood consumption	0.99
Plywood consumption	8.78
Change in forest cover	2.85

6.1.4. Rate of Royalty

Table 6.5 indicates the most likely effects of such a 'sustainable' management policy scenario, which is represented by an increase in harvesting costs. As there is insufficient data to determine the extent to which costs would rise if such a policy were to be implemented in Malaysia, the researcher has chosen an average royalty per m^3 of timber harvest as a cost incurred by the concessionaires in the harvest activities. Increases of 10 to 100 percent were selected for comparison.

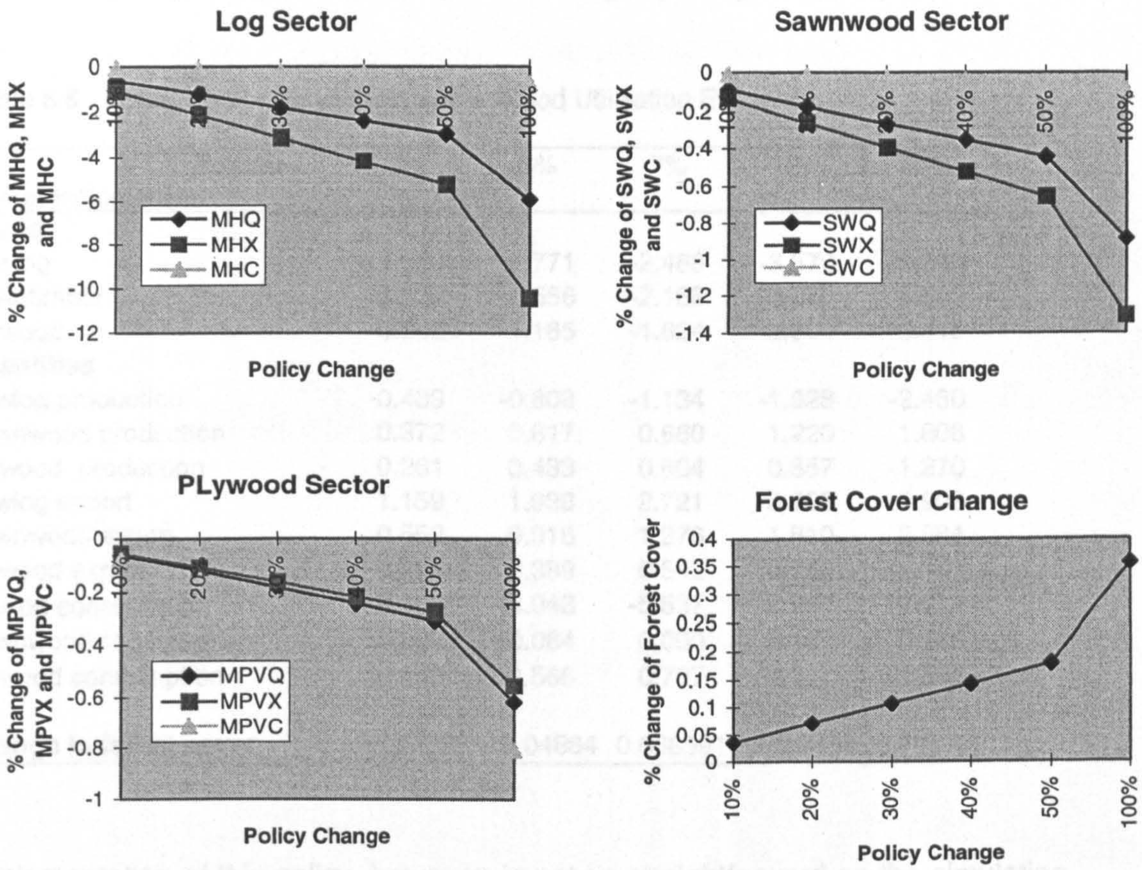
Table 6.5 Forest Sector Policy Scenario- Change in Rate of Royalty

Market Indicators / Policies	10%	20%	30%	40%	50%	100%
Prices						
Sawlog	0.952	1.905	2.857	3.809	4.761	9.523
Sawntimber	0.222	0.443	0.665	0.887	1.108	2.217
Plywood	0.166	0.332	0.498	0.664	0.830	1.660
Quantities						
Sawlog production	-0.589	-1.179	-1.768	-2.357	-2.947	-5.894
Sawnwood production	-0.088	-0.176	-0.264	-0.352	-0.440	-0.879
Plywood production	-0.062	-0.123	-0.185	-0.247	-0.309	-0.617
Sawlog export	-1.042	-2.083	-3.125	-4.167	-5.208	-10.417
Sawnwood export	-0.130	-0.261	-0.391	-0.522	-0.652	-1.305
Plywood export	-0.055	-0.111	-0.166	-0.222	-0.277	-0.555
Sawlog consumption	-0.073	-0.146	-0.218	-0.291	-0.364	-0.728
Sawnwood consumption	-0.009	-0.018	-0.027	-0.037	-0.046	-0.092
Plywood consumption	-0.080	-0.161	-0.241	-0.322	-0.402	-0.805
Change in forest cover	0.035642	0.071283	0.106925	0.142567	0.178209	0.356419

The results show that increase in average rate of royalty, as expected, would reduce log production. The log price would increase, causing a high cost of production to domestic processors. This would lead to reduction in production, not only because of the high cost of production, but also because of the effect of decline in domestic consumption and export due to the high price. The policy would help reduce the pressure on forest area harvest, and help improve the forest cover, compared to the base year.

An important result from this policy would be the size of effect on production of sawlog, sawnwood and plywood. A 100 per cent increase in royalty would cause only a small decrease in sawlog production, about 6 per cent, and less than 1 per cent on production of sawnwood and plywood. These results indicate that an increase in the rate of royalty would be a good instrument for the government to increase revenue from forest sector without excessive distortion to the processing sector. Besides that, not only would this policy improve the forest cover from the effect of reduction in log production, but also the government could increase expenditure on forests from the royalty revenue.

Figure 6.2 Forest Sector Policy Scenario - Change in Rate of Royalty



6.1.5. Wood Utilisation Efficiency

One important issue about wood processing in tropical wood producing countries is that it is less efficient than that produced in developed countries, thus wasting the wood resource, and its consequence is that more wood is needed for the production of the same amount processed products. The government could check the efficiency of wood utilisation by imposing it as a policy. For example, the government could make it a condition for licensing. An implication of this policy is presented in Table 6.6. An increase in overall production efficiency (increase in recovery rate) in the sawnwood and plywood sectors would cause an increase of production in each sector. For a similar quantity of processed production, fewer logs would be demanded causing a decrease in log production. Excess supply from the log sector would be exported. The results show that an increase in overall efficiency by 5 percent would increase log export by almost 2 per cent.

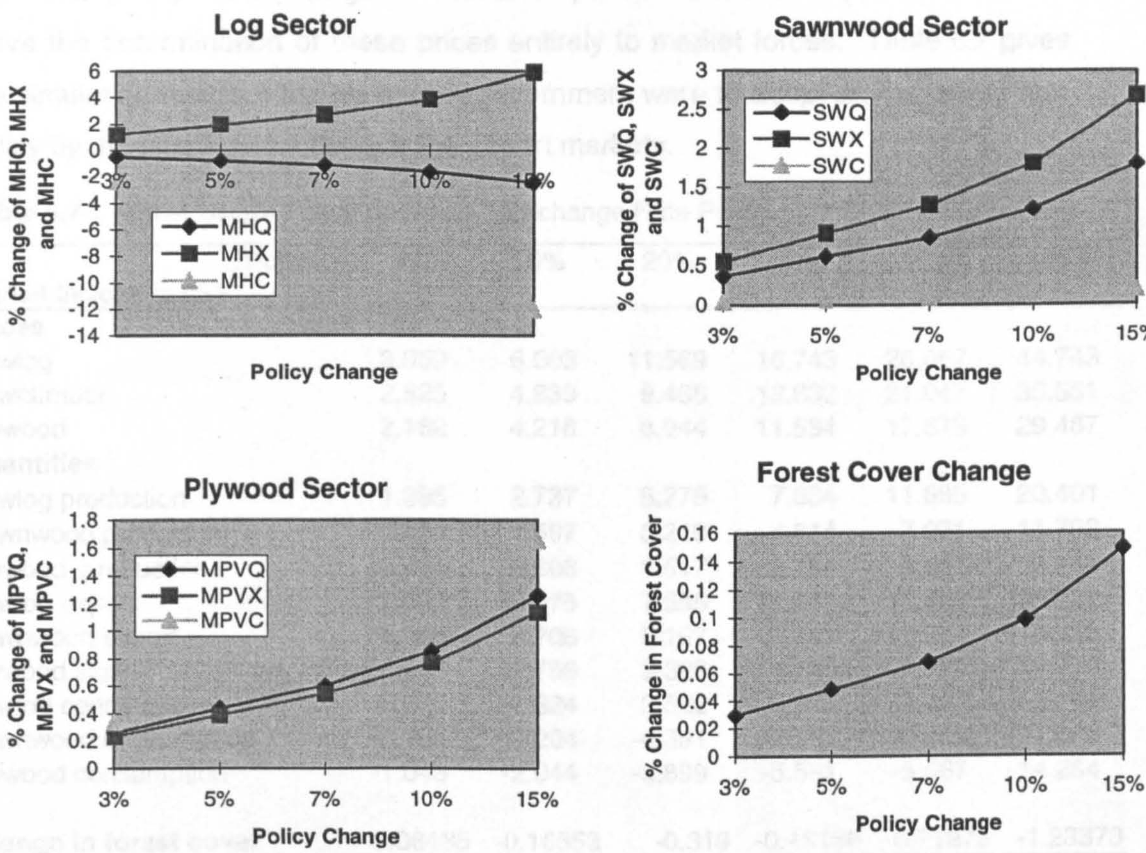
Table 6.6 Forest Sector Policy Scenario – Wood Utilisation Efficiency.

Policies Market Indicators	3%	5%	7%	10%	15%
Prices					
Sawlog	-1.059	-1.771	-2.488	-3.570	-5.396
Sawntimber	-0.938	-1.556	-2.168	-3.076	-4.560
Plywood	-0.702	-1.165	-1.624	-2.304	-3.415
Quantities					
Sawlog production	-0.483	-0.808	-1.134	-1.628	-2.460
Sawnwood production	0.372	0.617	0.860	1.220	1.808
Plywood production	0.261	0.433	0.604	0.857	1.270
Sawlog export	1.159	1.938	2.721	3.905	5.903
Sawnwood export	0.552	0.916	1.276	1.810	2.684
Plywood export	0.235	0.389	0.542	0.769	1.141
Sawlog consumption	-2.358	-3.943	-5.537	-7.947	-12.011
Sawnwood consumption	0.039	0.064	0.090	0.127	0.188
Plywood consumption	0.340	0.565	0.787	1.117	1.655
Change in forest cover	0.029212	0.04884	0.068591	0.098444	0.148793

Implementation of this policy, however, is not so straightforward as the simulation suggests. First, efficiency would not change overnight. More importantly to this is that the efficiency varies with the size and quality of timber. Thus, implementation would need a very specific definition and tools to identify efficiency. The policy would also require more staff to supervise the activities of the firms in the industries.

The simulation results overestimate the effect on production, as they do not take into consideration entry/exit of firms with the implementation. Efficiency of production does not necessarily mean increase in profit, there could be increase in cost as a substitute to increase conversion efficiency, such as acquisition of machines and capital. What is certain about this policy is that the consumption of wood per unit of production would be reduced, and log production would decline thus having a positive effect to forest cover. An overall increase in wood utilisation efficiency in the sawnwood and plywood sectors by 10 per cent would increase forest cover by 1 per cent compared to the base year.

Figure 6.3 Forest Sector Policy Scenario - Wood Utilisation Efficiency



6.1.6. Exchange Rate Policy

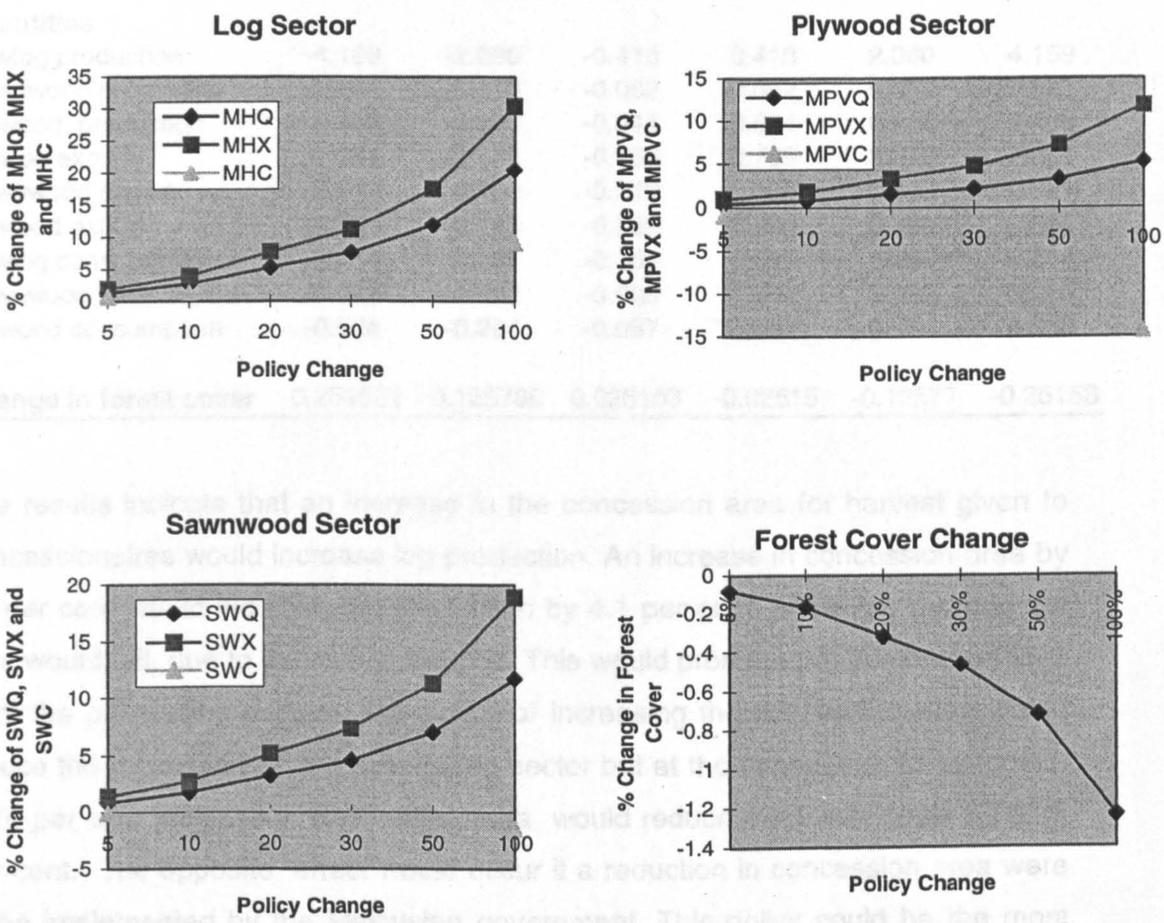
The exchange rate is a price. It is not, however, just one price among others such as the price of timber or plywood; it is a very different price. The importance of the exchange rate as a price derives from two special features. The first feature concerns the range of influence of a change in this price. A change in the price of timber exerts an influence almost solely on the market for timber and possibly on the markets for other substitutes such as timber from the temperate region or timber from other regions; all other markets remain essentially unaffected. On the other hand, a variation in the exchange rate changes the price of national money in term of foreign monies. It thereby produces disequilibria in the timber market. Devaluation in exchange rate, for example, will make the relative price of timber cheaper for importing countries, and so would increase the demand. Supposing the exporting countries respond to this, then it will increase the export of timber. It is therefore not surprising that the exchange rate has gained a strategic position in economic policy and that governments or policy makers are quite reluctant to leave the determination of these prices entirely to market forces. Table 6.7 gives the simulation results if the Malaysian government were to adopt an exchange rate policy by devaluation to influence the export markets.

Table 6.7 Forest Sector Policy Scenario - Exchange Rate Policy.

Policies Market Indicators (%)	5%	10%	20%	30%	50%	100%
Prices						
Sawlog	3.059	6.003	11.569	16.743	26.067	44.743
Sawntimber	2.525	4.939	9.466	13.632	21.047	35.581
Plywood	2.162	4.218	8.044	11.534	17.673	29.467
Quantities						
Sawlog production	1.395	2.737	5.275	7.634	11.885	20.401
Sawnwood production	0.864	1.687	3.218	4.614	7.071	11.793
Plywood production	0.414	0.803	1.517	2.154	3.247	5.248
Sawlog export	2.022	3.975	7.685	11.155	17.453	30.222
Sawnwood export	1.388	2.708	5.167	7.411	11.361	18.958
Plywood export	0.903	1.756	3.328	4.745	7.198	11.779
Sawlog consumption	0.679	1.324	2.522	3.613	5.527	9.185
Sawnwood consumption	-0.104	-0.204	-0.391	-0.563	-0.869	-1.469
Plywood consumption	-1.048	-2.044	-3.899	-5.591	-8.567	-14.284
Change in forest cover	-0.08435	-0.16553	-0.319	-0.46166	-0.71876	-1.23373

The results shows that devaluation of the exchange rate would promote the production of log, sawnwood and plywood. Initially, the domestic producers would receive higher profit for similar cost of domestic production. The price of Malaysian forest products would be cheaper to the importer, compared to similar products from other parts of the world, thus would increase the demand. Increase in demand from the export market would be at the expense of the domestic market, so domestic consumption of sawnwood and plywood would decrease. Because devaluation of exchange rate promotes log production, the consequence of the policy would be to reduce the forest cover. For example, a 50 per cent devaluation of the Malaysian Ringgit against the US dollar would reduce the forest cover by 1.2 per cent compared to the base. Thus, application of exchange rate as a policy measure, would undoubtedly increase the output production from the forest sector but at the expense of Malaysia's forest cover.

Figure 6.4 Forest Sector Policy Scenario - Exchange Rate Policy



6.1.7. Area Harvest Policy.

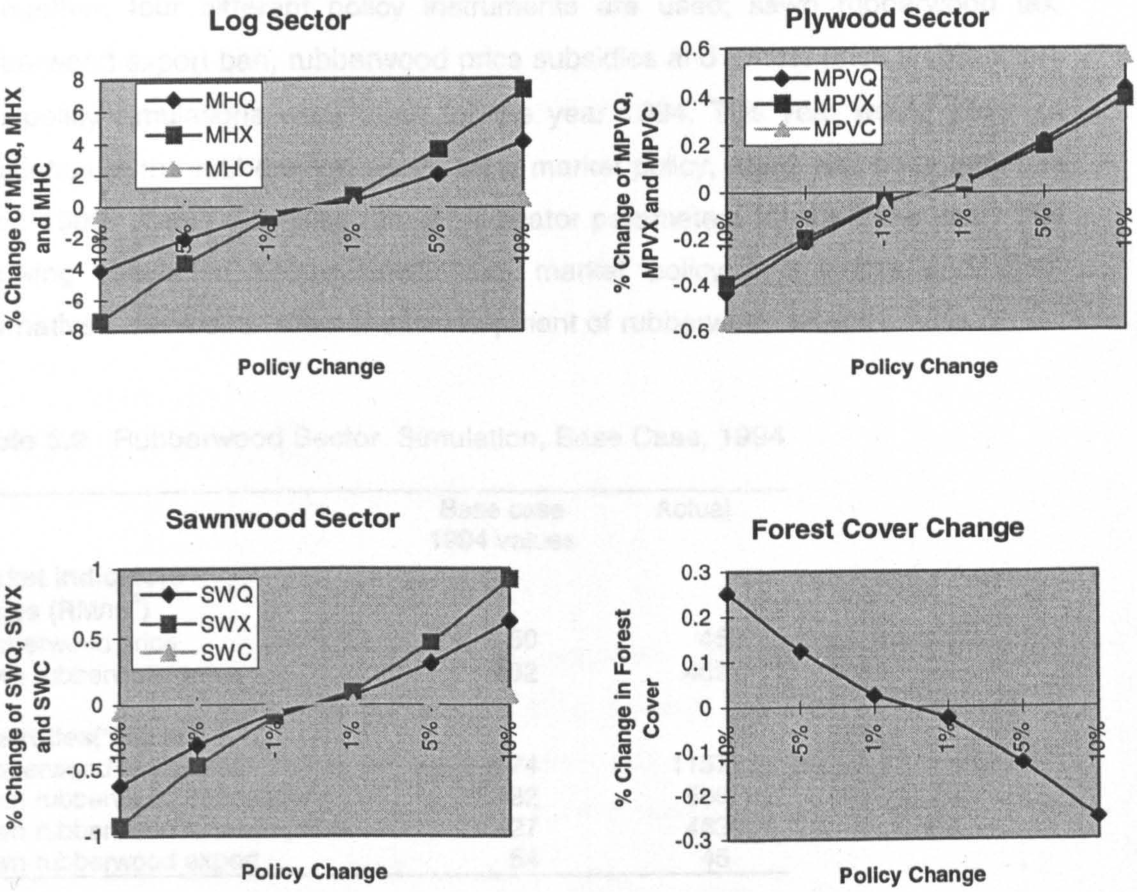
As stated earlier in this thesis, it is assumed that the total harvest area is equal to the area approved for harvest in any given year. This is based on the policy that the concessionaires have to harvest the area allocated to them within a year of approval (see Chapter 2 and Chapter 4). Table 6.8 gives the simulation results if the government were to increase the concession area.

Table 6.8 Forest Sector Policy Scenario - Area Harvest Policy

Policies / Market Indicators	-10%	-5%	-1%	1%	5%	10%
Prices						
Sawlog	6.720	3.360	0.672	-0.672	-3.360	-6.720
Sawntimber	1.564	0.782	0.156	-0.156	-0.782	-1.564
Plywood	1.172	0.586	0.117	-0.117	-0.586	-1.172
Quantities						
Sawlog production	-4.159	-2.080	-0.416	0.416	2.080	4.159
Sawnwood production	-0.621	-0.310	-0.062	0.062	0.310	0.621
Plywood production	-0.436	-0.218	-0.044	0.044	0.218	0.436
Sawlog export	-7.351	-3.676	-0.735	0.735	3.676	7.351
Sawnwood export	-0.921	-0.460	-0.092	0.092	0.460	0.921
Plywood export	-0.391	-0.196	-0.039	0.039	0.196	0.391
Sawlog consumption	-0.514	-0.257	-0.051	0.051	0.257	0.514
Sawnwood consumption	-0.065	-0.032	-0.006	0.006	0.032	0.065
Plywood consumption	-0.568	-0.284	-0.057	0.057	0.284	0.568
Change in forest cover	0.251531	0.125765	0.025153	-0.02515	-0.12577	-0.25153

The results indicate that an increase in the concession area for harvest given to concessionaires would increase log production. An increase in concession area by 10 per cent would increase log production by 4.1 per cent. However, the price of logs would fall, due to excess production. This would promote the demand for logs from the processing sectors. The policy of increasing the concession area would induce the expansion of the processing sector but at the expense of forest cover. A 10 per cent increase in concession area would reduce the forest cover by 0.25 per cent. The opposite effect would occur if a reduction in concession area were to be implemented by the Malaysian government. This policy could be the most effective way to save the forest cover.

