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AN INVESTIGATION INTO THE USE OF MACROECONOMETRIC MODEL SIMULATION AND OPTIMAL CONTROL FOR POLICY PLANNING IN THE MALAYSIAN RUBBER AND OIL PALM INDUSTRY

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ABSTRACT

This study examines the use of macroeconometric model simulation and optimal control techniques, for sectoral policy planning concerning the optimal allocation of rubber and oil palm in the Malaysian plantation industry. Optimal crop allocation, which illustrates sectoral planning problems in the developing economy, provides an alternative diversification strategy for tackling the commonly encountered problem of income instability associated with the exports of primary commodities.

Rubber and palm oil contribute significantly to the Malaysian economy and this leads to the selection of a macromodelling approach as the appropriate methodology for studying the impact of sectoral policy changes in the plantation industry. Both historical and futuristic policy experiments were carried out within the consistent framework of a macroeconometric model constructed for this study. An evaluation of the competitiveness of rubber and palm oil is also presented to complement the results from the macroeconometric model.

The simulation results show that the pattern of crop allocation for the plantation industry was not optimal, especially for the rubber smallholding sector, and that an optimal strategy would have been to maximise the planting of oil palm during the 1970-1983 period. Policies for the projected period of 1984-1995 were examined by the optimal control technique. Besides providing some ideas of the optimal paths for various planting strategies for rubber and oil palm, the technique was also shown to be complementary to traditional simulation procedures in macromodel analysis. The results, though exploratory, support the formulation of policies which slightly favour reverting towards increased planting of rubber relative to oil palm for the 1990s.

It was shown that the macromodel simulation and optimal control techniques could be effectively used for sectoral planning, and they provided a way of quantifying the impact of past and future sectoral policies on the country's economy. Ways of improving and adapting the model for actual applications were discussed.

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List of Acronyms

BNM : Bank Negara Malaysia (Central Bank)
BR : Butadiene Rubber
CMS : Constant Market Share
ECAFE : Economic Commision for Asia and the Far East
EEC : European Economic Community
EPU : Economic Planning Unit
ESCAP : Economic and Social Commission for Asia and the Pacific
FAO : Food and Agricultural Organization
FELCRA : Federal Land Consolidation and Rehabilitation Authority
FELDA : Federal Land Development Authority
ffb : fresh fruit bunches
GDP : Gross Domestic Product
GNP : Gross National Product
ICP : Integrated Commodity Programme
IMF : International Monetary Fund
INRA : International Rubber Agreement
IR : Isoprene Rubber
IRSG : International Rubber Study Group
KLCE : Kuala Lumpur Commodity Exchange
LDC : Less Developed Countries
MARDEC : Malaysian Rubber Development Corporation
MOPGC : Malaysian Oil Palm Growers Council
MRELB : Malaysian Rubber Exchange and Licensing Authority
NAG : Numerical Algorithm Group
NAP : National Agricultural Policy
NEP : New Economic Policy
NR : Natural Rubber
OECD : Organization for Economic Co-operation and Development
OLS : Ordinary Least Squares
2SLS : Two Stage Least Squares
3SLS : Three Stage Least Squares
OPP : Outline Perspective Plan
PORIM : Palm Oil Research Institute of Malaysia
PORLA : Palm oil Registration and Licensing Authority
RBD : Refined, Bleached and Deodorised
RISDA : Rubber Industry Smallholders Development Authority

RRIM	:	Rubber Research Institute of Malaysia
RSS1	:	Ribbed Smoked Sheet rubber grade 1
RSS3	:	Ribbed Smoked Sheet rubber grade 3
SBR	:	Styrene Butadiene Rubber
SMR	:	Standard Malaysian Rubber
SNA	:	Systems of National Account
SR	:	Synthetic Rubber
TES	:	Techno-Economic Suitability Index
TSP	:	Time Series Processor
UNCTAD	:	United Nations Conference on Trade and Development
UK	:	United Kingdom
UN	:	United Nations
U.S.A.	:	United States of America
USDA	:	United States Department of Agriculture
WHO	:	World Health Organization

CHAPTER 1: INTRODUCTION: THE PROBLEM AND APPROACH TO THE STUDY

1.1 Introduction

The principal objective of this thesis is to analyse the contributions of rubber and palm oil in the development of the Malaysian economy. The study will also examine, through its broader implications, three other related issues. These are

i) the role of primary commodities in the economic growth of Malaysia which could typify the situation found in many other less-developed countries,

ii) the question of how such a country could face up to the challenges posed by the well-known problems of commodity price instability and

iii) the appropriate analytical techniques for conducting such a study.

The main motivation to the inquiry, however, lies in the recognition that there is an urgent need to evaluate quantitatively the potential of rubber relative to oil palm in their capacity as major crops for the Malaysian plantation sector. Both these crops have been well established and Malaysia is currently the world's largest producer and exporter of the two commodities, but there is still a controversy over the amount of oil palm to be cultivated in relation to rubber, and the situation is made more acute by the lack of explicit policy guidelines from the authorities [1] and the paucity of quantitative studies on the problem.