Figure 6.5 Forest Sector Policy Scenario - Area Harvest Policy.



6.2. Rubberwood Sector Simulation

Altogether, four different policy instruments are used; sawn rubberwood tax, rubberwood export ban, rubberwood price subsidies and rubber price stabilisation. The policy simulations were done for the year 1994. This year would allow an evaluation of the rubberwood sector for a market policy, which has been imposed since 1990. Table 6.9 gives market indicator parameters for the base year. The following simulation shows how these market policy instruments and other alternative instruments affect the development of rubberwood sector.

Table 6.9 Rubberwood Sector Simulation, Base Case, 1994.

	Base case 1994 values	Actual
Market Indicators		
Prices (RM/m^3)		
Rubberwood price	50	45
Sawn rubberwood price	462	459
Quantities('000 m^3)		
Rubberwood production	1574	1157
Sawn rubberwood production	482	508
Sawn rubberwood consumption	427	463
Sawn rubberwood export	54	45

6.2.1. Sawn Rubberwood Export Tax

Table 6.10 shows the impact of tax removal of the tax on sawn rubberwood on its production, export and consumption. The results show that the rubberwood sector would benefit from the removal of sawn rubberwood tax. The primary impact of a removal in sawn rubberwood tax would be on exports of on the sawn rubberwood, which would increase by 32 per cent. The effect on rubberwood would be positive, which is to say there would be more demand for rubberwood, causing an increase in rubberwood price by almost 0.6 percent. Increase in rubberwood price implies that the rubber producers would shorten the cycle of the rubber tree, making earlier replanting possible. Thus, the result shows an increase in rubberwood production. Rubber producers would benefit from this policy by receiving a higher price for logs. Therefore, the tax reduction policy seems to be a good instrument to encourage the development of the rubberwood sector.

Table 6.10 Rubberwood Sector Policy Scenario - Removal of Sawn Rubberwood Export Tax.

Market Indicators	%
Prices	
Rubberwood price	0.591
Sawn rubberwood price	1.504
Quantities	
Rubberwood production	0.787
Sawn rubberwood production	0.951
Sawn rubberwood consumption	-3.036
Sawn rubberwood export	32.158

6.2.2. Export Ban on Sawn Rubberwood.

The Malaysian government, in 1994, proposed an export ban on sawn rubberwood to ensure an adequate supply of material for the furniture industry. However, implementation was delayed and export continued in 1995. The following simulation looks at the impact on the rubberwood sector if the export ban proposal were to be implemented.

Table 6.11 Rubberwood Sector Policy Scenario - Export Ban on Sawn Rubberwood.

Market Indicators	%
Prices	
Rubberwood price	-
Sawn rubberwood price	-
Quantities	
Rubberwood production	-2.451
Sawn rubberwood production	-2.961
Sawn rubberwood consumption	9.455
Sawn rubberwood export	-100

Table 6.11 gives the results for a sawn rubberwood export ban scenario. The results show that rubberwood production would decline, as a consequence of a decline in sawn rubberwood production. Even if domestic consumption increased, it could not absorb all the production left by the export market.

6.2.3. Rubber Price Subsidies

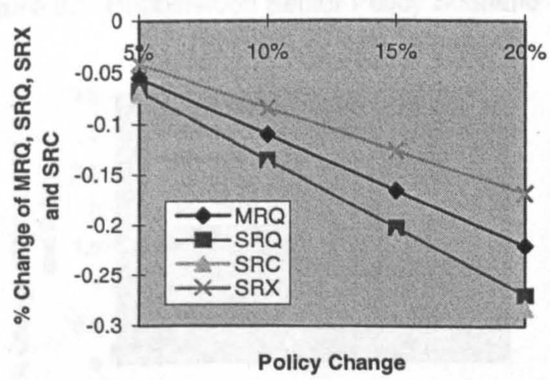
Rubber price subsidies have been implemented in Malaysia to give support to smallholders whose main income comes from rubber plantations. The government has been buying rubber from small holders through government agencies such as The Malaysia Rubber Development Corporation (MARDEC) and Rubber Industry and Smallholders Development Authority (RISDA). This intervention in the rubber market would affect supply of rubberwood. The regression result in the chapter 5 has showed that the price of rubber has a negative relationship with rubberwood production. An increase in rubber price would reduce the supply of rubberwood to the market. This form of intervention is unwelcome as far as rubberwood development is concerned. Table 6.12 gives the possible effect on the rubberwood sector of the implementation of rubber price subsidies. Table 6.12 shows that a 10 percent increase in the price of rubber over the simulated base price would decrease rubberwood production by 0.11 percent. The price of rubberwood would increase due to shortage of supply, causing reduction in consumption, production and export in the sawn rubberwood sector.

A similar direction of effect would apply if rubber price was stabilised above the simulated base price through intervention in the international rubber market, under the International Natural Rubber Agreement (INRA). Rubber price is quoted using Malaysian Ringgit. The price intervention level also is in Malaysian Ringgit. Rubber producers have for sometime favoured an upward revision of the rubber price, due to the weakening of the Malaysian Ringgit and the currencies in other major rubber producing countries

Table 6.12 Rubberwood Sector Policy Scenario - Rubber Price Subsidies.

Market indicator / Policies	5%	10%	15%	20%
Prices				
Rubberwood price	0.4282	0.8565	1.2847	1.7129
Sawn rubberwood price	0.0303	0.0607	0.0910	0.1213
Quantities				
Rubberwood production	-0.0550	-0.1099	-0.1649	-0.2198
Sawn rubberwood production	-0.0674	-0.1348	-0.2022	-0.2696
Sawn rubberwood consumption	-0.0707	-0.1413	-0.2120	-0.2826
Sawn rubberwood export	-0.0419	-0.0839	-0.1258	-0.1678

Figure 6.6 Rubberwood Sector Policy Scenario - Rubber Price Subsidies.



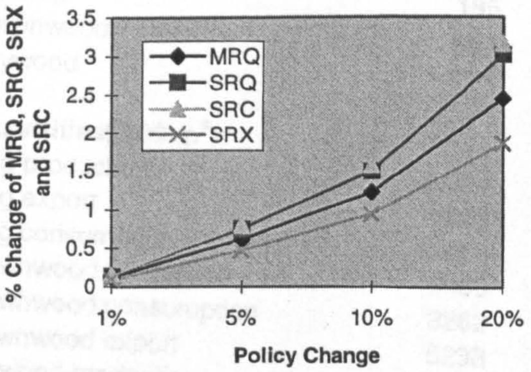
6.2.4. Rubberwood Price Subsidies

Another alternative policy in the rubberwood sector is by giving subsidies on rubberwood price. The objective of this intervention would be to promote more rubberwood in the market. Table 6.13 gives the simulated results of this policy. The results show that rubberwood production and sawn rubberwood production would increase with the implementation of this policy, but the price of rubberwood and sawn rubberwood price would fall, as more rubberwood and sawn rubberwood became available in the market.

Table 6.13 Rubberwood Sector Policy Scenario - Rubberwood Price Subsidies..

Market Indicators / Policies	1%	5%	10%	20%
Prices				
Rubberwood price	-0.9614	-4.8071	-9.6143	-19.2286
Sawn rubberwood price	-0.0681	-0.3405	-0.6810	-1.3621
Quantities				
Rubberwood production	0.1234	0.6170	1.2339	2.4678
Sawn rubberwood production	0.1513	0.7566	1.5131	3.0263
Sawn rubberwood consumption	0.1586	0.7932	1.5865	3.1729
Sawn rubberwood export	0.0942	0.4709	0.9418	1.8836

Figure 6.7 Rubberwood Sector Policy Scenario - Rubberwood Price Subsidies



6.3. Forest-Rubberwood Sector Policy Simulation

This section provides simulation results for the Forest-Rubberwood sector. The objective of this simulation is to look into the effect of policies in both sectors of wood resource, focusing particularly on the rubberwood sector. The base year market indicators for this simulation are presented in Table 6.14. Table 6.14 shows that the base case for simulation is good. The differences between the base case and the actual figures are small.

Table 6.14 Forest-Rubberwood Simulation Model - Base Case, 1990.

Market indicators	Base Case 1990 Values	Actual
Prices (RM/m^3)		
Sawn rubberwood	533	467
Rubberwood	30	27
Sawlog	185	195
Sawnwood	631	616
Plywood	724	789
Quantities('000 m^3)		
Log production	38394	39128
Log export	19327	20088
Log consumption	19066	19040
Sawnwood production	8495	8492
Sawnwood consumption	3262	3313
Sawnwood export	5233	5179
Plywood production	1811	1843
Plywood consumption	508	494
Plywood export	1303	1349
Rubberwood production	1080	971
Rubberwood consumption	1080	971
Sawn rubberwood production	299	287
Sawn rubberwood consumption	194	183
Sawn rubberwood export	105	103
Employment		
Log sector	67372	66108
Sawnwood sector	53230	53250
Plywood sector	21705	21337
Forest Cover ('000 ha)	23168	19418

Note: The following assumptions are used for employment simulation:
a. Malaysia relies only on its own timber resources for raw materials.
b. Existing technology is maintained and the apparent productivity in the employment unit concept, L_i/Q_i is maintained. Where L_i is employment in sector i and Q_i is total production in sector i (i= log, sawnwood and plywood).

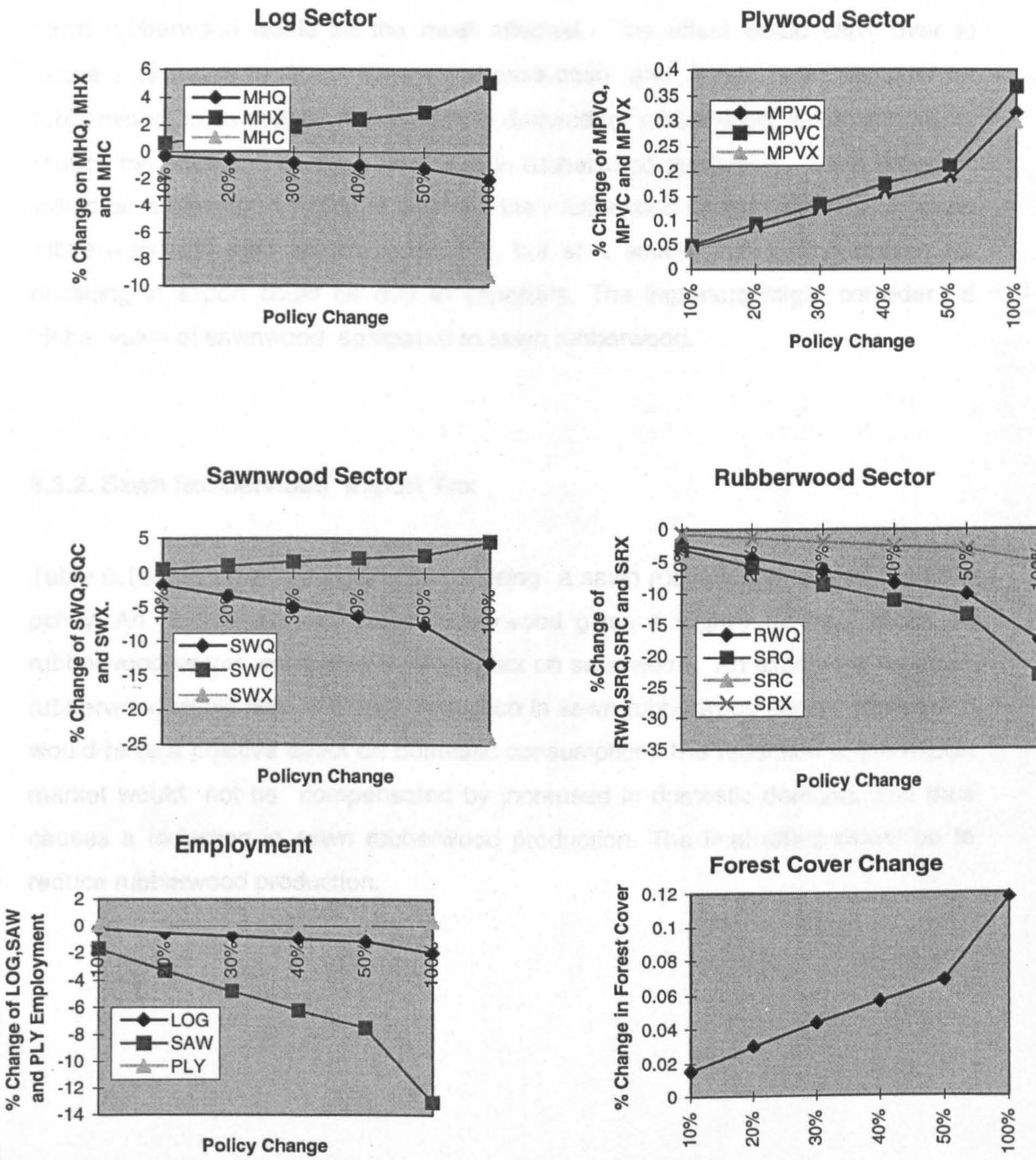
6.3.1. Sawnwood Export Tax

Table 6. 15 provides the results of the simulation with regard to sawnwood export tax. The results show that a sawnwood export tax would have similar effects on the forest sector as discussed in the previous section, of particular concern, now, is the effect of the policy on the rubberwood sector. The results show that rubberwood production and consumption would decrease with the implementation of an export tax on sawnwood. The rubberwood sector would shrink as a result of this policy.

Table 6.15 Forest-Rubberwood Policy Scenario - Sawnwood Export Tax

Policies / Market Indicators	10%	20%	30%	40%	50%	100%
Prices						
Sawn rubberwood	-1.8464	-3.5691	-5.1803	-6.6902	-8.1083	-14.0753
Rubberwood	-1.9137	-3.6993	-5.3692	-6.9343	-8.4041	-14.5887
Sawlog	-0.5129	-0.9914	-1.4390	-1.8584	-2.2524	-3.9099
Sawnwood	-3.4644	-6.6969	-9.7198	-12.5531	-15.2139	-26.4098
Plywood	-0.1127	-0.2179	-0.3163	-0.4084	-0.4950	-0.8593
Quantities						
Log production	-0.2643	-0.5108	-0.7414	-0.9576	-1.1605	-2.0146
Log export	0.6665	1.2884	1.8700	2.4150	2.9270	5.0809
Log consumption	-1.2078	-2.3347	-3.3886	-4.3764	-5.3040	-9.2073
Sawnwood production	-1.7120	-3.3094	-4.8033	-6.2034	-7.5183	-13.0510
Sawnwood consumption	0.5911	1.1427	1.6585	2.1419	2.5959	4.5063
Sawnwood export	-3.1481	-6.0853	-8.8322	-11.4067	-13.8245	-23.9980
Plywood production	0.0416	0.0804	0.1166	0.1506	0.1826	0.3169
Plywood consumption	0.0482	0.0931	0.1351	0.1745	0.2115	0.3672
Plywood export	0.0390	0.0754	0.1094	0.1413	0.1713	0.2974
Rubberwood production	-2.2717	-4.3912	-6.3734	-8.2311	-9.9759	-17.3171
Rubberwood consumption	-2.2717	-4.3912	-6.3734	-8.2311	-9.9759	-17.3171
Sawn rubberwood production	-3.0320	-5.8609	-8.5064	-10.9860	-13.3146	-23.1129
Sawn rubberwood consumption	-4.3183	-8.3475	-12.1156	-15.6471	-18.9638	-32.9192
Sawn rubberwood export	-0.6626	-1.2809	-1.8591	-2.4010	-2.9099	-5.0514
Employment						
Log sector	-0.2643	-0.5108	-0.7414	-0.9576	-1.1605	-2.0146
Sawnwood sector	-1.7120	-3.3094	-4.8033	-6.2034	-7.5183	-13.0510
Plywood sector	0.0416	0.0804	0.1166	0.1506	0.1826	0.3169
Change in forest cover	0.0154	0.0298	0.0432	0.0559	0.0677	0.1175

Figure 6.8 Forest-Rubberwood Policy Scenario - Sawnwood Export Tax



The production of rubberwood and sawn rubberwood would be reduced. The negative effect on the rubberwood sector can be attributed to price effect. The policy would cause the price of sawnwood to fall, making it cheaper relative to sawn rubberwood, because sawnwood and sawn rubberwood are substitutes for each other, a fall in sawnwood price would increase demand for it and reduce the demand for sawn rubberwood. The results show that the domestic demand for sawn rubberwood would be the most affected. The effect would carry over to cause a decrease in sawn rubberwood production and finally cause demand for rubberwood to decrease. A decrease in demand for rubberwood would effectively reduce the price and cause a decrease in rubberwood production. Such an effect would be a blow for a policy to promote the rubberwood sector. Exports of sawn rubberwood are also shown to decline, but at a smaller rate. The reason for declining in export could be due to importers. The importers might consider a higher value of sawnwood compared to sawn rubberwood.

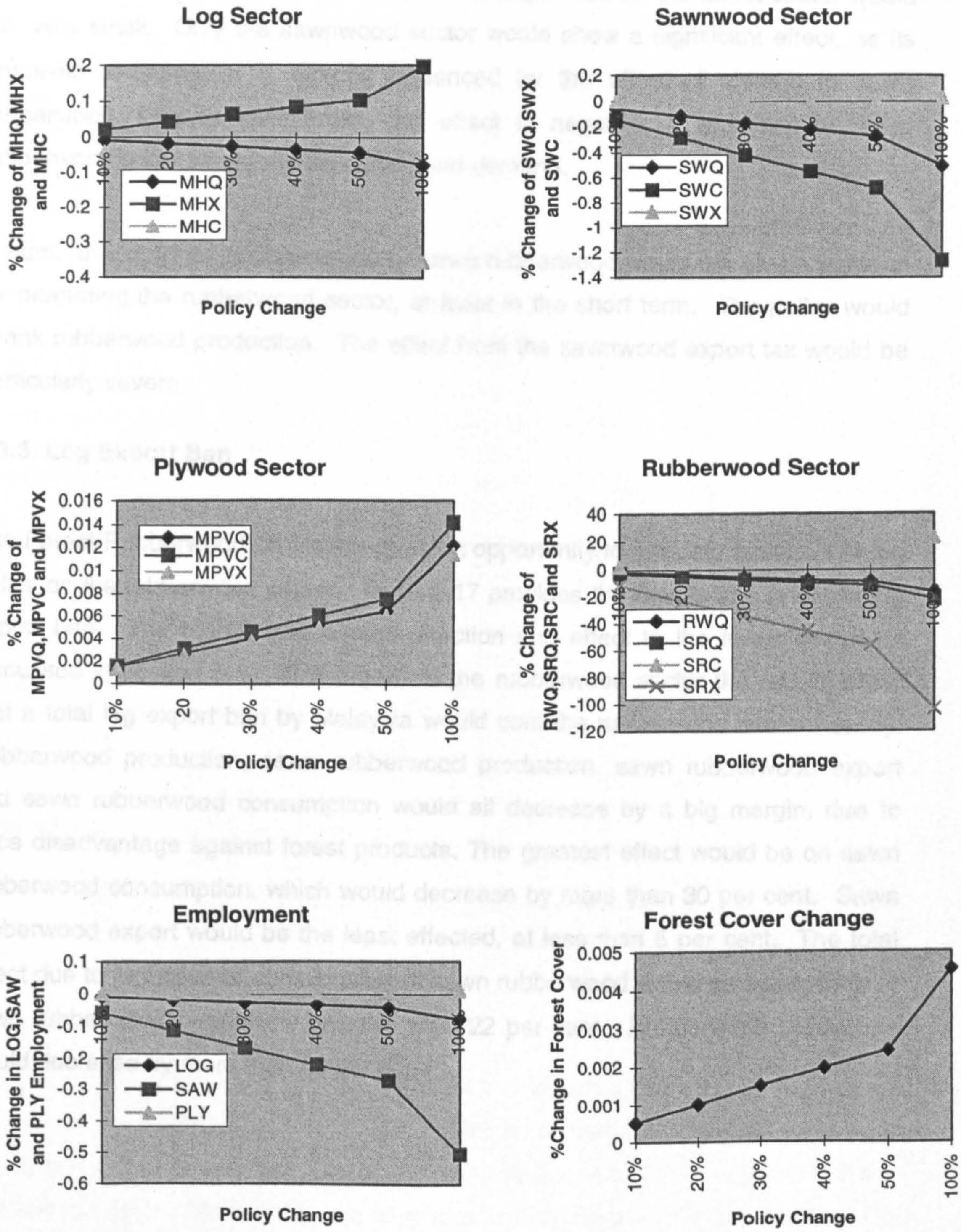
6.3.2. Sawn Rubberwood Export Tax

Table 6.16 gives the simulation results using a sawn rubberwood export tax as a policy. An export tax on sawn rubberwood gives a slightly different effect on rubberwood sector compared to export tax on sawnwood. An export tax on sawn rubberwood would lead to a huge reduction in sawn rubberwood export. However it would have a positive effect on domestic consumption. The reduction in the export market would not be compensated by increased in domestic demand, and thus causes a reduction in sawn rubberwood production. The final effect would be to reduce rubberwood production.

Table 6.16 Forest-Rubberwood Policy Scenario - Sawn Rubberwood Export Tax

Policies / Market indicators	10%	20%	30%	40%	50%	100%
Prices						
Sawn rubberwood	-1.5098	-2.9747	-4.3966	-5.7775	-7.1191	-13.2919
Rubberwood	-1.5649	-3.0832	-4.5570	-5.9883	-7.3788	-13.7768
Sawlog	-0.0171	-0.0337	-0.0498	-0.0655	-0.0807	-0.1507
Sawnwood	-0.1156	-0.2278	-0.3367	-0.4424	-0.5452	-1.0179
Plywood	-0.0038	-0.0074	-0.0110	-0.0144	-0.0177	-0.0331
Quantities						
Log production	-0.0088	-0.0174	-0.0257	-0.0338	-0.0416	-0.0776
Log export	0.0222	0.0438	0.0648	0.0851	0.1049	0.1958
Log consumption	-0.0403	-0.0794	-0.1174	-0.1543	-0.1901	-0.3549
Sawnwood production	-0.0571	-0.1126	-0.1664	-0.2186	-0.2694	-0.5030
Sawnwood consumption	-0.1440	-0.2837	-0.4193	-0.5511	-0.6790	-1.2678
Sawnwood export	0.0030	0.0059	0.0087	0.0114	0.0140	0.0262
Plywood production	0.0014	0.0027	0.0040	0.0053	0.0065	0.0122
Plywood consumption	0.0016	0.0032	0.0047	0.0062	0.0076	0.0142
Plywood export	0.0013	0.0026	0.0038	0.0050	0.0061	0.0115
Rubberwood production	-1.8575	-3.6598	-5.4093	-7.1082	-8.7587	-16.3533
Rubberwood consumption	-1.8575	-3.6598	-5.4093	-7.1082	-8.7587	-16.3533
Sawn rubberwood production	-2.4792	-4.8847	-7.2197	-9.4872	-11.6902	-21.8265
Sawn rubberwood consumption	2.5750	5.0735	7.4987	9.8539	12.1420	22.6700
Sawn rubberwood export	-11.7883	-23.2260	-34.3285	-45.1102	-55.5849	-100.00
Employment						
Log sector	-0.0088	-0.0174	-0.0257	-0.0338	-0.0416	-0.0776
Sawnwood sector	-0.0571	-0.1126	-0.1664	-0.2186	-0.2694	-0.5030
Plywood sector	0.0014	0.0027	0.0040	0.0053	0.0065	0.0122
Change in forest cover	0.000514	0.001014	0.001498	0.001969	0.002426	0.004529

Figure 6.9 Forest-Rubberwood Policy Scenario - Sawn Rubberwood Export Tax



Obviously, the effect of a sawn rubberwood export tax on the forest sector would be very small. Only the sawnwood sector would show a significant effect, as its domestic consumption is directly influenced by the effect of change in sawn rubberwood. Due to substitution, the effect is negative, a reduction in sawn rubberwood price would reduce sawnwood demand.

In sum, an export tax on sawnwood or sawn rubberwood would not give a platform for promoting the rubberwood sector, at least in the short term. The policy would shrink rubberwood production. The effect from the sawnwood export tax would be particularly severe.

6.3.3. Log Export Ban

The Forest-Rubberwood simulation gives an opportunity to evaluate the effect of log policy on the rubberwood sector. Table 6.17 provides the results of a possible log export ban. The results give similar direction and effect to the forest sector as discussed in section 6.1. With regard to the rubberwood sector the results show that a total log export ban by Malaysia would cost the rubberwood sector heavily. Rubberwood production, sawn rubberwood production, sawn rubberwood export and sawn rubberwood consumption would all decrease by a big margin, due to price disadvantage against forest products. The greatest effect would be on sawn rubberwood consumption, which would decrease by more than 30 per cent. Sawn rubberwood export would be the least effected, at less than 5 per cent. The total effect due to reduction of consumption of sawn rubberwood would be a reduction of sawn rubberwood production by more than 22 per cent. Rubberwood production would decrease by more than 16 per cent

Table 6.17 Forest-Rubberwood Policy Scenario - Log Export Ban

Policies	Log Export Ban
Market indicators	
Prices	
Sawn rubberwood	-13.4474
Rubberwood	-13.9379
Sawlog	-
Sawnwood	-25.2316
Plywood	-19.8355
Quantities	
Log production	-46.503
Log export	-100
Log consumption	7.7270
Sawnwood production	9.0415
Sawnwood consumption	4.3052
Sawnwood export	11.9946
Plywood production	7.31610
Plywood consumption	8.47625
Plywood export	6.86391
Rubberwood production	-16.5446
Rubberwood consumption	-16.5446
Sawn rubberwood production	-22.0818
Sawn rubberwood consumption	-31.4507
Sawn rubberwood export	-4.82601
Employment	-17.3
Log sector	-46.5
Sawnwood sector	9.04
Plywood sector	7.31
Change in forest cover	2.71

6.3.4. Rate of Royalty

Table 6.18 gives the effect of an increase in the rate of the royalty on forest harvest on the rubberwood sector. The results show that an increase in the rate of royalty per unit harvest would increase rubberwood production, thus promoting the rubberwood sector. As with the previous results, the effect on the forest processed products sector would be small. A 100 per cent increase in royalty rate would only reduce sawnwood and plywood production by less than 1 per cent.

Table 6. 18 Forest-Rubberwood Policy Scenario- Change in Rate of Royalty

Policies / Market Indicators	10%	20%	30%	40%	50%	100%
Prices						
Sawn rubberwood	0.1302	0.2604	0.3906	0.5208	0.6510	1.3019
Rubberwood	0.1349	0.2699	0.4048	0.5398	0.6747	1.3494
Sawlog	0.8738	1.7476	2.6213	3.4951	4.3689	8.7378
Sawnwood	0.2443	0.4886	0.7328	0.9771	1.2214	2.4428
Plywood	0.1920	0.3841	0.5761	0.7682	0.9602	1.9204
Quantities						
Log production	-0.6088	-1.2175	-1.8263	-2.4350	-3.0438	-6.0876
Log export	-1.1355	-2.2710	-3.4065	-4.5420	-5.6774	-11.3549
Log consumption	-0.0748	-0.1496	-0.2244	-0.2992	-0.3740	-0.7481
Sawnwood production	-0.0875	-0.1751	-0.2626	-0.3501	-0.4377	-0.8754
Sawnwood consumption	-0.0417	-0.0834	-0.1250	-0.1667	-0.2084	-0.4168
Sawnwood export	-0.1161	-0.2323	-0.3484	-0.4645	-0.5806	-1.1613
Plywood production	-0.0708	-0.1417	-0.2125	-0.2833	-0.3542	-0.7083
Plywood consumption	-0.0821	-0.1641	-0.2462	-0.3283	-0.4103	-0.8206
Plywood export	-0.0665	-0.1329	-0.1994	-0.2658	-0.3323	-0.6645
Rubberwood production	0.1602	0.3204	0.4805	0.6407	0.8009	1.6018
Rubberwood consumption	0.1602	0.3204	0.4805	0.6407	0.8009	1.6018
Sawn rubberwood production	0.2138	0.4276	0.6414	0.8551	1.0689	2.1379
Sawn rubberwood consumption	0.3045	0.6090	0.9135	1.2180	1.5225	3.0449
Sawn rubberwood export	0.0467	0.0934	0.1402	0.1869	0.2336	0.4672
Employment	-0.33554	-0.67109	-1.00663	-1.34217	-1.67771	-3.35543
Log sector	-0.6088	-1.2175	-1.8263	-2.4350	-3.0438	-6.0876
Sawnwood sector	-0.0875	-0.1751	-0.2626	-0.3501	-0.4377	-0.8754
Plywood sector	-0.0708	-0.1417	-0.2125	-0.2833	-0.3542	-0.7083
Change in forest cover	0.035511	0.071021	0.106532	0.142043	0.177553	0.355107

Figure 6.10 Forest - Rubberwood Policy Scenario- Change in Rate of Royalty

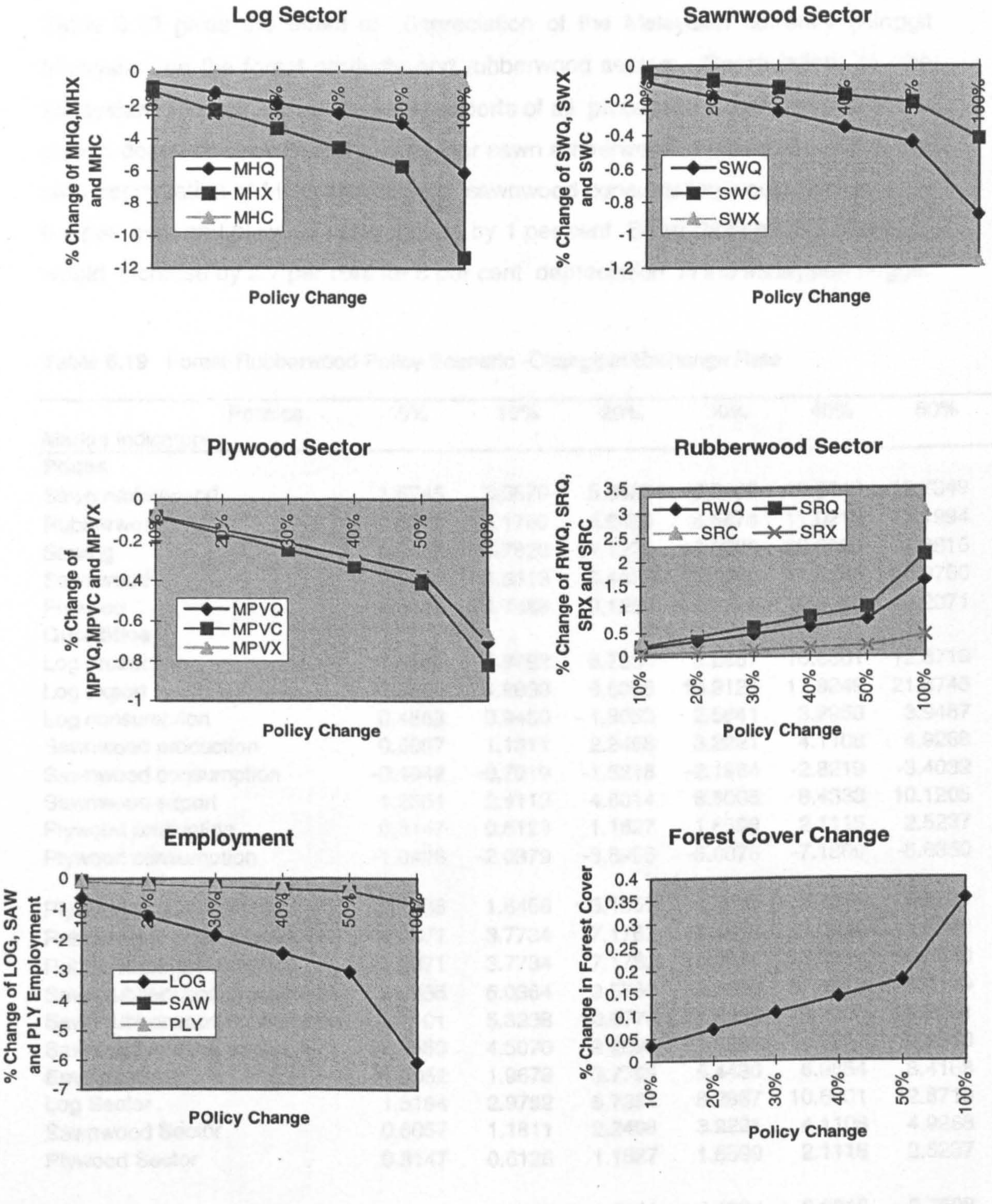


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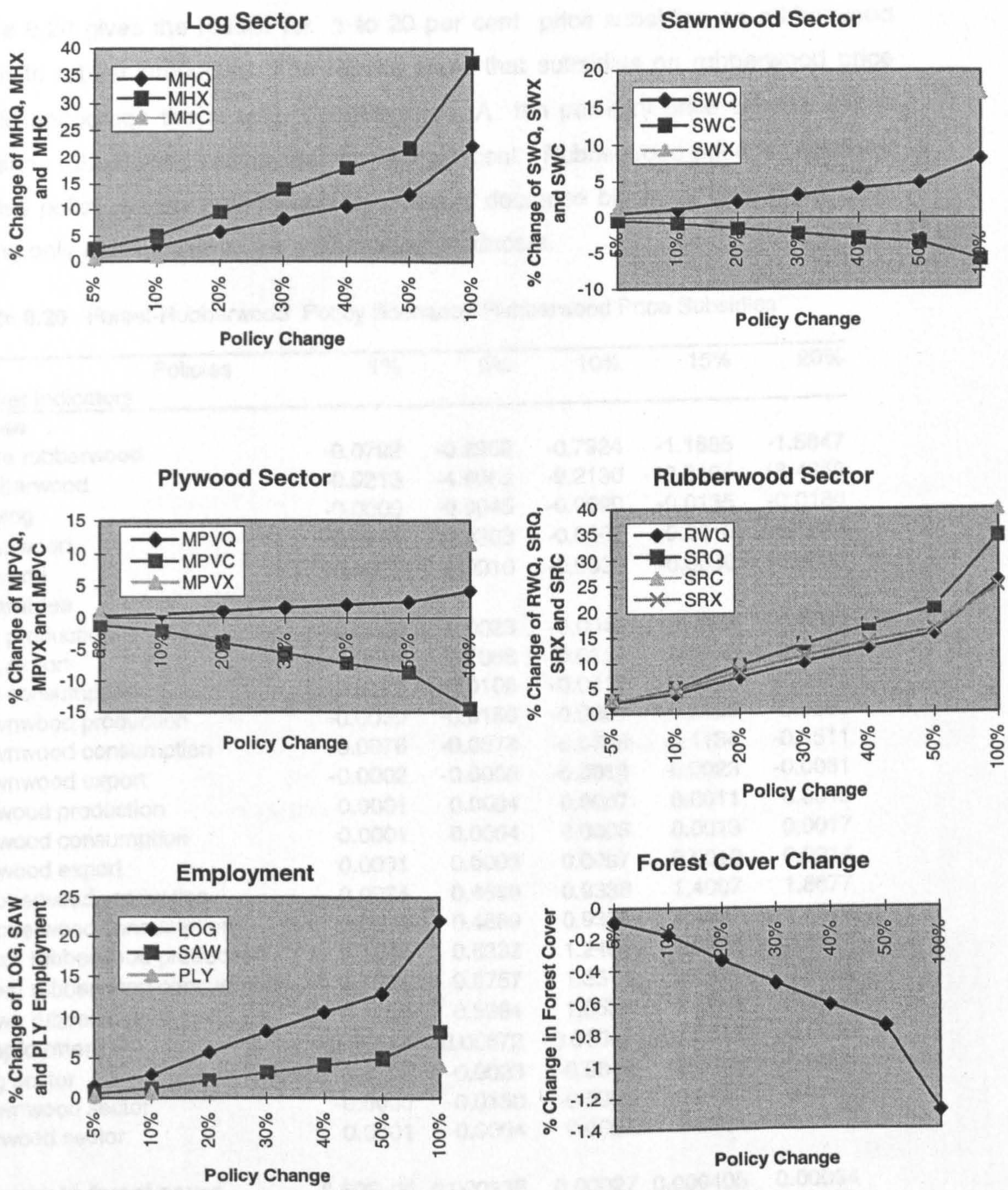
Figure 6.11 Forest-Rubberwood Policy Scenario -Change in Exchange Rate



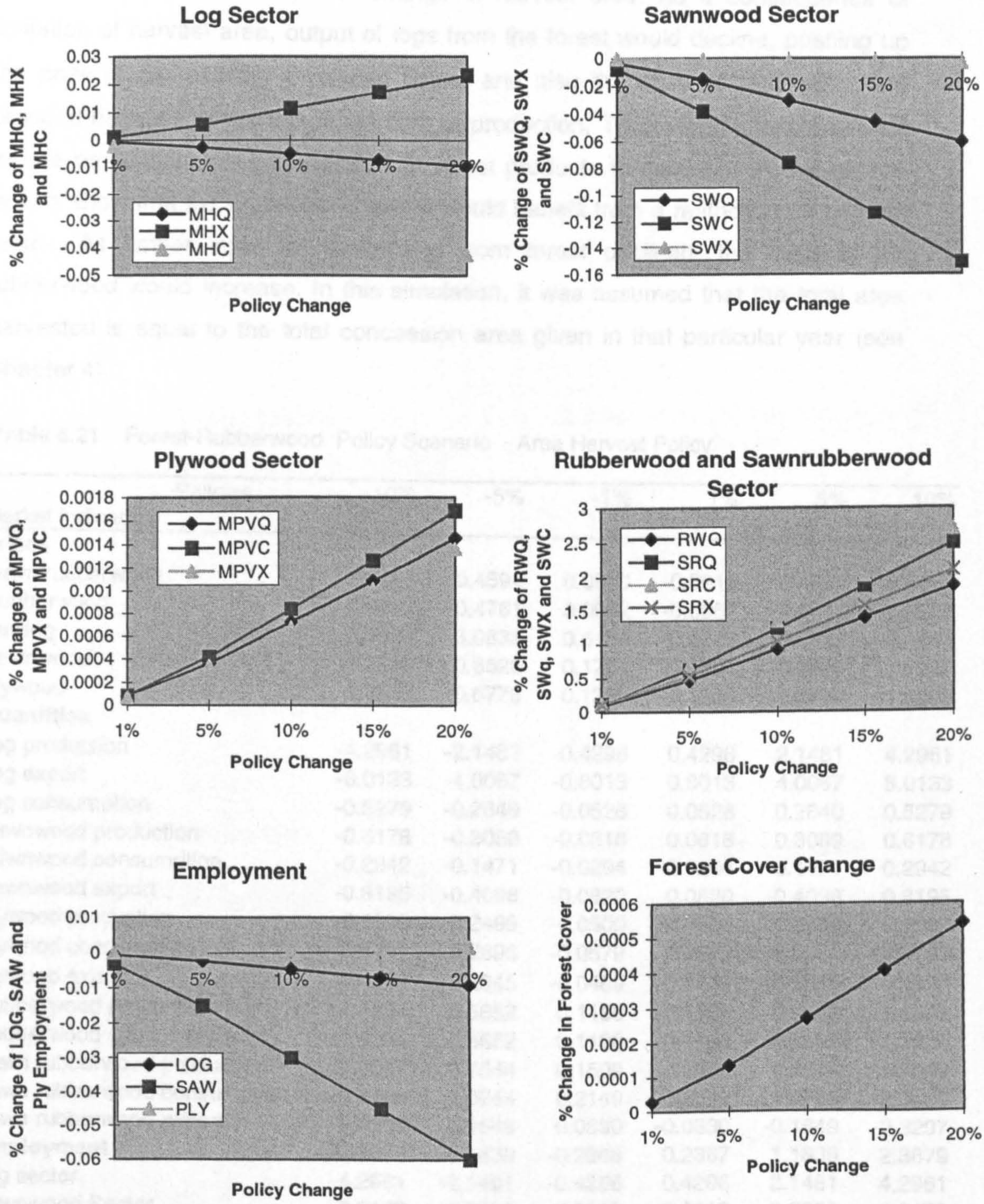
6.3.6. Rubberwood Price Subsidies.

Table 6.20 gives the results for 1 to 20 per cent price subsidies on rubberwood given to rubber producers. The results show that subsidies on rubberwood price would encourage the supply of rubberwood. A ten per cent price subsidy would increase rubberwood production by 0.9 percent. Rubberwood price is penalised by this policy, as the rubberwood price would decrease by more than 8 per cent, giving only a small gain to the rubberwood producers.

Table 6.20 Forest-Rubberwood Policy Scenario - Rubberwood Price Subsidies

Policies / Market Indicators	1%	5%	10%	15%	20%
Prices					
Sawn rubberwood	-0.0792	-0.3962	-0.7924	-1.1885	-1.5847
Rubberwood	-0.9213	-4.6065	-9.2130	-13.8194	-18.4259
Sawlog	-0.0009	-0.0045	-0.0090	-0.0135	-0.0180
Sawnwood	-0.0061	-0.0303	-0.0607	-0.0910	-0.1214
Plywood	-0.0002	-0.0010	-0.0020	-0.0030	-0.0039
Quantities					
Log production	-0.0005	-0.0023	-0.0046	-0.0069	-0.0093
Log export	0.0012	0.0058	0.0117	0.0175	0.0233
Log consumption	-0.0021	-0.0106	-0.0212	-0.0317	-0.0423
Sawnwood production	-0.0030	-0.0150	-0.0300	-0.0450	-0.0600
Sawnwood consumption	-0.0076	-0.0378	-0.0756	-0.1134	-0.1511
Sawnwood export	-0.0002	-0.0008	-0.0016	-0.0023	-0.0031
Plywood production	0.0001	0.0004	0.0007	0.0011	0.0015
Plywood consumption	0.0001	0.0004	0.0008	0.0013	0.0017
Plywood export	0.0001	0.0003	0.0007	0.0010	0.0014
Rubberwood production	0.0934	0.4669	0.9338	1.4007	1.8677
Rubberwood consumption	0.0934	0.4669	0.9338	1.4007	1.8677
Sawn rubberwood production	0.1246	0.6232	1.2464	1.8695	2.4927
Sawn rubberwood consumption	0.1351	0.6757	1.3514	2.0271	2.7028
Sawn rubberwood export	0.1053	0.5264	1.0529	1.5793	2.1058
Employment	-0.00134	-0.00672	-0.01345	-0.02017	-0.0269
Log sector	-0.0005	-0.0023	-0.0046	-0.0069	-0.0093
Sawnwood sector	-0.0030	-0.0150	-0.0300	-0.0450	-0.0600
Plywood sector	0.0001	0.0004	0.0007	0.0011	0.0015
Change in forest cover	2.69E-05	0.000135	0.00027	0.000405	0.00054

Figure 6.12 Forest-Rubberwood Policy Scenario - Rubberwood Price Subsidies



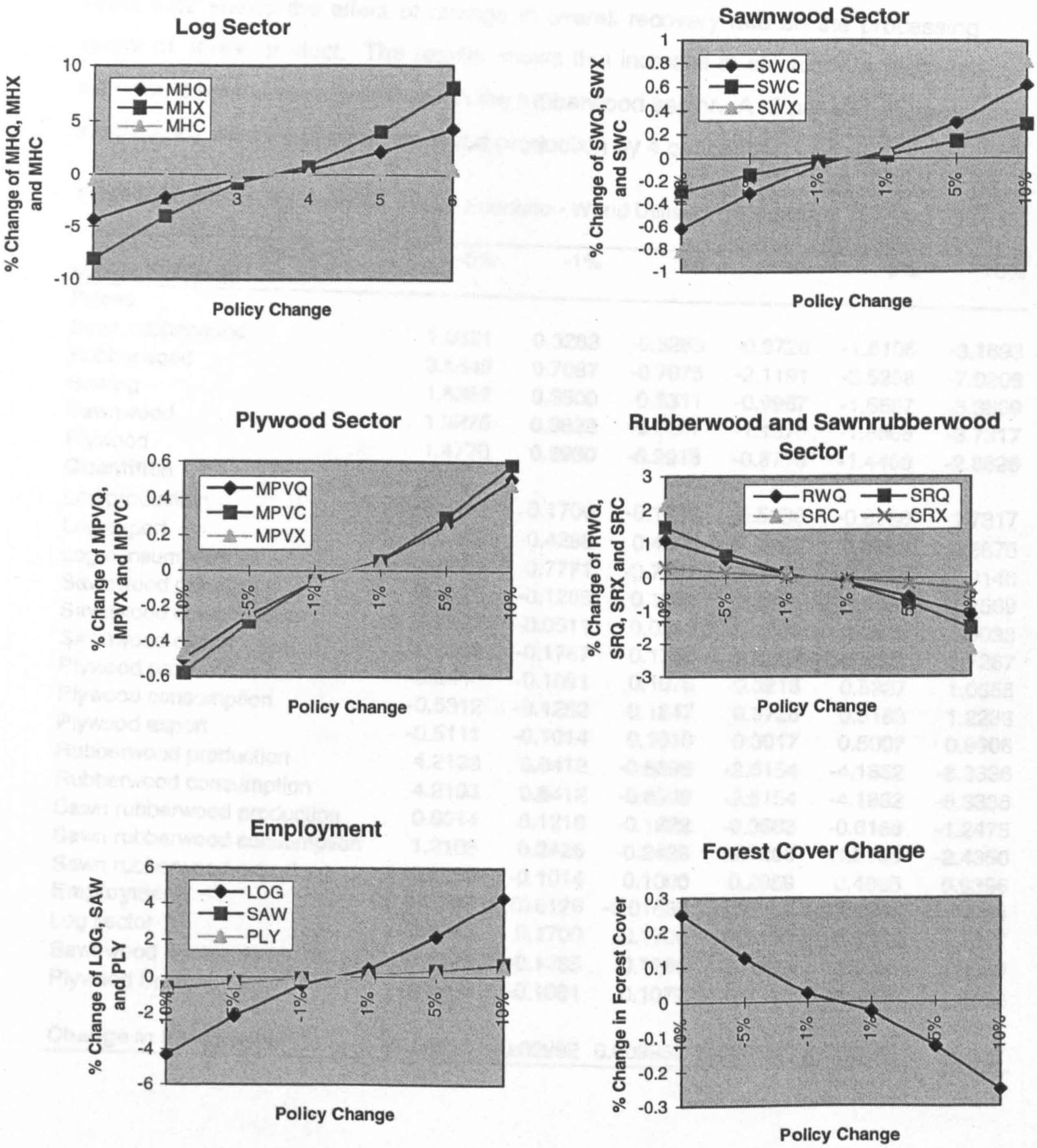
6.3.7. Area Harvest Policy

Table 6.21 shows the effect of change in harvest area. As a consequence of limitation of harvest area, output of logs from the forest would decline, pushing up the price of domestically produced timber and also the price of sawnwood and plywood because of the increased cost of production. The overall effect would be for the production and consumption of forest products to decline. However, the results show that the rubberwood sector would benefit from a restriction on harvest area. As timber input for processing from forest declined, the demand for rubberwood would increase. In this simulation, it was assumed that the total area harvested is equal to the total concession area given in that particular year (see Chapter 4).

Table 6.21 Forest-Rubberwood Policy Scenario - Area Harvest Policy

Policies Market Indicators	-10%	-5%	-1%	1%	5%	10%
Prices						
Sawn rubberwood	0.9188	0.4594	0.0919	-0.0919	-0.4594	-0.9188
Rubberwood	0.9523	0.4761	0.0952	-0.0952	-0.4761	-0.9523
Sawlog	6.1664	3.0832	0.6166	-0.6166	-3.0832	-6.1664
Sawnwood	1.7239	0.8620	0.1724	-0.1724	-0.8620	-1.7239
Plywood	1.3553	0.6776	0.1355	-0.1355	-0.6776	-1.3553
Quantities						
Log production	-4.2961	-2.1481	-0.4296	0.4296	2.1481	4.2961
Log export	-8.0133	-4.0067	-0.8013	0.8013	4.0067	8.0133
Log consumption	-0.5279	-0.2640	-0.0528	0.0528	0.2640	0.5279
Sawnwood production	-0.6178	-0.3089	-0.0618	0.0618	0.3089	0.6178
Sawnwood consumption	-0.2942	-0.1471	-0.0294	0.0294	0.1471	0.2942
Sawnwood export	-0.8195	-0.4098	-0.0820	0.0820	0.4098	0.8195
Plywood production	-0.4999	-0.2499	-0.0500	0.0500	0.2499	0.4999
Plywood consumption	-0.5791	-0.2896	-0.0579	0.0579	0.2896	0.5791
Plywood export	-0.4690	-0.2345	-0.0469	0.0469	0.2345	0.4690
Rubberwood production	1.1304	0.5652	0.1130	-0.1130	-0.5652	-1.1304
Rubberwood consumption	1.1304	0.5652	0.1130	-0.1130	-0.5652	-1.1304
Sawn rubberwood production	1.5087	0.7544	0.1509	-0.1509	-0.7544	-1.5087
Sawn rubberwood consumption	2.1489	1.0744	0.2149	-0.2149	-1.0744	-2.1489
Sawn rubberwood export	0.3297	0.1649	0.0330	-0.0330	-0.1649	-0.3297
Employment	-2.3679	-1.1839	-0.2368	0.2367	1.1839	2.3679
Log sector	-4.2961	-2.1481	-0.4296	0.4296	2.1481	4.2961
Sawnwood Sector	-0.6178	-0.3089	-0.0618	0.0618	0.3089	0.6178
Plywood Sector	-0.4999	-0.2499	-0.0500	0.0500	0.2499	0.4999
Change in forest cover	0.250605	0.125303	0.02506	-0.02506	-0.1253	-0.25061

Figure 6.13 Forest-Rubberwood Policy Scenario - Area Harvest Policy



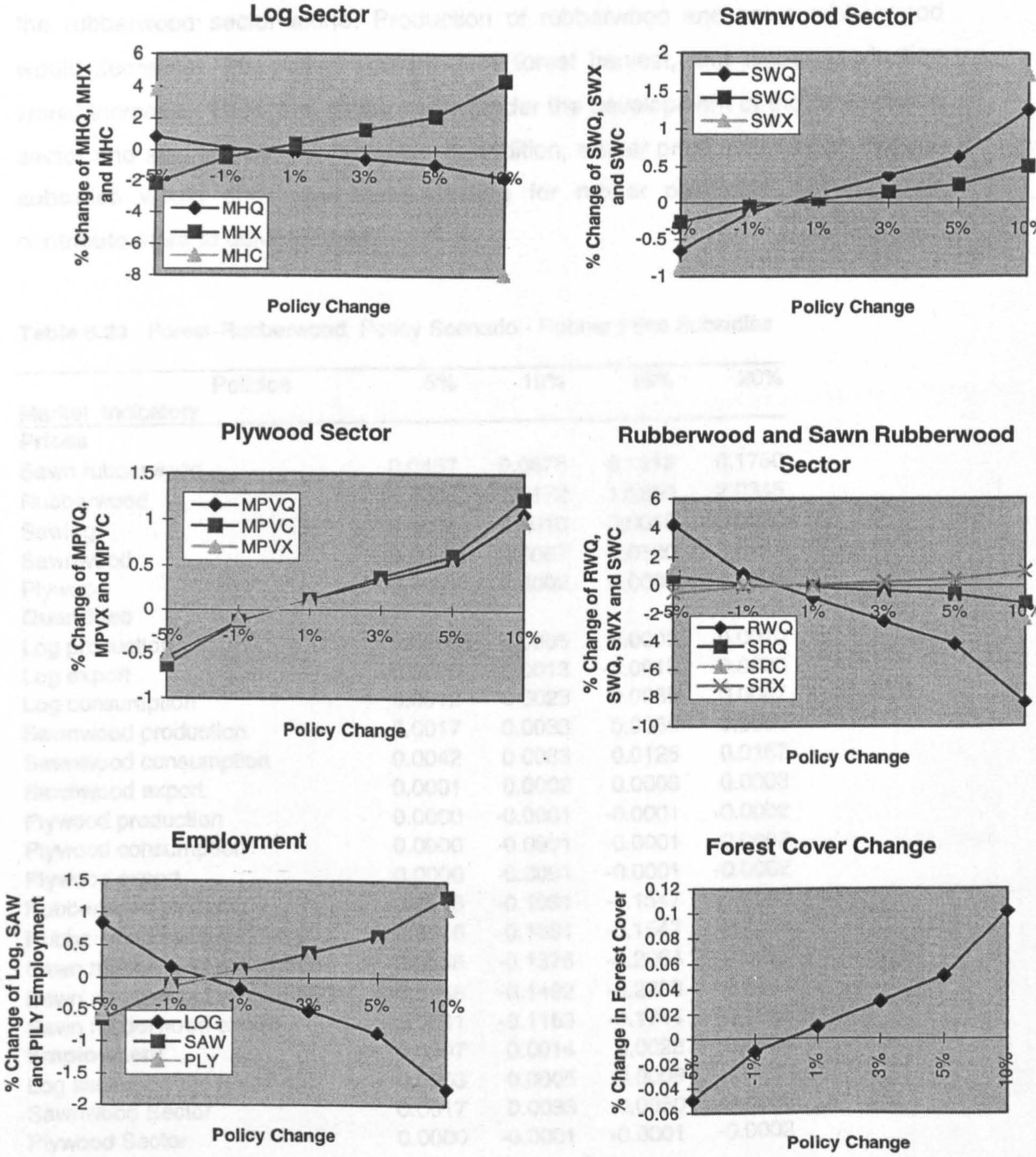
6.3.8. Wood Utilisation Efficiency

Table 6.22 shows the effect of change in overall recovery rate on the processing sector of forest product. The results shows that increase in efficiency in recovery rate would have a negative effect on the rubberwood sector. A 5 per cent increase in efficiency would reduce rubberwood production by 4 per cent.

Table 6.22 Forest-Rubberwood Policy Scenario - Wood Utilisation Efficiency

Policies Market Indicators	-5%	-1%	1%	3%	5%	10%
Prices						
Sawn rubberwood	1.6621	0.3283	-0.3263	-0.9726	-1.6106	-3.1693
Rubberwood	3.5545	0.7087	-0.7075	-2.1191	-3.5258	-7.0206
Sawlog	1.6387	0.3300	-0.3311	-0.9967	-1.6667	-3.3609
Sawnwood	1.9275	0.3823	-0.3807	-1.1370	-1.8868	-3.7317
Plywood	1.4770	0.2930	-0.2918	-0.8718	-1.4469	-2.8626
Quantities						
Log production	0.8443	0.1700	-0.1706	-0.5136	-0.8588	-1.7317
Log export	-2.1295	-0.4288	0.4303	1.2952	2.1659	4.3676
Log consumption	3.8589	0.7771	-0.7797	-2.3471	-3.9249	-7.9146
Sawnwood production	-0.6475	-0.1285	0.1280	0.3825	0.6349	1.2569
Sawnwood consumption	-0.2571	-0.0511	0.0510	0.1526	0.2535	0.5033
Sawnwood export	-0.8909	-0.1767	0.1760	0.5259	0.8727	1.7267
Plywood production	-0.5448	-0.1081	0.1076	0.3216	0.5337	1.0558
Plywood consumption	-0.6312	-0.1252	0.1247	0.3726	0.6183	1.2233
Plywood export	-0.5111	-0.1014	0.1010	0.3017	0.5007	0.9906
Rubberwood production	4.2193	0.8412	-0.8399	-2.5154	-4.1852	-8.3336
Rubberwood consumption	4.2193	0.8412	-0.8399	-2.5154	-4.1852	-8.3336
Sawn rubberwood production	0.6014	0.1216	-0.1222	-0.3683	-0.6168	-1.2475
Sawn rubberwood consumption	1.2105	0.2426	-0.2428	-0.7290	-1.2159	-2.4350
Sawn rubberwood export	-0.5205	-0.1014	0.1000	0.2959	0.4865	0.9396
Employment	0.075297	0.016126	-0.01666	-0.05159	-0.08868	-0.19084
Log sector	0.8443	0.1700	-0.1706	-0.5136	-0.8588	-1.7317
Sawnwood Sector	-0.6475	-0.1285	0.1280	0.3825	0.6349	1.2569
Plywood Sector	-0.5448	-0.1081	0.1076	0.3216	0.5337	1.0558
Change in forest cover	-0.04925	-0.00992	0.009952	0.029957	0.050095	0.101017

Figure 6.14 Forest-Rubberwood Policy Scenario - Wood Utilisation Efficiency



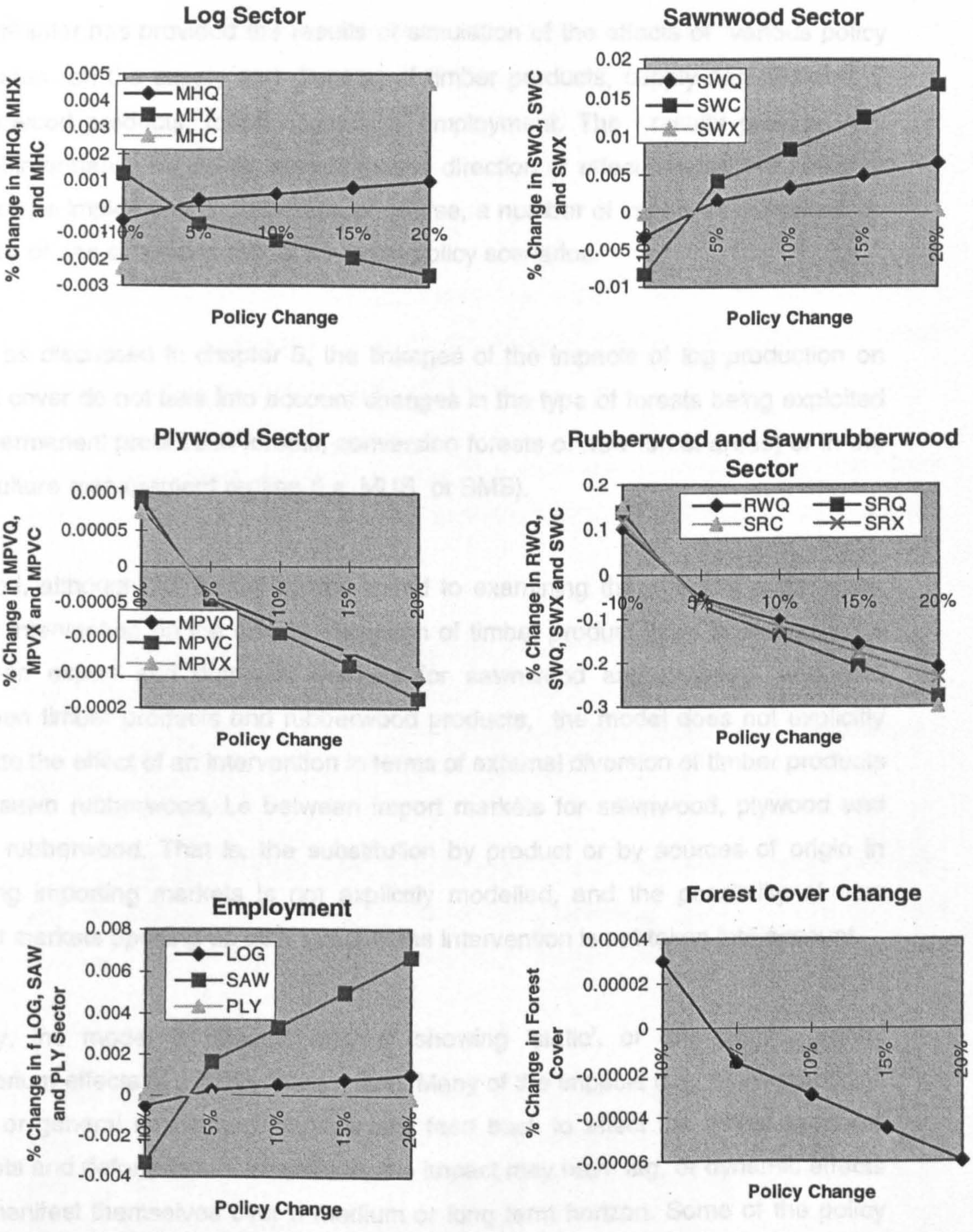
6.3.9. Rubber Price Subsidies

The simulation results in Table 6.23 indicate a similar direction of change to that for the rubberwood sector alone. Production of rubberwood and sawn rubberwood would decrease. The policy would induce forest harvest, and timber production would increase. Thus, this policy would hinder the development of the rubberwood sector and also induce deforestation. In addition, rubber price stabilisation through subsidies would encourage land clearing for rubber plantation, which would contribute more to deforestation.

Table 6.23 Forest-Rubberwood Policy Scenario - Rubber Price Subsidies

Policies Market Indicators	5%	10%	15%	20%
Prices				
Sawn rubberwood	0.0437	0.0875	0.1312	0.1750
Rubberwood	0.5086	1.0172	1.5259	2.0345
Sawlog	0.0005	0.0010	0.0015	0.0020
Sawnwood	0.0033	0.0067	0.0100	0.0134
Plywood	0.0001	0.0002	0.0003	0.0004
Quantities				
Log production	0.0003	0.0005	0.0008	0.0010
Log export	-0.0006	-0.0013	-0.0019	-0.0026
Log consumption	0.0012	0.0023	0.0035	0.0047
Sawnwood production	0.0017	0.0033	0.0050	0.0066
Sawnwood consumption	0.0042	0.0083	0.0125	0.0167
Sawnwood export	0.0001	0.0002	0.0003	0.0003
Plywood production	0.0000	-0.0001	-0.0001	-0.0002
Plywood consumption	0.0000	-0.0001	-0.0001	-0.0002
Plywood export	0.0000	-0.0001	-0.0001	-0.0002
Rubberwood production	-0.0516	-0.1031	-0.1547	-0.2062
Rubberwood consumption	-0.0516	-0.1031	-0.1547	-0.2062
Sawn rubberwood production	-0.0688	-0.1376	-0.2064	-0.2752
Sawn rubberwood consumption	-0.0746	-0.1492	-0.2238	-0.2984
Sawn rubberwood export	-0.0581	-0.1163	-0.1744	-0.2325
Employment	0.0007	0.0014	0.0022	0.0029
Log sector	0.0003	0.0005	0.0008	0.0010
Sawnwood Sector	0.0017	0.0033	0.0050	0.0066
Plywood Sector	0.0000	-0.0001	-0.0001	-0.0002
Change in forest cover	-1.5E-05	-3E-05	-4.5E-05	-6E-05

Figure 6.15 Forest-Rubberwood Policy Scenario -Rubber Price Subsidies



6.4. Summary and Conclusion

This chapter has provided the results of simulation of the effects of various policy scenarios on the supply and demand of timber products, supply and demand of rubberwood products, forest cover and employment. The results provide very useful information for policy makers on the direction of effect, should the policy or policies be implemented. There are, of course, a number of important limitations on the use of the simulation model for these policy scenarios.

First, as discussed in chapter 5, the linkages of the impacts of log production on forest cover do not take into account changes in the type of forests being exploited (i.e. permanent production forests, conversion forests or new forest areas) or in the silvilculture management regime (i.e. MUS or SMS).

Second, although the model is well suited to examining the effect of a particular policy intervention on the internal diversion of timber product flows in Malaysia, i.e between export and domestic markets for sawnwood and plywood, and also between timber products and rubberwood products, the model does not explicitly indicate the effect of an intervention in terms of external diversion of timber products and sawn rubberwood, i.e between import markets for sawnwood, plywood and sawn rubberwood. That is, the substitution by product or by sources of origin in existing importing markets is not explicitly modelled, and the possibility of new import markets opening up as a result of the intervention is not taken into account.

Finally, the model is capable only of showing 'static', or one period, partial equilibrium effects of a policy intervention. Many of the impacts may have economy-wide, or general equilibrium, impacts that feed back to affect the timber products markets and deforestation. In addition, the impact may have lag, or dynamic effects that manifest themselves over a medium or long term horizon. Some of the policy interventions themselves, such as wood efficiency utilisation and the implementation of sustainable management practices, would realistically involve a longer process of implementation than a single period.

Despite its simplicity and keeping these obvious limitations in mind, it is nevertheless useful to use the simulation model to obtain an approximate indication of the relative impacts of different trade and alternative policy intervention on Malaysia's timber product markets and forest resource base. The simulation results enable the policy maker to identify policies that are likely to be beneficial for promotion of growth in the timber products industry and wood resource management in Malaysia. This simulation analysis leads to six broad results:

i. The results support previous studies that show within a two period framework that a restriction on sawnwood export would reduce timber harvest, reduce sawnwood production and increase plywood production.

ii. The results support previous studies that show within a two period framework that a restriction or total ban on log export would further develop the processing sector, and improve the forest cover.

iii. The results support the hypothesis that export restriction on sawnwood would distort the development of the rubberwood sector. The rubberwood sector would shrink because of a decline in sawn rubberwood consumption due to substitution by sawnwood.

iv. Within two period framework, market restriction on processed timber products, with the objective of promoting the timber processing sector, always shows a positive result for forest cover. Increased in market restriction would improve the forest cover.

v. Short supply of timber resources would promote the rubberwood sector. This implies that policy changes such as trade liberalisation would be expected to yield not only economic but also environmental benefits from rubberwood sector, in the form of reduced pressure on existing forests.

vi. Except for a log restriction policy, a wood utilisation efficiency policy would not only promote the development of the processing sector but also improve the forest cover.

Chapter 7

SPECIES ANALYSIS

The effect of several policies on timber production and forest cover has been discussed in Chapter 6. The discussion was based wholly on aggregate timber production which encompasses a wide range of timber species, and no reference was made to the effect on timber species themselves. The objective of this chapter is to investigate the effect of policies discussed in chapter 6 on the efficiency of species utilisation. It examines the efficiency of timber utilisation base on species. This chapter also examines the conflict between the policy promoting timber species utilisation and conservation of tree species. This chapter introduces a species approach in investigating the forest cover relationship. As an introduction to this chapter, a discussion is presented of tree species diversity in Malaysia, which is a very useful information for the discussion of species analysis. The data used, and the sources of that data for analysis are described in the relevant sections.

7.1. Malaysian Timber Species Diversity.

Detailed studies of trees and vine inventories have found that plant species richness shows clear increases with total rainfall and length of rainy season. Thus the greatest plant species richness is in tropical forest. All tropical rainforests are fabulously rich in both plant and animal species (Whitmore, 1984, 1990); they appear to have more species than any other ecosystem on earth. Consider just the trees: the whole of Europe north of the Alps and west of the Commonwealth of Independent States (CIS) has 50 native tree species, and all of eastern North America has 171 species. By comparison, small sample plots of tropical rainforest commonly have 100 species (and many have more than 200 species) of trees at least 10 cm in diameter at breast height (dbh).

Malaysian rain forest belongs to the Malesia floristic region of archipelagic Southeast Asia. The region extends from the Kra Isthmus (just north of the border between west Malaysia and Thailand) through the archipelago to the Torres Strait (between Australia and New Guinea) and the Bismarck Archipelago (east of New Guinea), occupying a total land area of approximately 3 million km^2. The Malesia region is one of the most species-rich terrestrial ecosystems, comparable to, if not richer than tropical rainforest elsewhere in the world. More than 40,000 species of vascular plants have been recorded in this region. Of these tropical species, slightly more than 36,000 are flowering plants distributed in 266 families and 3076 genera and 87 species are conifers, which belong to 5 families and 12 genera (de Laubenfels, 1988; Ross, 1992. Cited in Soepadmo 1995). If trees with a diameter at breast height (dbh) of 10 cm or larger are considered, the 50 ha plot at Pasoh Forest Reserve, Peninsular Malaysia, contains 660 species in 244 genera and 67 families. The species diversity and density of trees per hectare at Pasoh Forest Reserve are comparable to those of other lowland rainforests in Malesia, and they exceed those of much larger plots in other tropical regions (Seopadmo, 1995), such as the 36,000 km^2 forest at Corocovado National Park, Costa Rica, which has 238 species, or the 170 ha plot at Rio Palenque, Equador, which has 154 species. The 10 most specious families encountered at Pasoh Forest Reserve are listed in Table 7.1.

Table 7.1 The Ten Most Specious Families of Plants 10 cm dbh or Greater in the 50 ha Plot of Pasoh Forest Reserve.

Rank	Family	Species (Peninsular Malaysia/Pasoh)
1	Euphorbiaceae	371 / 87
2	Myrtaceae	210 / 50
3	Lauraceae	213 / 48
4	Rubiaceae	450 / 46
5	Annonaceae	198 / 44
6	Meliaceae	91 / 43
7	Anacardiaceae	74 / 32
8	Clusiaceae	121 / 31
9	Myristicaceae	53 / 31
10	Diptrocarpaceae	155/ 30

Source: Kochummen et al., (1990), cited in Seopadmo (1995).

Ecological studies on the diversity and distribution patterns of the flora of Mt. Kinabalu in Sabah, East Malaysia by Beaman and Beaman (1990) have recorded about 4,000 species of vascular plants, representing 180 families and 950 genera within an area of about 700 km^2. The structural complexity of tropical rainforests in Malesia is due largely to the presence of diverse plant species in a particular habitat. Wyatt-Smith (1964) provides a concise description of this structural complexity

> The primary lowland forests are usually dense, though comparative freedom of movement on the ground is possible. They are composed of many thousands of species of trees (often up to one hundred different species with a girth of more than one foot are found to the acre), as well as shrubs, herbs and woody climbers. The upper or emergent storey is usually about 100 to 150 feet high, though trees nearly 200 feet in height are often present. This storey is often discontinuous. An average of one or two trees per acre may have a girth of ten feet or more. This upper or emergent storey is usually characterised by a high occurance, about fifty per cent, of the family Dipterocarpaceae, though in some forests they are rare or almost absent. The main storey or second tree layer, which occupies a region of about 70 to 100 feet from the ground, forms a continuous canopy except immediately below the large emergent storey trees. This storey consists of young trees of the normal upper storey species together with, predominantly, members of the families Burseraceae, Guttiferae, Myristicaceae, Myrtaceae (Eugenia spp) and Sapotaceae. The understorey or third tree layer consists of saplings of the upper two storeys together with members of such families as Annonaceae, Euphorbiaceae, Flacourtiaceae and Rubiaceae. The density of the shrub layer varies from very thick and dense to open. It contains young saplings of larger trees, shrub species of Annonaceae, Euphorbiaceae and Rubiaceae and palms. The herb layer consists mainly of young seedlings of the other layers and lianes, with some aroids and ferns near streams and in moist valleys. Epiphytes are usually poorly represented. There is usually a comparatively poor layer of litter, though fallen leaves often cover the forest floor. Many of these trees are buttressed; some have stilt roots; others have fluted stems. The bark ranges from smooth, scaly to fissured, and the form of the stems is excellent, with typically a long clear bole and little taper.
>
> (Wyatt-Smith,1964: 203-204)

A lot of work has been devoted to estimating the diversity of plant species in Malaysia, describing and classifying them. Despite the energetic work of many botanists during the past century, many species of plants await description, and many others await redescription and probable reclassification. Crude estimates of species numbers, however, suffice to emphasise the enormous richness of

Malaysia's plant resources. Table 7.2 gives a summary of some of the earlier works on Peninsular Malaysia's plant species.

Dunn (1975) has estimated that there are between 9,000 and 10,000 species of plants in Peninsular Malaysia, including 8,000 to 9,000 flowering species. According to Dunn, perhaps five percent of these species have been introduced to Peninsular Malaysia in recent times. His estimation was based on Desch (1951,1954) and Henderson (1954, 1959),

Table 7.2 Plant Species of Peninsular Malaysia.

Plants (terrestrial)	No. Genera in Lists	No. Species in List
Timber Trees (Dicotyledons) (Desch 1941, 1954)	749	3830+
Additional Dicotyledons (Henderson 1959)	200+	850++
Monocotyledons (Henderson 1954)	319	1670
Ferns (Holttum 1954)	111	480
Other Plants	?	200+
Totals	1,379+	7,030++
(True plant total probably about 9,000 - 10,000 species)		

Source : Dunn (1975).

Another perspective on Peninsular Malaysia's plant diversity is provided by Burkill (1966). 92 per cent of Burkhill's work was devoted to botanical products, six percent to zoological items, and only two per cent to non-biotic materials. He listed 1751 botanical genera, including marine plants, fungi, algae, ferns, fern-allies, trees herbs, grasses and climbers. Of these genera only about 50 are not indigenous to Peninsular Malaysia. Burkhill listed an average of five species per genus, which makes the total number of species about 8,755.

For the ferns, the best available estimate is that of Holttum (1954), who recognised 480 species in 111 genera. Several hundred species of mosses and non-marine algae have also been recorded for Peninsular Malaysia.

The largest form of plant species are the timber trees. Desch (1941,1954) listed trees capable of reaching sawmill size and some of their relatives, and only those recognised as indigenous to the Peninsular Malaysia. With these limitations, he still found it necessary to treat 83 families that accommodate 749 genera and substantially more than 3,830 species of trees. In a complementary work, Corner (1952) provided descriptions of 76 families, 392 genera, and 950 species of trees found in habitats other than the primary forest. Corner's work included many species introduced to Peninsular Malaysia in recent times. Corner estimated that the total number of species of Peninsular Malaysia's flowering plants to be upward of 8,000.

Henderson (1954, 1959) noted that there are thought to be 'between 8,000 and 9,000 species of flowering plants in Peninsular Malaysia-and this excludes ferns, mosses, lichens, fungi and so on.' In Henderson's volume on Dicotyledons, he listed 38 families, several hundred genera, and well over 850 species of indigenous flowering plants in addition to those covered in Desch's manual. In his Monocotyledon volume he treated 29 families, 319 genera, and 1670 species, most of which are indigenous. Whitmore (1984) estimated that, there are around 2,500 tree species in Peninsular Malaysia, with 890 of these species reaching harvestable sizes of at least 45 cm dbh. In Peninsular Malaysia there are 2,830 tree species in 532 genera and 100 families (Ng et al., 1990), whereas in Sabah and Sarawak at least 3,500 species in 500 genera and 105 families have been reported (Anderson, 1980; Burgess, 1966).

Peninsular Malaysia's forest has been known to be one of the richest area of tree species in the Diptrocarpacaeae family among the tropical rainforests. Most of the major timber species produced from Peninsular Malaysia are from this family. Most of these rainforest diptrocarps are huge trees, up to 40-50 m or more in height and up to 2-3 m in diameter. Commercially they can be grouped into light hardwood, medium hardwood and heavy hardwood. A descriptive comparison of the species of Peninsular Malaysia with other regions of Africa and Asia is given by Ashton (1982). Ashton reported that Peninsular Malaysia has 14 genera of this type of tree, with a total of 168 species, which is the second highest, behind Borneo (Table 7.3).

Table 7.3 Distribution of Dipterocarpacaeae

Region/Countries	No of genera	No of species
Africa	2	34
India	6	14
Seychelles	1	1
Sri Lanka	10	44
Burma	10	34
Thailand	10	32
Peninsular Malaysia	14	168
Sumatra	2	72
Java	5	10
Borneo	13	276
Sulawesi	4	6
Indo-China	10	32
Peninsular		
Philippines	11	52
New-Guinea	3	5
Moluccas	4	8

Source: Ashton (1982)

A particularly good example of Malaysia's plant diversity has been provided by Causens (1958). Causens reports on a complete enumeration of 63 hectares of primary forest of Pangkor Island, Peninsular Malaysia. The study included large trees only, over four feet in girth at breast height or above buttresses. The tract contained 4,267 large trees; about 70 trees per hectare. With respect to identification Causens has this to say:

> Sixty two percent of the 4267 trees measured were of well known species with monospecific Malay names, thirty one percent were matched with reasonable certainty as the species, two percent (76) could only be placed in their genus, four percent (164) belonged to three genera for which two species could not be separated confidently in the records, and less than two percent (67) remained unidentified.
>
> (Causens 1958: p. 157).

The Pangkor Island tract contained 173 species of large trees. Of these, 41 species were represented only by single trees in the entire tract, 24 species occurred only twice, and 14 species occurred three times. At the other extreme, the tenth most frequent species (119 individuals) was distributed at less than four times per acre. As the acreage enumerated increased the total species count also increased. Thus, 4.047 hectares (10 acres) revealed 57 species, 8.094 hectares (20 acres) revealed 78 species, 20.235 hectares (50 acres) revealed 110 species, 24.282 hectares (60 acres) revealed 129 species, 32.376 hectares (80 acres) revealed 143 species and the final 63 hectares (155 acres) revealed 173 species. A second example, cited by Harrison (166:16), gives another indication of botanical richness in the Malaysian forest. In about one hectare of lowland forest near Kuala Lumpur, a count showed 559 mature trees of 227 different species. The commonest of these species was represented by fewer than 40 individuals.

Low (1967) has reported an enumeration survey by the Malaysian Forest Department in the subsistence zone[1] . The survey was done according to type of forest. The classification of forest types is based on common species[2] found in the particular area of survey. Table 7.4 gives the information about the trees and the species of the survey. These type characterisations serve only as an introduction to the botanical richness and diversity of the reserve.

Table 7.4 Tree Species of Subsistence Zone for Three Forest Types.

Type of Forest	Counted species	No of large trees	Average trees per acre
Kempas-kedondong -kelat	16	43	28.7
	22	56	23.4
Kempas-Red Meranti	23	52	34.6
Red Meranti	19	40	26.6
Average trees per acre			28.3

Source: Low (1967).

[1] A subsistence zone here is defined as that region around a settlement that is open to exploitation and is regarded as exploitable and familiar territory by at least some members of the community. The limits of the zone may extend beyond one day's round trip from the settlement if swidden field huts or temporary forest shelters are used for overnight stays away from the village. The community in this survey refers to the Temuan Community in Northern Selangor, Peninsular Malaysia.

[2] Kempas-Kedondong-Kelat forest is the forest that has common species of Kempas (Koompassia malaccensis), Kedondong (Burseraceae - Canarium spp, Sanitiria spp) and Kelat (Eugenia spp). Kempas-Red Meranti forest is rich in Kempas and Red Meranti (Shorea leprosula). A similar classification was made by Wyatt-Smith (1964).

In a study by Dunn (1975), he estimated that, in the three layered forest dominated by Kempas, Kedondong and Kelat and Meranti tembaga, it is likely that complete tree enumeration would produce counts in the range of 200-250 large and small trees of perhaps 100-150 different species (and 75-100 genera) per acre. According to Dunn, for the reserve as a whole, the species count for trees stands above 500 and probably closer to 1000. Including all other plants, the species total for this relatively small forest reserve probably stands between 2,000 and 3,000.

A characteristic of high diversity is the presence of relatively few individuals per species per unit area. In tropical rainforest areas like Malaysia, there are many species of plants, but not very many individuals of any single species. These circumstances contrast with the low biotic diversity of deserts and lands at high latitude or high altitude; under such conditions plants and animal species are few but those species that are present are represented by very large numbers of individuals per unit area. The rarity or low density of conspecific trees is even more prominent if we consider only trees with a dbh of 30 cm or greater. Studies by Poore (1968) and Ho et al. (1987) at the Jangka Forest Reserve found that each of the approximately 38% of the tree species reaching a dbh of 30 cm or larger was represented by a single mature individual. Even the most common species on the plots account for only a small percentage of the total number of trees (Primack and Hall, 1991).

7.2. Timber Species[3] Utilisation

Implicit in the richness and diversity of timber tree in the Malaysia forest, however, are problems in the utilisation of such varied species. Of the very large number of tree species, only a few are acceptable to the timber trade. Some species are in high demand, while others are merely accepted.

According to Whitmore (1984), of 890 species which reach harvestable size in Peninsular Malaysia, only 402 species are considered commercial, but even at the

[3] Botanical names for all timber species mentioned in this chapter are listed in Appendix 4.

peak of timber exporting from Peninsular Malaysia, less than half (30 species and species groups) were exported in significant quantities. Similar figures for commercial species were reported by Ng et al., (1990), according to them of the 2,830 tree species in Peninsular Malaysia, 677 species, or about 20%, reach timber size (40 cm dbh or larger), and 402 of these have been listed as commercial species and graded into 53 timber groups and 4 main timber class. In Sabah, Burgess (1966) listed 400 tree species in 233 genera and 47 families as timber species; of these, about 150 species are currently being exploited commercially. Numerous non-commercial species have not been harvested and utilised.

The popular timber species that have dominated the market are confined to a few species of the dipterocarp family, such as meranti, keruing and kapur, and they are sold under individual timber names. Some other timber species, which may not have the volume of popular species, are commercially less accepted and usually marketed as timber groups, such as red woods or mixed hardwood. In the early 80's, an effort was made by the Forest Research Institute, Forestry Department and Malaysian Timber Industry Board to identify and list under-utilised or commercially less-accepted timber species as a means to promote their subsequent utilisation. A total of 58 less-known timber species were found to have a quality that is sufficiently large to justify their promotion. Out of 58 species, 25 species are already included in the Malaysian Grading Rules as commercial timbers. The increase in the number of acceptable species is encouraging, but it is certainly not enough as evidenced by the fact that more than 800 species are capable of producing timber in Peninsular Malaysia. Utilisation of lesser-known timber species is discussed further in the following section.

A list of commercial timber was first presented by Foxworthy (1922). Some 50 timber species were included in the list. When the Peninsular Malaysia Grading Rules were first established in 1949, 47 timber species were listed as commercially available. The number of timber species listed increased to 53 in 1968 and since 1984 to 100, to reflect the prevailing market and utilisation situation.

Naturally, over time, a scale of preference in timber utilisation has developed. The utilisation of Malaysian timber species (resources) rises through the scale of traditional use, commercial use of a few species, and intensive use of many species. As timber resources become scarcer, however, and the real price of prime species rise, the lesser- known species (LKS) and the small price logs gain wider acceptance and thus graduate into the marketable group.

In Peninsular Malaysia, logging for timber in the 19th century was focused almost entirely on one particular heavy hardwood, Cengal, a naturally durable heavy hardwood resistant to fungus and termite attack. In the first two decades of the 20th century the demand was still centred on the heavy hardwoods, including, Merbau, Resak, Giam and Balau (Wyatt-Smith, 1959). Even up to 1938, efforts at silviculture mainly concentrated on regenerating the heavy hardwoods at the expense even of the Meranti, which were counted as weeds. Attention focused on medium heavy hardwood and light heavy hardwood only after the severe depression of the1930's, when both local and domestic market expanded.

The marketing practice today and technological advances such as timber preservation, saw-blade improvement and kiln-drying have led to new species being acceptable to the market. Use of wood preservatives to improve the property of tropical timber is one of the most important factors that has led to the greater marketability of species. For example, in Peninsular Malaysia, untreated Keruing could last only for two years in contact with the ground but it lasts for twenty years when pressure treated. As certain non-naturally durable species, when so treated, have a considerably longer life than the naturally durable ones, the demand for the latter declined, the more so since they were also extremely difficult to treat. Thus the 1:2 ratio of durable hardwood to non-durable declined progressively to 1:12 by 1955 and by 1969 the heavy hardwoods' advantage in terms of strength and durability had been nullified by advances in timber preservation. The non-naturally durable timbers had also proved to be satisfactory for structural end usage in temperate climates (Wyatt-Smith, 1959; Mok, 1969).

Acceptance and utilisation of timbers were mainly dependent upon traditional standards. For example, more than two decades ago, chengal and balau were the mainstays of heavy construction work and railway sleepers and no other species were accepted. Timber was sold by names, which were already well known, and the utilisation of these species was never in doubt. What was not known was simply not utilised. The marketing of timbers based on this system did not allow for any expansion, nor for the introduction of a new species into the market. Any attempt to promote a new species would be looked upon with suspicion and distrust. As a result, there was a great deal of wastage during logging. Only trees with a market value were taken and lesser-known species were either rejected or sold as low grade wood. To break the market dominance of popular timber species, the government has taken action to promote the utilisation of other species by classifying the timber species according to suitability of use. This approach has divided timber into seven classes of utilisation; timber suitable for construction, timber suitable for panelling and partitioning, timber suitable for furniture, timber suitable for flooring, timber suitable for veneers and plywood, timber suitable for railway sleepers, timber suitable for poles and timber suitable for boxes and pallets.

7.2.1. Utilisation of Lesser-known Species (LKS).

One of the crucial questions in tropical forest management today is the future of lesser-known species (LKS). LKS are defined as commercially less accepted species left in the forest after logging operations (Yeom, 1984). Hanson (1983) defines an LKS as a species that is not being put to best advantage. Hundreds of potentially valuable trees are left behind-often simply to be burnt-in forest clearing operations like logging, agricultural conversion and dam building. Little is known at present about their possible end-uses, or even their physical properties.

Forestry Department Statistics (Forestry Department, 1992), indicate that the average volume of logs harvested per hectare from 1971 to 1978 was 24 m^3/ha, while that from 1979 to 1990 was 45 m^3/ha. The increase in log volume per hectare harvested was attributed to the increased utilisation of timber species, especially the commercially-less accepted species or under utilised species. It was reported in a study of the timber consumption pattern in Peninsular Malaysia 1983 - 1987, that the most common under-utilised timbers used for various local end uses were mixed light hardwoods and mixed medium hardwoods. Most of these timbers were used by the construction sector for temporary structure link scaffolding, form-work and other applications in low cost housing schemes. It was estimated that the total gross volume of under utilised timber for trees having a diameter greater than 30cm dbh 440 million m^3 amounted to 50 percent of all the timber available.

According to Yeom (1984), it has to be stressed that fuller utilisation of under utilised timber species and the LKS for Malaysia is possible in the case of Peninsular Malaysia only because of the presence of a well-developed log processing industry, coupled with a relatively sizeable local market. The situation is quite different with Sabah and Sarawak, where domestic consumption is small and forest industries are not well developed. Table 7.5 and its related figure show this. Peninsular Malaysia which has a more developed processing industry, has produced more LKS compared to Sabah and Sarawak. Similarly, Sabah, which developed its processing industries in the late 1980s, has shown an increase in percentage production of LKS.

Table 7.5 Percentage Production of LKS, Malaysia, 1980-1991.

Year	Sabah	Sarawak	PM
80	4.61	4.07	27.65
81	3.15	6.10	29.41
82	5.59	4.38	25.91
83	2.69	6.41	20.28
84	4.77	5.07	27.37
85	5.17	5.79	18.18
86	4.94	6.31	19.41
87	9.20	4.05	20.49
88	11.16	3.78	25.67
89	11.78	3.12	30.70
90	11.12	3.29	20.71
91	13.16	2.66	24.36

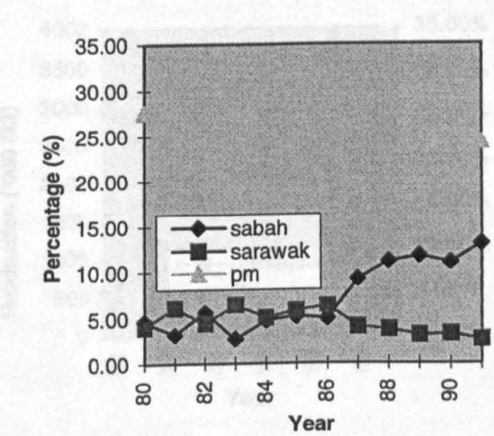
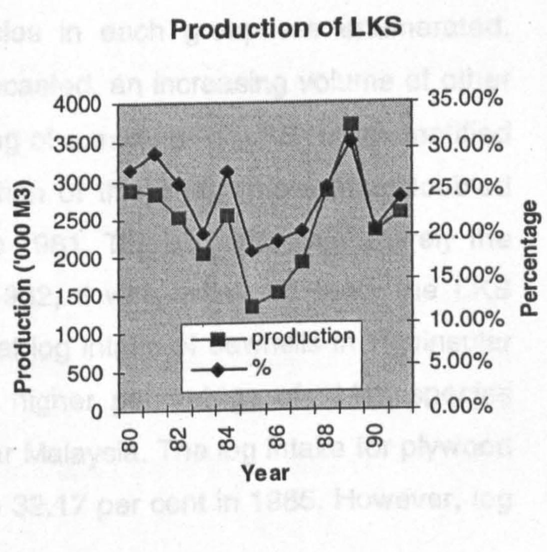


Table 7.6 explains further the behaviour of production of LKS for Peninsular Malaysia. The production of LKS has declined since Peninsular Malaysia imposed the export restriction policy on logs. The production of LKS reached the lowest point when the total log ban was imposed on all sizes of log from Peninsular Malaysia. In 1980 the total production of LKS was 2.882 million m^3 and in 1985 it reduced to only 1.336 million m^3. The decline was only short term; production increased in the following year and reached over three million m^3 in 1991. The Table 7.6 and its related graph also show that the production of LKS declined slightly when the government started imposing export taxes on sawnwood and plywood in 1990. These changes could be due to the availability of a lot of higher quality timber from well known timber species for the domestic market, which caused the demand for LKS decline. The graph also shows that there is a close relationship between production of LKS and its percentage of total production. The share of LKS is at its highest when the total production is at its peak and the share is at its lowest when production is at the lowest. This indicates that the variation in production is related to the extraction of LKS; if the timber is in demand, more LKS will be harvested. This also indicates that the primary species cannot meet the market demand, leading to reliance on LKS species.

Table 7. 6 Production of Lesser-known Species of Peninsular Malaysia ('000 m^3).

year	production		
	total	lks	lks/total (%)
1980	10424	2882	27.65%
1981	9672	2845	29.41%
1982	9774	2532	25.91%
1983	10175	2063	20.28%
1984	9371	2565	27.37%
1985	7348	1336	18.18%
1986	7829	1520	19.41%
1987	9358	1917	20.49%
1988	11129	2857	25.67%
1989	12082	3709	30.70%
1990	11281	2336	20.71%
1991	10638	2591	24.36%



The importance of the home market in the utilisation of the LKS in the situation of dwindling forest resources and a well developed timber industry is further illustrated by the experience in Peninsular Malaysia. Here, there are 38 plywood/veneer mills and 644 sawmills processing logs, both for export and local consumption, an expanding domestic market. Although there are local shortages of logs, supplies are generally adequate. However it was projected that shortage will be experienced towards the end of 1999 (Yeom, 1984). According to him Peninsular Malaysia was beginning to bypass the utilisation problem of the LKS in the late 1970s: choice species are exported while LKS are mainly sold in the home market. This development is well illustrated by examining the log intake of sawmills and plywood mills in Trengganu, one of the east coast states in Peninsular Malaysia.

Table 7.7 Log Intake of Sawmills and Plywood Mills in Trengganu, 1977-1981.

Year	Total log intake	other light hardwood
	(thousands of cubic metres)	
1977	1708	84 (4.9%)
1978	1522	135 (8.9%)
1979	1912	217 (11.3%)
1980	1892	259 (13.7%)
1981	1738	222 (12.8%)

Source: Yeom (1984).

Timber species here have been classified into three main hardwood groups: heavy, medium and light hardwood. Species in each group are enumerated. However with declining forest resources forecasted, an increasing volume of other light hardwoods is now being used, consisting of a mixture of LKS of unidentified species. As shown in Table 7.7, the utilisation of this group more than doubled during the five year period between 1977 to 1981. This increase was entirely the result of the increased use of LKS. In 1982, it was estimated that the LKS accounted for about 12.5 percent of the total log intake of sawmills in Peninsular Malaysia. Seng and Choon (1994) give a higher percentage of LKS species utilised for plywood and sawmill in Peninsular Malaysia. The log intake for plywood was 37.14 percent in 1981 but decreased to 32.17 per cent in 1985. However, log intake from sawmills increased from 20.96 per cent in 1981 to 29.89 per cent in 1985 (Table 7.8).

Table 7.8 Percentage Intake of LKS by Plywood mills and Sawmills for Peninsular Malaysia, 1981 -1985.

Year	Plymills	Sawmills
1981	37.14	20.96
1982	34.25	25.97
1983	34.54	28.29
1984	33.90	28.79
1985	32.17	29.89

Source: Seng and Choon (1994).

The prospects are now increasingly favourable for the utilisation of the LKS in their disintegrated form as chips and particles. Table 7.9 shows that the wood-chip trade is a large and growing market. Total world exports amounted to more than 17 million m^3 in 1981 and more than doubled to more than 34 million m^3 in 1995, but most of these were from and to developed countries and involved only softwood chips (FAO, 1983). Export of tropical wood chips in Malaysia began in the 1960s with chips from old rubber trees, dipterocarp mill residues and mangroves to meet the requirements of the pulp industry in Japan. Exports declined in 1980s due to an increase in local consumption. However, they increased in the 1990s as more production came from the Sabah and Sarawak region.

Table 7.9 Exports of Woodchips ('000 m^2)

Region	year					
	1971	1981	1989	1991	1994	1995
World	5774	17469	24424	27735	30575	37021
Malaysia	612	531	60	21	34	76
ASEAN	613	531	852	694	737	846

Source: FAO (1997).

The demand for LKS also comes from the production of fibreboard. The world production of fibreboard has increased over time from over 4 million m^3 in 1971 to 20 million m^3 in 1995. Similar expansion of production also happened in the ASEAN region. In 1994 and 1995 Malaysia produced more than 200,000 m^3, most of this being exported (Table 7.10).

Table 7.10 Production and Export of Fibreboard ('000 m^2)

	1961	1970	1980	1990	1992	1993	1994	1995
World								
Production	4674	14021	16961	20215	18054	19131	19951	20375
Export	857	2062	2312	3488	4004	4408	5301	5922
ASEAN								
Production	12	69	98	167	269	410	563	514
Export	1	4	16	8	122	219	291	357
Malaysia								
Production					na	na	200	260
Export	na	0.2	na	na	31	95	186	251

Source:FAO (1997).

The discussion on timber species utilisation above indicates that without fully developed wood based industries, the present economic development and timber market conditions are not conducive to the utilisation of the LKS, especially in the following cases; agri-conversion and related development of forested land, inundation of forested land due to construction of dams, conversion of natural forest into forest plantation and low logging out-turn. Undoubtedly, it is in the first three cases above that wastage is most serious. Where forests are being clear felled for agricultural and forest plantation development, the LKS and all other vegetation are burnt for site preparation. In Sabah and Sarawak, thousands of hectares of forest were cleared annually for the cultivation of crops during the 1970s and 80s, and this trend continues at present and is expected to continue in the future.

Other than the state of industry and economic development described above, the following section analyses and discusses how market factors and policy influence the utilisation of these timber species.

7.3. Efficiency Use of Malaysian Timber Species.

Efficient use of wood resources is one of the main issues in the forest literature. Most of the discussion on efficiency (see for example Gillis, 1988b; Vincent, 1992 and Barbier et al., 1995) and the analysis in Chapter 6 of this study are focused at the industry level. Less efficient industry, would use more timber per unit of product. As argued in previous chapter the effect on forest harvest would be that more would be needed from the forest; however, the discussion did not mention the behaviour of harvest at the forest level. No attempt was made to investigate this issue. This section will fill this gap.

Forest surveys in Peninsular Malaysia have shown that the average tonnage of utilisable timber above 6" d.b.h is about 200 tons per hectare. However, the actual tonnage of timber extracted is about 30 to 50 tons per hectare (Anon, 1973). The actual amount of timber extracted per hectare of logging area is defined as harvest intensity. Harvest intensity was discussed in an earlier chapter with relation to deforestation. Harvest intensity indicates the efficiency of used of timber at forest level, a decrease in harvest intensity means a waste of timber; either it is left on the ground or the tree is left uncut.

Where there is a high diversity of timber species, analysis of efficiency using aggregate harvest is less appropriate, because different species have their own market demand and supply. Thus, at forest level, efficiency can be analysed for different timber species available. The harvest intensity is postulated to be a function of price and area harvest. The functional relationship is:

$$y_i = f(p_i, A) \qquad (7.1)$$

$$\partial y_i/\partial p_i > 0 \ , \quad \partial y_i/\partial A < 0$$

where y_i is harvest intensity for species i, p_i is price for species i, and A is the total area of harvest. The estimating equation is:

$$y_i = b_{0i} + b_{1i}p_i + b_{2i}A \qquad (7.2)$$

The coefficients b_{1i} and b_{2i} measure the harvest intensity of species *i* with respect to change in variables p_i and A respectively. b_{1i} is expected to have a positive relationship with harvest intensity; increase in price would increase the harvest intensity, which is to say that more less valuable timber of the primary species would be taken out of the forest to the market and more LKS species also would be harvested. b_{2i} is expected to have a negative relationship; increase in area harvest would reduce harvest intensity. A similar argument applies to the effect of area change on intensity of harvest, as the production relationship analysed in Chapter 5, that the loggers will harvest less per unit area of logging for more log area available. As the area increases, the loggers will be more selective; less valuable timber will be left on the ground and lesser-known species will be uncut.

7.3.1 Efficiency Analysis

In this particular analysis, the country is divided into three regions; Peninsular Malaysia, Sabah and Sarawak. This is done because of different timber species produced and differences in data availability between Peninsular Malaysia, Sabah and Sarawak. The data for analysis cover the period 1970 to 1991 for Peninsular Malaysia and Sarawak, and 1980 to 1991 for Sabah. The prices of timber species for Peninsular Malaysia are the average domestic prices; for Sabah and Sarawak, the prices used are FOB prices. The prices of lesser-known species for Sabah and Sarawak are not available; thus, no estimation could be made for this group.

The relationship was estimated using OLS estimation. The results of the analysis are shown in Table 7.11. The results in Table 7.11 show that price and area variables have the expected sign, and most of these variables are significant at the one per cent level. Price has a positive relationship, which is to say that a greater volume of a particular species will be harvested as the price increases. Area has a negative relationship, indicating that an increased area of harvest would reduce harvest intensity. That indicates that producers seem to be more selective, in terms of either the value of log or type of timber species.

Table 7.11 Harvest Intensity Relationship

Peninsular Malaysia

Heavy hardwood

$y_{bal} = 1.552$	+	$2.145 * 10^{-3}\, p_{bal}$	-	$2.25 * 10^{-6}\, A$
(4.965)***		(2.318)**		(-4.182)***
R^2 (Adj) = 0.680		d-w = 1.279		F=22.28***

$y_{cen} = 0.570$	+	$1.149 * 10^{-3}\, p_{cen}$	-	$1.32 * 10^{-6} A$
(3.589)***		(3.563)***		(-2.891)***
R^2 (Adj) = 0.795		d-w = 1.393		F=39.72***

$y_{hlks} = 0.302$	+-	$1.177 * 10^{-3} p_{hlks}$	+	$9.958 * 10^{-7}\, A$
(0.850)		(0.430)		(1.207)
R^2 (Adj) = 0.035		d-w = 1.555		F=1.366

Medium Hardwood

$y_{kem} = 1.749$	+	$1.227 * 10^{-2}\, p_{kem}$	-	$4.53 * 10^{-6}\, A$
(1.992)		(3.127)***		(-3.069)***
R^2 (Adj) = 0.683		d-w= 1.930		F=22.50***

$y_{kru} = 5.088$	-	$8.20 * 10^{-4}\, p_{kap}$	-	$2.30 * 10^{-6}\, A$
(.4.370)		(-1.040)		(-0.211)
R^2 (Adj) = -0.044		d-w = 1.566		F= 0.576

$y_{mlks} = 2.109$	+	$1.128 * 10^{-2}\, p_{mlks}$	-	$5.66 * 10^{-6}\, A$
(2.599)***		(2.913)***		(-3.238)***
R^2 (Adj) = 0.530		d-w = 0.800		F=12.271***

Light Hardwood

$y_{mers} = 1.568$	+	$9.097 * 10^{-4}\, p_{mers}$	-	$2.45 * 10^{-6}\, A$
(7.670)***		(1.845)*		(-4.949)***
R^2 (Adj) = 0.625		d-w= 1.456		F = 17.669***

$y_{rm} = 15.185$	+	$1.445 * 10^{-2}\, p_{rm}$	-	$2.79 * 10^{-5} A$
(17.279)***		(3.906)***		(-13.903)***
R^2 (Adj) = 0.906		d-w = 2.159		F= 96.969***

$y_{llks} = 7.551$	+	$4.918 * 10^{-2}\, p_{llks}$	-	$2.50 * 10^{-5}\, A$
(2.953)***		(2.942)***		(-5.593)***
R^2 (Adj) = 0.702		d-w = 1.910		F= 24.505***

$y_{lks} = 7.720$	+	$8.146 * 10^{-2}\, p_{lks}$	-	$3.29 * 10^{-5} A$
(2.695)***		(4.313)***		(-6.831)***
R^2 (Adj) = 0.764		d-w = 1.883		F= 33.312***

Table 7.10 continue

Sarawak

y_{sal} = 0.493 +	$2.796 * 10^{-2}\ p_{sal}$ -	$8.210 * 10^{-6}$ A
(1.609)	(5.347)***	(-3.595)***
R^2(Adj) = 0.773	d-w = 2.389	F=19.768***
y_{al} = 10.029 +	$2.715*10^{-3}\ p_{al}$ -	$3.08*10^{-7}$A
(9.385)***	(1.379)	(-5.549)***
R^2(Adj) = 0.917	d-w = 2.350	F=61.457***
y_{jk} = 1.667 +	$5.234*10^{-3} p_{jk}$ -	$4.96*10^{-6}$ A
(9.049)***	(3.070)***	(-10.910)***
R^2(Adj) = 0.919	d-w = 1.458	F=63.52***
y_{kem} = 0.875 +	$2.592*10^{-3}\ p_{kem}$ -	$1.57 * 10^{-6}$ A
(2.475)	(0.625)	(-1.225)
R^2(Adj) = 0.086	d-w= 1.534	F=1.515
y_{mr}= 13.014 +	$0.117\ p_{mr}$ -	$3.960 * 10^{-5}$ A
(2.137)*	(2.008)*	(-1.984)*
R^2(Adj) = 0.188	d-w = 2.438	F=2.156

Sabah

y_{sall} = 8.564 +	$3.320*10^{-3}\ p_{sal}$ -	$2.28*10^{-5}$ A
(3.760)***	(0.712)	(5.406)***
R^2(Adj) = 0.788	d-w = 2.024	F=21.505***
y_{merb} = -.119 +	$1.093*10^{-3}\ p_{merb}$ -	$4.52*10^{-7}$ A
(-0.808)	(3.274)***	(-1.210)
R^2(Adj) = 0.703	d-w= 1.609	F=14.031***
y_{rs} = 32.330 -	$1.570 * 10^{-2}\ p_{rs}$ -	$5.01*10^{-2}$A
(7.498)	(-1.093)	(-6.562)***
R^2(Adj) = 0.789	d-w = 1.389	F=21.549***
y_{ws} = 19.857 -	$1.190*10^{-2}\ p_{ws}$ -	$3.26*10^{-2}$ A
(7.847)***	(-1.495)	(-6.264)***
R^2(Adj) = 0.772	d-w = 1.955	F=19.652***
y_{ys} = 7.917 +	$3.297 * 10^{-3}\ p_{ys}$ -	$1.73*10^{-2}$A
(6.481)***	(0.728)	(-7.115)***
R^2 (Adj) = 0.821	d-w = 2.181	F=26.222***

Notes:
bal=Balau, cen=Cengal, kem=Kempas, kap=Kapur, mer=Meranti, rm=Red Meranti sal=Salanggan, al=Alan Bunga, jk=Jongkong, ws=White Saraya, rs=Red Saraya, ys =Yellow Saraya,hlks= LKS of heavy hardwood, mlks=LKS of medium hardwood, llks= LKS of light hardwood and lks=lesser-known species which defined as total of hlks,mlks and llks.

Figures in parenthesis are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively.

Table 7.12 gives the elasticity of harvest intensity with respect to price and concession area. The figures show that except for LKS of light hardwood, all the elasticities with respect to price and area are inelastic.

Table 7.12 Elasticity of Species Harvest Intensity for Peninsular Malaysia[a]

Species	Price	Area
Balau	0.340	-0.515
Cengal	0.652	-0.809
hlks	0.217	0.391
Kruing	-0.344	-0.164
Kempas	0.810	-0.667
mlks	0.259	-0.310
Mersawa	0.180	-0.735
Red meranti	0.262	-0.839
llks	1.275	-1.226
lks	1.000	-1.370

Note:
[a] The elasticity calculated is only for Peninsular Malaysia, which is the region that gives the figure for comparison between group and species.

These results suggest that increase in price or reduction in concession area will give the highest effect on LKS of light hardwood. At least for Peninsular Malaysia, these results also suggest that LKS of light hardwood are the most inefficiently utilised, compared to others, when the market restriction policy on forest products is implemented. Given that a high proportion of Malaysian timber species are light hardwoods, and these species dominate concession areas (Whitmore, 1995), the LKS of light hardwood are the most likely under utilised or unused. Therefore the results also suggest that the government restriction policy on timber products to promote downstream industries will cause the government objective to promote species utilisation or less value timber will not be successful.

7.4 Timber Species Utilisation versus Conservation.

Plants are an important part of biodiversity that bind the interaction of ecosystem. The effect on the ecosystem differs widely between plant species because of great differences in their characteristics. Some species have a much greater influence on the ecosystem than the others. Plants are the basis of most terrestrial ecosystems; most animals, including humans, depend on them as sources of food. Worldwide, tens of thousands of species of higher plants, and several hundred species of lower plants, provide a host of other products for human use, including fuel, fibres, oils and medicine. In the tropics alone. 25,000-30,000 species are estimated to be in use (Heywood, 1992,1993), and up to 25,000 species have been employed in traditional medicines. Collectively, plants also provide many valuable ecological services, such as protecting watersheds, improving soils, moderating climate, cycling nutrients, and providing habitat for animals. These plant species are unevenly distributed between the continents. The largest numbers are in Latin America, followed by Asia, Africa, North America, Australia and Europe (Table 7.13).

Table 7.13 Distribution of World Plant Species

Continent	Species
Latin America	85,000
Africa	40,000-45,000
Asia	50,000
Australia	15,000
North America	17,000
Europe	12,500

Source: Jeffries (1997).

It is well recognised that plant life throughout the world, and especially in the tropics, is under serious threat as habitats are destroyed or modified. Many parts in the tropics are likely to lose their forest through this process. The loss of these forest will inevitably result in extinction of plant species. Table 7.14 shows the status of threatened plant species in the world estimated by Reid and Miller (1989). It can be seen that 384 species have disappeared since 1600, 3325 are endangered, 3022 are vulnerable, 6749 are rare and 5598 are indeterminate, which gives a total of 19,078 threatened species. The classification is based on IUCN categories of threat. Raven (1987) has estimated that as many as 60000 vascular plant species (about 25% of the world's vascular plant flora) could either become extinct or have their populations seriously reduced by 2050 if the present trends continue. According to an analysis of tropical floras by Myers (1988), approximately 17,000 vascular plants (7.5 per cent of the earth's vascular plant species) could become extinct in just ten critical areas, or 'hotspots,' (Table 7.15), covering 0.2% of the earth's land surface.

Table 7.14. Status of Threatened[4] Plants Species

Extinct (post-1600)	Endangered	Vulnerable	Rare	Indeterminate	Total
384	3325	3022	6749	5598	19078

Source. Reid and Miller (1989).

[4] The classification is based on IUCN categories of threat :

Extinct (Ex): Species not definitely located in the wild during the past 50 years.
Endangered (E): Taxa (species and sub-species) in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that are possibly already extinct but have definitely been seen in the wild in the past 50 years.
Vulnerable (V): Taxa believed likely to move into the 'Endangered' category in the near future if the causal factors continue operating. Included are taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat, or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security has not yet been assured; and taxa with populations that are still abundant but are under threat from severe adverse factors throughout their range.
Rare (R): Taxa with small world populations that are at present 'Endangered' or 'Vulnerable' but are at risk. N.B. in practice, the 'Endangered' and 'Vulnerable' categories may include, temporarily, taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category. These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.
Indeterminate (I): Taxa known to be 'Endangered' , 'Vulnerable', or 'Rare' but where there is not enough information to say which of the three categories is appropriate.

Table 7.15 Hotspot Areas

Region	Areas with tropical forests	Areas without tropical forests
Africa	Eastern Arc Forests of Tanzania	Cape Floristic Province of South Africa.
	Madagascar	
	Southwestern Ivory Coast	
Australia	Queensland	Southwestern Australia
Indian subcontinent	Southwestern Sri Lanka	Eastern Himalaya
	Western Ghats of India	
North America		California Floristic province
Pacific Ocean Islands	Hawaii	
	New Caledonia	
South America	Atlantic Coast of Brazil	Central Chile
	Colombian Choco	
	Upland of Western Amazonia	
	Western Equador	
Southeast Asia (Malesia)	Northern Borneo	
	Peninsular Malaysia	
	Philippines	

Sources: Myers (1988, 1990).

Note: Results of the 1996-1998 hotspots reanalysis (Mittermeier et al., 2000) have identified 25 hotspots area. Sixteen of these are either the same as or incorporate the original 18 hotspots identified by Myers (1988,1990).

Just how many species are at risk is a matter of some debate within scientific circles (Whitmore and Sayer 1992) and depends on predictions of the extent of habitat destruction, particularly in primary forests, and how many individual species may be able to survive in fragmented, modified, or secondary forest.

The objective of this section is to answer the question, does increased species utilisation effect plant species diversity? In this aspect it is necessary to draw a distinction between forest degradation and deforestation. According to Bruenig (1985), degradation as a result of logging will lead to a deterioration of timber species but is most unlikely to lead to extinction except perhaps in very large scale, rigorous exploitation. Substantial impact from selective logging is restricted generally to the shift of densities, and the threat of extinction of a few, particularly vulnerable species arises only locally. Deforestation, by contrast, will be the partial or total disappearance of all the forest species, depending on the size, patterns and condition of the deforested area and the environmental changes that results from forest clearing. Species extinction is an inevitable corollary of deforestation (Bee, 1993).

Bruenig (1996) reported that experimental comparison of tree-species richness in 20 1-ha research plots in Liberia between primeval natural forest and modified selection-harvested forests with and without silvicultural manipulation has shown that 15-20 years after intervention no statistically significant differences in tree-species richness and spectra exists between them. The dominance diversity shifted slightly but remained within the range of natural variation. In Sarawak, Sabal Forest Reserve, selective logging in Mixed Dipterocarp forest and Karangas forest has not reduced but more likely increased species richness in a forest (Bruenig et al., 1995)

The effect of logging on tree species diversity and composition in tropical forest has also been reported by Chua et al. (1998), Manokaran (1998) and Cannon et al. (1998). According to these studies, the immediate effect of logging is to reduce both tree density and tree diversity. Chua and Manokaran indicated that, after 35 years of logging; for tree sizes of 10cm dbh and above, logged forest has a higher tree density than the unlogged forest (Table 7.16). Cannon et al. also shows that, even 8 years after logging, the tree density in logged sites approached that of unlogged forest.

Table 7.16 Comparison of Tree Density of Logged and Unlogged, Pasoh Forest Reserve.

Study	logged	Unlogged
Manokaran	742.5	514.8
Chua et al.	709	579.2

With regard to species diversity, Manokaran and Cannon reported that logged forest has a higher species diversity than unlogged forest. Table 7.17. shows the results from Manokaran's study. Chua et al., however, reported a decrease in species diversity. Their study indicated that the logged forest contained only 60.8% of the plant diversity of the unlogged forest, 40 years after logging.

Table 7.17 Number of Families, Genera and Species of Trees of 10 cm Diameter and Larger in Primary and Regenerating Lowland Dipterocarp Forest at Pasoh

	Primary[a]	Regenerating
Families	44.5	47
Genera	129	148
Species	256.8	330

a. The figures are means of 4x2 ha sample plots.

What is interesting in the results from Chua et al., however, is the effect of logging on individual species or groups of species. The greatest difference in the percentage of diversity between logged and unlogged forest was found in the commercial and low conservation priority category and rare species category. Commercial species were more diverse in the logged forest, while rare species were more diverse in the unlogged forest. Although the logged forest had a greater number of individuals compared to the unlogged forest, it contained only 71 per cent of the rare species found in the unlogged forest. This finding shows that, though Chua's results differ from those of Manokaran (1998) and Cannon et al. (1998) in terms of species diversity, they agree on the tree species composition. All studies indicated that logged forest is dominated by commercial species of dipterocarp.

Another important point reported by Chua et al. is the effect on the diversity of endemic species The logged forest had only half the diversity of the unlogged forest. The families that recorded the greatest change in the composition of endemic tree species were Euphorbiaceae and Myrtaceae. Only two of the seven species of Euphorbiaceae and seven of the eleven species of Myrtaceae found in the unlogged forest occurred in logged forest. Although nothing is known of the species diversity of the forest prior to logging, the reduction in the diversity of endemic species indicates that changes had occurred during the 40 years after logging which significantly affected the diversity of endemic species. The results however do not indicate that either the species loss is only a local loss or extinction. This may be only a local loss. Studies by IUCN (1988 and following issues) have confirmed practical field experience that species extinction by timber harvesting alone is unlikely to happen beyond rare and localised events. These results have important implications for the conservation of plant diversity in managed forests in Malaysia. The results imply that Malaysia needs a totally protected core area for the conservation of plant species. Currently Peninsular Malaysia has 12 per cent of remaining forest area protected.

An increase in species utilisation and an increase in harvest intensity would undoubtedly modify the forest structure and also reduce both tree density and tree diversity. Given, promotion of timber species utilisation as an issue within the scope of regenerating forest then the above argument suggests that promotion of species utilisation is not a threat to plant species loss. According to Ewel and Conde (1980), many species can be lost by mismanagement of forest resources (such as girdling and poisoning remnant trees) but not by species harvested, more than that the species harvested are probably the least likely to disappear. Another important point on sound forest management is that, even the loss of timber species is most unlikely by an increase species utilisation, but the current practice of selective logging where the best individuals of the current commercial species; trees with sound boles and good form are selectively harvested in preference to individuals with undesirable characteristics, will lead to genetic erosion. The logging practice leaves only undesirable, smaller and genetically inferior individuals in the residual stand to provide seeds for the next crop (Blanche, 1978; Ewel and Conde, 1980).

7.5. Species Harvest and Deforestation

The forest cover estimation in Chapter 5 used total forest harvest as an explanatory variable. The total forest harvest is an aggregation of various timber species, prime species and lesser-known species. The volume of these species determines the total volume of total harvest. Thus, it is possible to estimate the forest cover using prime species volume or LKS volume as a proxy for total harvest. This section investigates the relationship of forest cover particularly with respect to species harvest. The relationship is similar to the analysis in Chapter 5, except the harvest and intensity variables are replaced with the quantity of a particular species or group of species and its harvest intensity. An alternative form of forest cover relationship, therefore, would be specified as follows:

$$MFOREST = f\,(MHQ_i, INT_i, AGP, RUI) \qquad (7.3)$$
$$\partial MFOREST/\partial MHQ_i < 0 \;, \partial MFOREST/\partial INT_i > 0 \;,$$
$$\partial MFOREST/\partial AGP < 0 \;\; \partial MFOREST/\partial RUI < 0.$$

where MFOREST = Malaysia forest cover
MHQ_i = Total harvest of particular species or group of species *i*.
INT_i = Harvest Intensity of species *i* or group of species.
AGP = Agriculture Productivity and
RUI = Rural Population Intensity.

Alternative forms of the forest cover equation were estimated to determine whether the species harvest and intensity would offer any additional explanatory relationship. We would expect the results to have a similar direction to the results in Chapter 5 but with different magnitude. Increase in species harvest will reduce the forest cover and increased intensity will increase the forest cover.

In estimation, the writer was faced with the problem of choosing which species can be used as a proxy for the relationship. With a wide range of species, it was decided to analyse using four groups of species as proxy variables. The first variable is a group of prime species[5] (CPS) produced in all three regions of Malaysia; Peninsular Malaysia, Sabah and Sarawak; the second variable is total prime species (TPS)[6], the third variable is the total of lesser-known species[7] (LKS) and the fourth variable is a group of the most abundant commercial prime species[8] (ABS) produced in all three regions, Peninsular Malaysia, Sabah and Sarawak. The most abundant species here were defined based on production reaching one million cubic metres per year. The estimated equations of these relationships are as in Table 7.18

Table 7.18 Forest Cover Relationship Using Species Harvest, 1980-1990.

$$MFOREST = \underset{(10.00)^{***}}{37722.05} + \underset{(1.564)}{0.330MHQ_{LKS}} - \underset{(-0.860)}{124.94INT_{LKS}} + \underset{(1.334)}{0.564\,AGP} - \underset{(-3.895)^{***}}{1.81 * 10^5\,RUI}$$

$R^2(Adj) = 0.728$ DW = 1.501   F=8.347***

$$MFOREST = \underset{(8.005)^{***}}{38991.63} + \underset{(1.468)}{0.120MHQ_{TPS}} - \underset{(-1.677)}{45.43INT_{TPS}} + \underset{(1.381)}{0.615\,AGP} - \underset{(-3.147)^{**}}{1.81 * 10^5\,RUI}$$

$R^2(Adj) = 0.690$ DW = 1.098   F=7.107**

$$MFOREST = \underset{(8.877)^{***}}{36807.08} + \underset{(0.418)}{0.148MHQ_{CPS}} - \underset{(-1.270)}{174.2INT_{CPS}} + \underset{(1.263)}{0.583\,AGP} - \underset{(-3.383)^{**}}{1.73 * 10^5\,RUI}$$

$R^2(Adj) = 0.664$ DW = 0.981   F=6.529**

$$MFOREST = \underset{(9.304)^{***}}{36579.38} + \underset{(1.032)}{0.108MHQ_{ABS}} - \underset{(-1.535)}{51.54INT_{ABS}} + \underset{(1.431)}{0.583\,AGP} - \underset{(-3.248)^{**}}{1.78 * 10^5\,RUI}$$

$R^2(Adj) = 0.666$ DW = 1.059   F=6.472**

Notes: Figures in parenthesis are *t*-statistics. One, two and three asterisks indicate significance at 10, 5 and 1 percent level respectively

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[5] The species are Kapur and Keruing
[6] The total species that has been consistently recorded for a period of analysis (1980-1991).
[7] Total log production minus total production of prime species (TPS).
[8] The species are Meranti, Kapur, Keruing, Alan Bunga and Selangan for Serawak, Seraya, Kapur,Keruing and Selangan for Sabah, and Meranti, Keruing, Kapur, Balau and Kempas for Peninsular Malaysia.

The results show that, except for rural population intensity, none of the variables give the same direction as in the forest cover relationship in Chapter 5. Rural population intensity is the most significant.

Though the results are not consistent with the analysis in Chapter 5, the relationships of all equations provide important results. The forest cover relationship with all group of species and intensity of respective species are in the same direction and produced similar results, in terms of explanatory power (R^2(Adj)) and also the coefficient of variables. The different results produced in Chapter 5 could be due to the different data available for analysis. Due to lack of data from Sabah, the analysis used only the data for the period 1980 to 1990. An investigation using the same period of data for aggregation analysis shows that the results are similar to the results produced using species analysis. The estimation result for this relationship is shown in Table 7.19.

Table 7.19 Forest Cover Relationship Using Total Forest Harvest, 1980-1990.

MFOREST = 39613.60 +	0.105MHQ -	32.84INT
(9.097)***	(1.987)*	(-1.525)
+ 0.605 AGP -	$1.94 * 10^5$RUI	
(1.431)	(-3.724)***	
R^2 (Adj)= 0.720	DW = 1.236	F= 8.072***

Notes: Figures in parenthesis are *t*-statistics. One and three asterisks indicate significance at 10 and 1 percent level respectively.

This result implies that, given the volume of harvest and the intensity of harvest for a particular species or group of species *i* as specified in this analysis, we can estimate the forest cover for Malaysia without the need for the total volume of forest harvest. This alternative relationship might have an advantage over the conventional estimation of forest cover because data on prime species, for example, are likely to be more reliable than data on the total production of all timber species.

7.6. Summary and conclusion

The challenges ahead for forest managers are phenomenal. Many species, which reach merchantable size, are not being utilised. A large volume of standing trees are left untouched. Malaysia has yet to find a solution to utilise the heterogeneous raw materials which are characteristic of her forest (Yeom, 1984; Wong, 1994). The analysis in this chapter gives some possible solutions to this problem. The results of the analysis show that price has a significant effect on the way timber species are harvested; increase in species price would increase harvest intensity. Thus, the market restriction policy, which was discussed in chapter 6, would affect species utilisation in two ways:

i. low utilisation of prime species. The prime species would not be utilised to their full potential, and less valuable species would be left in the forest or on the ground, instead of being brought to the market.

ii low utilisation of LKS. More LKS will not be harvested or left uncut or destroyed in the forest.

The results in this chapter show that acceptance of LKS is very difficult if there are always alternatives for prime or well accepted species. Thus, restricting the timber available by restricting the concession area would seem to be a good policy to increase species utilisation. A possible alternative is to reduce the harvest royalty on LKS. The results show that harvest intensity is elastic with respect to price of the LKS group. Thus, a policy that reduces the cost of production (increases the net price) such as the royalty, would give a net revenue benefit to the forest sector. Accordingly, increasing the royalty on prime species would bring a net benefit to the forest sector, because harvest intensity is inelastic with respect to price.

Analysis of forest cover using species harvest provides a new direction to analyse forest cover relationships. This thesis, shows that the forest cover relationship using species harvest gives similar results to those obtained using total log harvest; the quantity of harvest and the harvest intensity gives the same sign in both cases. The result suggests that, without full data on the quantity of forest harvest, species harvest data would be sufficient to estimate the effect of policies on forest cover.

There could be a local species loss or degradation of genetic erosion due to logging activities in Malaysia. This implies that Malaysia needs a totally protected core area for the conservation of timber species. Thus promoting the timber species utilisation within the current setting of Malaysian forest management; with a protected area of forest and regenerating forest after harvest does not contravene to the conservation of timber species. Indeed, promoting species utilisation policy would at least increase timber supply constraint in wood-based industry.

The use of harvest intensity as an indicator of harvest efficiency and as an explanatory variable in forest cover relationships has some limitations. First, harvest intensity does not take into account the type of forest; different types of forest would eventually give different intensities of harvest for particular species. For example, the prime species of Red Meranti would have greater intensity in Kempas-Red Meranti forest than in Kempas-Kedondong-Kelat forest. Second, the size of timber tree is not considered. It should be noted that, different regions, different management regimes and different timber species could differ in the minimum size of tree that can be harvested (see Table 7.20). The smaller the minimum permissible size, the greater harvest intensity is likely to be, because more timber would be available for harvest.

Table 7.20 Minimum Girth Limits for Merchantable Species.

Country	Minimum Diameter at Breast High (dbh) (cm)
Ghana	48
Francophone Africa	70
Indonesia	50
Peninsular Malaysia	58 for harvesting under MUS 50 for dipterocarps under SMS 45 for non-dipterocarps under SMS
Sabah	60
Sarawak	40 for ramin species 45 for other species
Philippines	60 - 80 for dipterocarps

Source: Bee (1993)

Chapter 8

SUMMARY AND CONCLUSION

Shortage of timber input for processing industries is the main issue facing the Malaysian forest sector. The need to implement policies which will ease the pressure on timber shortage and promote the expansion of forest sector industry is becoming increasingly urgent. The Malaysian government has announced and implemented three main policies: market restriction, encourage utilisation of rubberwood and promotion of lesser-known timber species (LKS). Application of timber market restriction policies is a course of considerable dispute; firstly because of widespread disagreement over the effect on efficiency of utilisation of timber that leads to timber harvest and deforestation, and secondly it will undermine the government,s effort to promote utilisation of rubberwood and lesser-known timber species. In this thesis, an attempt has been made to enlarge the available empirical knowledge of such effect through a multi-sectoral forest - rubberwood sector model simulation. The production, consumption and export of timber, sawnwood, plywood, rubberwood and sawn rubberwood have been examined in relation to a number of market policies: export taxes, export ban and import ban, and other alternative policies; royalty, exchange rate, wood utilisation efficiency and subsidies. A series of simulations was undertaken to describe the effect of these policies.

8.1. Summary of Results

This simulation analysis leads to six broad results:

i. The results support previous studies that show within a two period framework that a restriction on sawnwood export would reduce timber harvest, reduce sawnwood production and increase plywood production.

ii. The results support previous studies that show within a two period framework that a restriction or total ban on log would further develop the processing sector, and improve the forest cover.

iii. The results support the hypothesis that an export restriction on sawnwood would distort the development of the rubberwood sector. The rubberwood sector would shrink because of a decline in sawn rubberwood consumption due to substitution by sawnwood.

iv. Within two period framework, market restriction on processed timber products, with the objective of promoting the timber processing sector, always shows a positive result for forest cover. Increased in market restriction would improve the forest cover.

v. Short supply of timber resources and improved relative price of rubberwood products against timber would promote the rubberwood sector. This implies that policy changes such as trade liberalisation would be expected to yield not only economic but also environmental benefits, in the form of reduced pressure on existing forests

vi. Except for a log restriction policy, only wood utilisation efficiency would promote the development of the processing sector and also improve the forest cover.

In addition to sectoral analysis, an extended analysis using species harvest was undertaken, as a new approach to investigate efficiency of utilisation of wood resource and forest cover. The results indicated that the utilisation of lesser-known timber species would be most affected from the policy changes.

Analysis of forest cover using species harvest provides a new direction to analyse the forest cover relationship. In this thesis, at least, it appears that the forest cover relationships using species harvest give similar results to those obtained using total log harvest. These results suggest that, in the absence of full data on the quantity of log harvest, species harvest data would be an alternative to estimate the effect of policies on forest cover.

8.2. Research Limitation

There are, of course, a number of important limitations on the use of the simulation model for these policy scenarios.

As discussed in Chapter 5, the linkages of the impacts of log production on forest cover do not take into account changes in the type of forests being exploited (i.e. permanent production forests, conversion forests or new forest areas) or in the silviculture management regime (i.e. MUS or SMS).

Although the model is well suited to examining the effect of a particular policy intervention on the internal diversion of timber product flows in Malaysia, i.e. between export and domestic markets for sawnwood and plywood, and also between timber products and rubberwood products, it does not explicitly indicate the effect of an intervention in terms of external diversion of timber products, i.e between import markets for sawnwood and plywood. That is, the substitution by product or by sources of origin in existing importing markets is not explicitly modelled, and the possibility of new import markets opening up as a result of the intervention is not taken into account.

The model is capable of only showing 'static', or one period, partial equilibrium effects of a policy intervention. Many of the impacts may have economy-wide, or general equilibrium, impacts that feed back to affect the timber products markets and deforestation. For example, during the Malaysian financial crisis in 1997, when the exchange rate against the US dollar depreciated by about 50 per cent, Malaysian exports of major timber products did not behave as suggested in the simulation (see Table 8.1). This is because other timber exporting countries such as Indonesia and Thailand, and major timber importing countries from Malaysia such as Japan and South Korea experienced similar financial crisis.

Table 8.1 Export of Major Timber products, Malaysia, 1995-1997 ('000 m^3)

Year	Sawlog	Sawntimber	Plywood
1995	7864	4796	3462
1996	6987	3660	4068
1997	6593	3007	3825

Source: Malaysia (1998).

In addition, the policy impact may have lag, or dynamic effects that manifest themselves over a medium or long term horizon. Some of the policy interventions themselves, such as wood efficiency utilisation and the implementation of sustainable management practices would realistically involve a longer process of implementation than a single period.

The harvest intensity variable used in the analysis has some limitations. First, the harvest intensity does not take account of forest type; different types of forest would eventually give different intensities of particular species harvest. For example, intensity of prime species of Red Meranti from Kempas-Red Meranti forest would be greater than from Kempas-Kedondong-Kelat forest. Second, the permissible size of timber tree is not considered. It should be noted that different regions, different management regimes and different timber species could differ in the minimum size of trees that can be harvested. The smaller the minimum permissible size, the greater the harvest intensity is likely to be, because more timber would be available for harvest.

Analysis of the rubberwood sector is also faced with some limitations. No account is taken of the different supply functions of rubberwood between smallholders who dominate the Malaysian rubber sector and the estate sector which owns most of the latest technology, including processing facilities to process rubberwood. In addition, palm oil plantations are not considered in rubberwood supply, to reflect the supply of rubberwood arising from the effect of cutting down rubber trees to replace rubber with palm oil.

8.3. Policy Recommendations

It is perhaps risky to mention the policy implications of a thesis, which uses data for a limited period, and with a high level of aggregation, and does not include the wide range of newly developed timber products. However, if the policy maker wished to draw the policy implications of the thesis for the Malaysian forest - rubberwood sector economy, the following observations could be made:

i. In respect of market restriction policies, the simulation results suggest that all of these policies would reduce the timber harvest, at least in the short run. Given the finding that timber production is a factor causing deforestation (changing the forest cover) all these policies could have an immediate effect on reducing deforestation. However, the current market policy, a sawnwood export tax, at least, imposes high economic costs on forest industries. A high export tax appears to make little headway in the short run in achieving the objective of spurring development of plywood and other downstream sectors.

   The independence of wood utilisation policy from market forces means that this policy should be implemented to offset such negative effects from the timber market restriction policy. An argument for timber products market restriction is to protect the infant industries, which are uncompetitive in the market due to inefficiency in production, would be more effective with wood utilisation efficiency policy. Without a wood utilisation policy, the market restriction policy to achieve efficiency of the timber industry will not be realised and the industry will need longer protection from the government.

Increased efficiency of wood utilisation would reduce the pressure on forest harvest. However, this is not a quick policy to influence the forest harvest; firms will take time to adjust. The government could implement the wood utilisation efficiency policy on the basis of incentives, for example, the government could used it as a tax incentive to the producer, whereby more efficient firms will receive more tax relief. Efficiency could also be made a condition of licensing. At an extreme position, those firms which do not meet to certain level of processing efficiency, would not have their licence renewed and would have to close the operation.

ii. The results of policy simulation indicate that the rubber industry now should be looked at in its totality, as an integrated economic entity. The development of the rubberwood sector seems to be influenced not only by the policy in the rubberwood sector but also by the forest sector policy. Implementation of a market restriction policy on timber products, such as the sawnwood export tax, would distort the development of the rubberwood sector. Thus, it is suggested that a less restricted market in timber products would be a better condition for the development of the rubberwood sector. However the policy should be selective, because not all timber species are substitute input to rubberwood; thus, it is recommended that the policy makers need to determine which timber species are substitutes for rubberwood and place less restriction on these species in the export market. Within the rubber sector itself the policy makers need to be aware, for example, that the policy of rubber price subsidies could have adverse effects on rubberwood production. Thus, it is suggested that consideration should be given to the net effect of the policy on the sector.

iii. The market restriction policy would effect species utilisation in two ways: First it will cause low utilisation of prime species. The prime species would not be utilised to their full potential, and less valuable species would be left in the forest or on the ground, instead of being brought to the market.

Secondly it will cause low utilisation of lesser-known species. More lesser-known species will not be harvested or left uncut or destroyed in the forest. Promotion of lesser-known timber species will not be achieved by the market restriction policy.

The results indicate that, restricting the timber available by restricting the concession area would seem to be a good policy choice to increase species utilisation, thus the utilisation of wood resources. Without this policy intervention, most likely, until Malaysia experiences a shortage of wood resources, the lesser-known species will be left on the ground, unharvested. An alternative policy, such as restructuring the timber harvest royalty would be a better option. Currently, the royalty margin between prime species and lesser-known species is too small to induce more harvest of lesser-known species. For example, in 1991, the rate of royalty for the top prime species, Cengal, with an average price of RM450/m^3, was less than RM20/m^3, while the royalty on mixed hardwood, with an average price of RM150/m^3, was RM10/m^3. The government should consider increasing more royalty on prime species and reducing further royalty on LKS. This is in a view that the harvest intensity of prime species is inelastic and LKS is elastic. Because harvest intensity of prime species is inelastic with respect to price, increase in rate of royalty of these species is a good source of income for forest management, with less effect on timber supply. Simulation results show that a high increase in royalty rate would cause only a small percentage of reduction in timber harvest.

8.4. Future Research

Having talked of policy implications and the limitations of the thesis, it cannot be emphasised strongly enough that the Forest-Rubberwood sector model is only a pilot model which, it is hoped, can be improved and implemented with better data as they become available. The model should never cease to be a tool which is designed to make predictions about the behaviour of the real interaction between forest sector and rubberwood sector. Perhaps one of the most important uses of the model in its present stage of development is to teach us something about the relative importance of interdependencies between rubberwood sector and forest sector, which should be taken into account when formulating protective policy.

Future research could extend this model further, to include other processing sectors or wood sectors, or both. The processing sector researched could be the furniture sector, the fastest growing industry in the forest sector. Wood sectors, which merit investigation, are the plantation forest and palm oil sector. The plantation sector now contributes significant wood input to the processing industries. Palm oil plantation, which is the main competitor to the rubber industry, has become an important source of wood resource. The palm oil trunk now is becoming popular as a source of material in the furniture industries. With the area of palm oil plantation exceeding that of rubber plantation, the palm oil sector is expected to contribute significantly to ease raw material shortage.

APPENDICES

Appendix 1
Export Levy on Timber Products for Peninsular Malaysia

Table A1.1. Export Levy on Selected Species of Sawntimber and Veneer for Peninsular Malaysia.

	Implementation Dates			
Species[a]	1.6.1990	1.9.1990	1.3.1991	Levy Rates (RM/m3)
Cengal		All sizes	All Sizes	120
Damar Minyak		Strips	All Sizes	120
Ramin		Strips	All Sizes	120
Red Meranti		Strips	All Sizes	120
Kembang semangkuk		Strips	All Sizes	120
Nyatoh		Strips	All Sizes	120
Jelutong		Strips	All Sizes	120
Sepetir		Strips	All Sizes	120
Mersawa		Strips	All Sizes	60
Sesenduk		Strips	All Sizes	60
Yellow and White Meranti		Strips	All Sizes	60
Red Balau		Strips	All Sizes	60
Kempas		Strips	All Sizes	60
Merbau		Strips	All Sizes	60
Mengkulang		Strips	All Sizes	60
Geronggang		Strips	All Sizes	60
Bintangor		Strips	All Sizes	60
Garutu		Strips	All Sizes	60
Durian		Strips	All Sizes	60
Keruing		Strips	All Sizes	60
Veneer		All Species	All Species	120
Rubberwood	All Sizes	All Sizes	All Sizes	120

[a] Botanical names of the species are listed in Appendix 4.

Source: Maskayu (1990).

Table A1.2 Revised Rate of Export Levies on Selected Species of Sawntimber, Veneer and Other Timber Products for Peninsular Malaysia.

Sawntimber of species	All Sizes: Kiln-dried	All Sizes: Air-dried
	RM/M^3	
Group A		
Chengal	250	250
Damar Minyak	250	250
Group B		
Jelutong	120	180
Sepetir	120	180
Kembang Semangkok	120	180
Nyatoh	120	180
Raminlow grade	120	180
Dark Red Meranti	120	180
Light Red Meranti/Red Seraya	120	180
Red Meranti	120	180
Melantai/Kawang	120	180
White Meranti/Melapi	120	180
White Seraya	120	180
Perupok	120	180
Merbau	120	180
Balau	120	180
Rubberwood	120	180
Mersawa	120	180
Kempas		
Group C		
All other species	40	40
Other Timber Products		
Railway sleepers & crossing, transmission posts,		
unassembled pallets, fine ripped door stiles, agriculture		
stakes, cross-arms stiffeners for flakeboard, fenders and	40	
walling *	80	
Dressed Timber of Rubberwood	80	
Finger-jointed and/or laminated sawn timber of Rubberwood	40	
Dressed Timber of species other than Rubberwood	40	
Finger-jointed and/or laminated sawn timber of species other		
than Rubberwood	120	
Veneer	40	
Utility Plywood		

* To be exported in their final sizes or to final shape. The products will have to undergo inspection by Malaysian Timber Industry Board (MTIB) before export. Consignments which do not comply with these conditions will be subjected to the levy rate of sawn timber.

Source: Maskayu (1993)

Appendix 2

Table A2.1 Malaysia - Population, 1970 –1996 ('000).

Year	Population	Rural	Urban
1970	10,853	7,222	3,631
1971	11,128	7,317	3,811
1972	11,407	7,407	4,000
1973	11,690	7,491	4,198
1974	11,973	7,570	4,404
1975	12,258	7,642	4,616
1976	12,543	7,709	4,834
1977	12,831	7,771	5,060
1978	13,126	7,833	5,294
1979	13,435	7,900	5,536
1980	13,763	7,977	5,787
1981	14,112	8,064	6,047
1982	14,479	8,162	6,317
1983	14,864	8,267	6,597
1984	15,264	8,375	6,889
1985	15,677	8,482	7,195
1986	16,103	8,589	7,514
1987	16,541	8,693	7,848
1988	16,987	8,794	8,193
1989	17,439	8,891	8,548
1990	17,891	8,983	8,909
1991	18,344	9,069	9,275
1992	18,796	9,149	9,648
1993	19,247	9,220	10,027
1994	19,695	9,280	10,415
1995	20,140	9,326	10,814
1996	20,581	9,361	11,220

Sources: ESCAP (Various Issues).

Table A2.2 Forest Area and Area Logged, Malaysia, 1970 -1994 ('000 hectare)

Year	Forest Area	Area Logged
1970	23,660	258
1971	23,320	317
1972	23,180	424
1973	22,641	753
1974	22,510	721
1975	21,652	714
1976	21,727	684
1977	21,307	683
1978	21,097	746
1979	20,766	604
1980	20,683	610
1981	20,951	769
1982	20,799	593
1983	19,524	585
1984	19,636	693
1985	19,608	630
1986	19,699	621
1987	19,521	634
1988	19,458	688
1989	19,474	673
1990	19,419	659
1991	19,248	813
1992	19,133	538
1993	19,056	442
1994	19,000	160

Sources: Forestry Department (1992). Data for the year 1990-1994 Provided by Dr Shahwahid Hj. Osman, Faculty of Resource Economics, Universiti Putra Malaysia, Malaysia.

Table A2.3 Malaysia- Agriculture Area and Production[a], 1970-1995.

Year	Agriculture Area (ha)	Agriculture Production (metric tons)
1970	2,738,662	6,884,524
1971	2,861,055	7,737,319
1972	3,004,554	8,368,279
1973	3,290,734	9,334,684
1974	3,319,310	10,729,000
1975	3,302,795	12,195,523
1976	3,472,292	12,710,383
1977	3,522,034	13,609,058
1978	3,562,915	15,458,937
1979	3,565,012	16,956,471
1980	3,601,379	18,756,171
1981	3,686,803	20,337,810
1982	3,716,055	24,047,060
1983	3,796,511	21,524,378
1984	3,796,488	25,480,311
1985	3,942,385	27,630,162
1986	4,089,192	29,459,684
1987	4,191,111	29,027,083
1988	4,539,283	31,776,552
1989	4,692,113	37,020,734
1990	4,776,312	37,514,586
1991	4,855,668	37,967,908
1992	4,863,368	39,638,560
1993	4,930,186	46,249,103
1994	4,975,025	45,385,493
1995	4,988,257	48,804,067

Source: ESCAP (Various Issues).

Note: [a] Agriculture area and production are only compound to principal crops; rice, cassava, bananas, cocoa beans, coffee, tea, tobacco, coconuts, palm oil, pineapples and rubber.

Table A2.4 Log Sector Data, 1970-1994.

Year	MHQ[a] ('000 m^3)	MHX[a] ('000 m^3)	TPNC[c] US$/$m^3$	MHP[a] RM/m^3	ROY[b] ('000 RM)
1970	17,792	8,914	34	72	91,472
1971	18,230	8,772	33	73	161,783
1972	20,618	9,119	38	65	153,245
1973	24,064	10,122	55	68	247,206
1974	21,372	9,553	67	108	304,173
1975	19,164	8,473	65	79	207,470
1976	26,595	15,394	73	96	404,788
1977	27,573	16,078	88	95	426,242
1978	28,685	16,727	105	100	501,274
1979	28,762	15,941	120	180	1,073,164
1980	27,915	15,117	133	173	1,196,397
1981	30,388	15,866	109	156	934,906
1982	32,724	19,270	98	175	1,189,030
1983	32,794	18,658	96	150	1,120,545
1984	31,088	16,878	84	165	944,578
1985	30,956	19,536	85	141	722,815
1986	30,815	18,951	104	150	784,046
1987	36,148	22,920	122	186	1,302,150
1988	36,484	20,547	109	195	1,391,105
1989	39,708	21,101	112	206	1,529,274
1990	40,099	20,354	89	196	1,498,234
1991	39,859	19,320	83	212	1,269,389
1992	43,512	17,797	75	215	.
1993	37,135	9,382	76	314	.
1994	35,672	8,561	67	302	.

Source: [a] Forestry Department (1992) and Malaysia (1995).
[b] Forestry Department (1992).
[c] FAO (Various issues).

Table A2.5 Malaysia - Sawnwood Sector Data, 1970-1994.

Year	SWQ[a] m³	SWX[a] m³	SAWMILL[a]	SAWSAL[b] RM	SWPNC[c] US$/m³	SWP[a] RM/m³
1970	3,130,500	1,383,550	448	2,230	72	148
1971	3,036,000	1,322,050	478	2,190	57	138
1972	3,729,000	1,801,950	490	2,335	64	155
1973	4,205,500	2,198,050	636	2,640	84	259
1974	4,103,500	2,113,100	684	2,906	115	238
1975	3,925,500	1,837,800	672	3,118	119	244
1976	5,178,000	3,052,150	647	3,435	116	289
1977	5,704,000	2,949,050	720	3,549	135	274
1978	5,963,000	2,804,150	753	3,730	136	275
1979	5,885,000	3,475,900	792	4,057	198	378
1980	6,284,000	3,211,800	913	4,685	224	412
1981	5,614,000	2,756,350	947	5,702	184	343
1982	6,307,000	3,091,250	945	6,348	170	370
1983	7,189,000	3,447,350	935	6,800	172	399
1984	5,848,000	2,842,150	917	6,963	162	412
1985	5,414,000	2,782,150	920	7,052	162	360
1986	5,455,500	2,991,100	903	6,933	214	417
1987	6,214,500	3,847,600	891	7,133	190	434
1988	6,588,000	4,102,700	902	7,620	204	475
1989	8,206,500	5,134,700	1,000	8,182	296	572
1990	8,780,000	5,283,000	1,060	8,522	257	581
1991	8,924,000	4,933,800	1,100	8,541	386	583
1992	9,300,000	5,417,080	1,150	8,628	424	645
1993	9,310,000	5,370,900	1,115	8,878	473	864
1994	8,758,000	4,560,400	1,145	8,973	527	886

Sources: [a] Forestry Department (1992) and Malaysia (1995).
[b] Data provided by Shahwahid HJ. Osman of Faculty of Resource Economics, Universiti Putera Malaysia, Selangor.
[c] FAO (Various issues).

Table A2.6 Rubberwood Sector Data, 1980-1994.

Year	RWQ[a] m^3	MRLP[a] RM/m^3	RUBP[b] RM/Kg	r[c]
1980	na	24	298	8.50
1981	na.	24	230	8.79
1982	30,056	25	180	11.08
1983	101,265	24	238	11.35
1984	502,636	26	215	11.54
1985	595,437	25	180	10.80
1986	696,210	26	202	8.19
1987	898,020	28	236	7.25
1988	1,240,979	28	301	7.00
1989	1,103,148	30	247	7.17
1990	971,033	27	221	8.13
1991	1,622,366	40	217	9.31
1992	1,837,000	42	213	9.05
1993	1,075,000	40	207	7.62
1994	1,157,000	45	289	8.20

Sources: [a] Malaysia (1995, 1998), the data also provided by Shahwahid HJ. Osman of Faculty of Resource Economics, Universiti Putera Malaysia, Selangor.
[b] MRELB (Various Issues).
[c] IMF (Various issues)

Table A2.7 Sawn Rubberwood Sector Data, 1980-1994

Year	SRQ m^3	SRP RM/m^3	SRX m^3
1980	.	282	17,515
1981	.	462	26,525
1982	.	379	31,525
1983	58,536	357	53,522
1984	98,532	333	95,764
1985	129,500	342	121,232
1986	194,586	354	178,425
1987	289,750	407	258,833
1988	248,199	426	204,070
1989	277,500	458	221,361
1990	287,350	467	103,478
1991	331,261	460	71,261
1992	338,658	439	38,833
1993	392,450	377	27,620
1994	508,763	459	45,529

Sources: Malaysia (1995, 1998), the data also provided by Shahwahid Hj. Osman of Faculty of Resource Economics, Universiti Putera Malaysia, Selangor.

Table A2.8 Plywood Sector Data, 1970-1996.

Year	MPVQ[a] (m³)	MPVX[a] (m³)	PVSAL[b] RM	MPVP[a] RM/m³	PLYMILLS[a]	PLUAN[c] US$/m³
1970	414,400	189,100	1,294	295	20	88
1971	465,900	300,800	1,364	228	27	83
1972	584,000	411,100	1,340	239	31	97
1973	649,900	559,500	1,892	329	40	139
1974	608,000	511,900	2,536	271	43	128
1975	725,000	402,000	2,042	334	43	112
1976	873,000	577,200	2,305	368	43	152
1977	942,000	551,405	2,410	337	43	160
1978	873,000	594,400	2,512	347	39	202
1979	932,000	590,200	2,984	551	40	264
1980	1,076,000	600,600	3,471	559	49	279
1981	1,114,000	626,900	4,449	555	50	231
1982	1,336,000	578,200	4,761	506	53	236
1983	1,536,000	1,033,000	4,677	454	57	243
1984	1,425,000	956,000	5,078	490	57	219
1985	1,353,000	778,000	5,331	482	57	282
1986	1,226,000	827,300	4,912	430	59	237
1987	1,415,000	1,170,500	5,200	484	59	314
1988	1,375,000	1,044,100	5,347	789	64	331
1989	1,535,000	1,177,300	5,677	742	79	336
1990	1,843,000	1,349,200	5,604	789	85	332
1991	2,375,000	1,662,200	6,146	777	99	376
1992	3,300,000	2,468,544	6,123	794	120	334
1993	4,943,000	3,141,000	6,695	1,125	135	442
1994	5,680,000	3,616,600	6,952	1,074	161	455
1995	5,796,000	4,048,200	-	1,025	-	454
1996	5,900,000	4,717,700	-	-	-	450

Source: [a] Forestry Department (1992), Malaysia (1995, 1998).
[b] Data provided by Shahwahid Hj. Osman of Faculty of Resource Economics, Universiti Putera Malaysia, Selangor.
[c] FAO (Various issues).

Table A2.9 Other Data, 1970-1996.

Year	OECDPC[a]	KPC[a]	MPINDX90[a]	PRECOV[b]	SRECOV[b]	VADI[b]	CONSTRUC[c]
1970	12,012	1,591	0.41	2.53	1.6	0.438834	675
1971	12,279	1,693	0.42	2.54	1.52	0.509065	925
1972	12,781	1,741	0.43	2.43	1.42	0.418392	977
1973	13,374	1,929	0.48	2.28	1.41	0.472487	1,114
1974	13,359	2,050	0.56	3.08	1.51	0.526582	1,247
1975	13,252	2,149	0.58	2.23	1.42	0.630507	1,119
1976	13,726	2,364	0.6	2.22	1.46	0.629536	1,220
1977	14,072	2,568	0.63	2.31	1.44	0.546265	1,368
1978	14,509	2,766	0.66	2.53	1.51	0.462994	1,572
1979	14,891	2,919	0.68	2.38	1.3	0.379723	1,761
1980	14,908	2,797	0.8	2.66	1.29	0.338087	2,066
1981	15,002	2,924	0.8	2.85	1.77	0.296452	2,367
1982	14,888	3,098	0.85	2.76	1.29	0.314468	2,598
1983	15,120	3,404	0.88	2.84	1.12	0.654482	2,867
1984	15,632	3,654	0.91	2.8	1.33	0.654452	2,988
1985	16,019	3,855	0.92	2.59	1.56	0.633804	2,738
1986	16,338	4,258	0.92	2.45	1.62	0.674354	2,354
1987	16,714	4,702	0.92	2.52	1.41	0.595661	2,077
1988	17,280	5,181	0.95	2.72	1.45	0.569308	2,133
1989	17,743	5,457	0.97	2.95	1.47	0.587958	2,380
1990	18,016	5,917	1	2.74	1.59	0.543886	2,835
1991	17,993	6,398	1.04	2.53	2.03	0.589709	3,250
1992	18,131	6,661	1.09	2.53	1.53	0.527847	3,615
1993	18,138	6,982	1.13	2.53	1.51	0.528447	4,023
1994	18,499	7,481	1.17	2.53	1.52	0.560360	4,589
1995	18,754	8,068	1.24	2.53	1.54	.	5,287
1996	19,091	8,557	.	2.53			

Sources: a IMF (Various issues).
b Data provided by Shahwahid HJ. Osman of Faculty of Resource Economics, Universiti Putera Malaysia, Selangor.
c ESCAP (Various Issues).

Appendix 3

Table A3.1 Price of Selected Timber Species, Peninsular Malaysia (RM/m^3)

Year	Species								
	Cengal	Balau	ohhw	Keruing	Kempas	omhw	Red Meranti	Mersawa	olhw
71	202.38	145.24	142.86	102.38	88.10	95.24	211.90	142.86	111.90
72	193.02	144.19	148.84	97.67	88.37	93.02	248.84	151.16	104.65
73	222.92	187.50	229.17	160.42	112.50	135.42	260.42	193.75	120.83
74	228.57	166.07	137.50	135.71	107.14	100.00	167.86	155.36	96.43
75	237.93	153.45	127.59	137.93	101.72	103.45	196.55	137.93	94.83
76	215.00	163.33	126.67	141.67	100.00	101.67	248.33	151.67	95.00
77	217.46	165.08	125.40	157.14	109.52	98.41	231.75	168.25	95.24
78	256.06	203.03	145.45	174.24	127.27	113.64	254.55	180.30	103.03
79	327.94	255.88	177.94	235.29	164.71	152.94	344.12	226.47	139.71
80	272.50	245.00	170.00	231.25	167.50	138.75	282.50	212.50	136.25
81	317.50	247.50	172.50	210.00	175.00	133.75	260.00	202.50	131.25
82	240.00	190.59	128.24	167.06	142.35	98.82	207.06	160.00	98.82
83	326.14	240.91	122.73	196.59	161.36	101.14	256.82	179.55	92.05
84	295.60	197.80	119.78	174.73	145.05	92.31	207.69	141.76	98.90
85	292.39	203.26	139.13	163.04	133.70	115.22	189.13	155.43	100.00
86	234.78	181.52	129.35	135.87	120.65	127.17	133.70	127.17	76.09
87	257.61	179.35	123.91	145.65	128.26	127.17	171.74	152.17	91.30
88	303.16	225.26	129.47	205.26	151.58	200.00	182.11	516.84	126.32
89	429.90	269.07	136.08	226.80	159.79	254.64	259.79	236.08	126.80
90	394.00	299.00	115.00	244.00	168.00	126.00	263.00	283.00	141.00
91	413.46	325.96	139.42	296.15	214.42	151.92	251.92	321.15	175.00

Source: Forestry Department (1992).

Table A3.2 Production of Selected Timber Species for Peninsular Malaysia. ('000 m^3)

Year	Species									
	Balau	Cengal	other hhw	Kapur	Kempas	Kruing	other mhw	Red Meranti	Mrsawa	Nyatoh	other lhw
1971	298	74	420	301	299	1656	400	2847	296	88	175
1972	288	74	330	352	461	1796	480	3587	333	103	729
1973	374	140	280	688	525	2046	450	2926	393	134	1395
1974	437	114	310	553	651	1778	400	2563	257	85	1231
1975	395	102	343	390	466	1427	620	2737	244	98	458
1976	499	129	378	495	513	1630	580	3235	346	138	1321
1977	521	141	330	608	517	1732	400	3314	337	148	1204
1978	467	157	300	572	664	1351	610	2842	336	167	1654
1979	491	196	406	618	740	1445	653	3059	258	221	1436
1980	393	156	343	604	647	1269	642	3319	210	256	1897
1981	402	135	299	450	969	1321	668	2854	261	167	1878
1982	352	94	282	364	706	1107	470	2600	297	157	1780
1983	376	128	105	453	666	1025	270	3140	258	250	1688
1984	253	143	173	282	600	876	401	2575	220	172	1991
1985	295	128	81	197	454	740	285	2340	210	130	970
1986	375	145	62	195	431	820	226	2453	228	127	1232
1987	326	183	138	320	474	939	317	2901	286	156	1462
1988	381	157	181	337	574	1015	545	2892	303	183	2131
1989	382	170	147	364	573	919	911	2982	301	163	2651
1990	344	159	86	301	537	971	540	2810	355	502	1710
1991	292	120	77	269	488	783	704	2048	256	233	1810

Source: Forest Department (1992).

Table A3.3 Production of Selected Timber Species for Sarawak, 1970-1991.

Year	Species						
	Meranti	Kapur	Keruing	Alan Bunga	Selanggan	Jongkong	Sepetir
1970	na	na	na	698470	na	na	na
1971	na	na	na	738210	na	na	na
1972	na	na	na	859448	na	na	na
1973	na	na	na	923765	na	na	na
1974	na	na	na	790451	na	na	na
1975	na	na	na	558514	na	na	na
1976	na	na	na	1056332	na	298341	na
1977	na	na	na	1112094	69444	281149	70979
1978	na	226281	127191	1124460	69782	292136	34670
1979	na	298878	157587	1012587	105406	276292	89516
1980	na	759349	573669	1131769	303995	250583	66928
1981	3247091	992583	815880	1196806	276412	226993	148495
1982	4300622	1294324	1058710	1307399	364471	254913	153677
1983	4200577	1431958	1234254	1064171	397115	215056	160949
1984	4375229	1482330	1202055	1333022	384886	222563	176155
1985	5115139	1729199	1353512	1253307	418945	212181	167477
1986	4564037	1561868	1161397	1319553	415657	247603	172098
1987	5349180	1762953	1195909	1394054	556232	283780	218452
1988	5668250	1763227	1171805	1507994	654682	280432	229679
1989	7695858	2267815	1742666	1227020	930576	256759	224953
1990	8618094	2361299	1818204	793438	1049086	243016	233234
1991	8868750	2260598	1725161	704480	1132824	201646	214770

Source: Forestry Department (1992).

Table A3.4 FOB Prices of Selected Timber Species for Sarawak, 1970-1991.

Year	Species						
	Meranti	Kapur	Keruing	Alan Bunga	Selangan	Jongkong	Sepetir
1970	114	96	96	56	84	81	na
1971	113	96	96	53	87	76	na
1972	102	85	85	55	101	74	na
1973	150	136	136	85	139	152	na
1974	157	139	139	85	140	137	na
1975	123	105	105	61	102	95	na
1976	193	167	167	104	141	168	na
1977	140	120	124	70	118	110	90
1978	150	128	128	80	116	120	80
1979	160	130	130	90	114	130	88
1980	153	132	134	92	112	132	96
1981	142	132	132	82	93	99	87
1982	159	149	146	100	109	139	115
1983	129	129	124	85	102	120	95
1984	159	150	146	107	124	103	110
1985	137	132	128	93	110	96	97
1986	146	138	124	95	115	92	101
1987	173	167	165	116	140	124	116
1988	179	167	171	113	153	123	120
1989	197	193	199	139	174	138	134
1990	195	192	197	129	183	156	140
1991	216	214	220	161	209	158	157

Source: Forestry Department (1992).

Table A3.5 FOB Prices of Selected Timber Species for Sabah, 1980-1991 (RM/m^3)

Year	Species						
	Merbau	Mengilan	Selangan	Red Seraya	White Seraya	Yellow. Seraya	Sepetir
1980	193	226	158	228	232	219	187
1981	160	268	137	194	202	188	160
1982	175	247	163	225	227	208	184
1983	205	256	148	188	194	177	160
1984	214	282	156	230	162	167	173
1985	199	248	147	178	187	163	138
1986	150	244	151	195	204	179	141
1987	253	333	180	271	275	250	171
1988	343	350	242	300	311	273	209
1989	350	372	244	303	317	278	233
1990	395	394	236	283	299	259	181
1991	422	379	253	283	299	259	169

Source: Forestry Department (1992).

Table A3.6 Production of Selected Timber Species for Sabah, 1980-1991

Year	Species						
	Merbau	Mengilan	Selangan	Red Seraya	White Seraya	Yellow Seraya	Sepetir
1980	2531	6979	395278	3421901	1653657	920429	37812
1981	4988	25510	548940	4158442	2272984	1125841	42683
1982	1557	69895	750988	4177961	2280034	1101069	39468
1983	2164	80161	1029479	4264680	2280565	1072333	48835
1984	4200	64721	1115585	3247663	1884118	862001	49862
1985	5129	93458	870220	3315002	2003835	965916	37603
1986	4129	107776	811033	2928192	1942081	850362	32984
1987	10786	122866	887474	3456567	1943828	1083506	55757
1988	13357	163437	1046141	2978194	1513251	952673	46683
1989	27945	129545	824872	2624363	1471751	838599	38221
1990	25738	146204	713661	2491038	1483852	724855	33996
1991	39056	136678	711460	2372299	1287161	746134	34569

Source: Forestry Department (1992).

Appendix 4

Table A4.1. Local Name, Botanical Name, Family Name and Group of Malaysian Timber Trees

Local Name	Botanical Name	Family	Classification
Alan Bunga	Shorea spp.	Dipterocarpaceae	LH
Balau	Shorea spp	Dipterocarpaceae	HH
Belian	Eusideroxylon zwageri	Lauraceae	HH
Berangan	Castanopsis spp	Fagaceae	LH
Bintangor	Calophyllum spp	Guttiferae	LH
Cengal	Neobalanocarpus heimii	Dipterocarpaceae	HH
Damar Minyak	Agathis borneensis	Araucariaceae	Softwood
Durian	Durio spp	Bombacaceae	LH
Garutu	Parashorea spp	Dipterocarpaceae	LH
Geronggong	Cratoxylum spp	Hypericaceae	LH
Jelutong	Dyera spp	Apocynaceae	LH
Jongkong	Dactylocladus stenostachys	Crypteroniaceae	LH
Kapur	Dryobalanops spp	Dipterocarpaceae	MH
Kelat	Eugenie spp	Myrtaceae	MH
Kembang semangkok	Scaphium spp	Sterculiaceae	LH
Kempas	Kompassia spp	Leguminosae	MH
Keruing	Dipterocarpus spp	Dipterocarpaceae	MH
Mengkulang	Heritiera spp	Sterculiaceae	MH
Meranti	Shorea spp	Dipterocarpaceae	LH
Merbau	Intsia spp	Leguminosea	HH
Mersawa	Anisoptera spp	Dipterocarpaceae	LH
Nyatoh	Palaquium spp	Sapotaceae	LH
Ramin	Gonystylus spp	Gonystylaceae	LH
Sepetir	Sindora spp	Leguminosae	LH
Seraya	Shorea spp	Dipterocarpaceae	LH
Sesenduk	Endospermum spp	Euphorbiaceae	LH

Note: HH is heavy hardwood, MH is medium hardwood and LH is light hardwood.
Source: http://www.greebid.com

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