Malaysia has traditionally depended on agriculture, with the plantation industry providing the central activity by contributing substantially towards employment opportunities, wealth creation and economic prosperity. The major plantation crops are rubber, oil palm, cocoa and coconut while the production of rice and other minor crops such as pepper, pineapple and tropical fruits has continued to command a secondary level of significance. Except for rice and local fruits, the crops are produced principally for exports to overseas markets. Consequently, the exports of primary commodities, like the situation in many developing countries, feature prominently as a source of foreign exchange revenue to the Malaysian economy.

The dominance of rubber and tin production, the two traditional export commodities in the Malaysian economy, has been a major cause for concern to the country's planners. The country's over-concentration in rubber and tin was allegedly undesirable as both products were being threatened by synthetic substitutes and unless economic diversification was introduced, the economy would be subject to frequent income fluctuations arising from price instability of the two commodities. As a result of diversification efforts in the last thirty years, the relative contribution of rubber has declined and new commodities including palm oil, timber, petroleum and manufactured goods are becoming increasingly important. Nevertheless, rubber cultivation is still a major sector. In 1983, export earnings from rubber amounted to M$ 3.664 billion, making up some 11 %

of the country's total export revenue while oil palm, which emerged strongly in the last two decades as the competing alternative crop to rubber, contributed some M$ 2.977 billion. The contributions of other agricultural commodities, excluding forestry products, were relatively small. Needless to say, rubber and palm oil provide not only a major source of foreign exchange earnings for Malaysia (see Table 1.1), but also employment opportunities for some 25 % of the country's work-force. The agricultural sector, in total, employs 1.953 million people or 35.7 % of the country's work-force in 1985 (Fifth Malaysia Plan, 1986, p. 138).

An underlying trend which is of major interest to this study concerns the increasing contribution of palm oil while that from rubber is declining. Past policies have no doubt contributed to the shift in the importance of the two crops, but the future of both crops remains uncertain principally for the following reasons:-

i) Both commodities are produced from perennial crops which have economic life cycles in excess of 20 years. Investment appraisal for these crops would thus require long term projections of expected price trends. This would be difficult in view of continuing uncertainty and instability in petroleum prices and other world economic indicators.

ii) There are competing substitutes, both natural and synthetic, in the respective markets for rubber and palm oil. These add to the uncertainty with respect to future demand for the commodities and the viability of their production.

Despite the significant contributions of rubber and oil palm to the Malaysian economy, there are also negative implications. The long productive life of these crops implies that constructive changes to their production structures can only be

Table 1.1 Malaysia: Exports of Major Commodities, M$ million

Commodities	1975	(%)	1980	(%)	1985	(%)
Rubber	2026	21.9	4617	16.4	2864	7.5
Palm oil	1320	14.3	2515	8.9	3944	10.4
Sawlogs	669	7.2	2621	9.3	2667	7.0
Sawn timber	392	4.2	1178	4.2	1020	2.7
Tin	1206	13.1	2505	8.9	1595	4.2
Petroleum crude	727	7.9	6709	23.8	8970	23.6
Manufactured goods	1917	20.7	6101	21.7	12229	32.2
Others	974	10.6	1926	6.8	4718	12.4
Total Exports of Commodities	9231	100.0	28172	100.0	38007	100.0

Sources: Economic Report, Ministry of Finance 1984/1985, and 1985/86; Quarterly Economic Bulletin, Vol. 18, No.4, December 1985.

implemented over an extended period of time. Such a situation leads inevitably to the difficulty in the implementation of new innovations, and this in turn contributes to the prevalence of some of the inefficient practices and conservative attitudes within the plantation industry. Nonetheless, the situation also suggests that there could be room for improvement in the formulation of policies and implementation of strategies in the plantation sector. This will be explored in this study.

A major consequence of the difficulty associated with planning and the implementation of development strategies for the rubber and oil palm sector is that the smaller units of the industry continue to be exposed to the threat of poverty and this has far-reaching socio-economic implications in terms of development planning in Malaysia. The earnings of the independent rubber smallholders, for instance, have hardly risen in real terms [2] for the last two decades, and those in this category belong to one of the lowest income groups in the country (see Table 1.2). The gravity of the problem can be better appreciated by noting that the smallholdings form a considerable majority (76.0 % in 1982) in the Malaysian rubber planting industry. In contrast, only 6 % of the oil palm sector is under independent smallholdings and the incidence of poverty among them is negligible.

The desire to uplift the economic status of the smallholders has been the major objective of numerous government development projects aimed at eradicating poverty. For example, there have been several attempts by the authorities to introduce a dynamic production strategy and other policies to stimulate rubber production (Fourth Malaysia Plan, 1981, p. 282). In this connection, various statutory authorities have been set up to implement the strategies especially for the development of the rubber industry. In addition, the future prospects for the industry are regularly monitored through policy evaluation exercises such as the preparation of the National Agricultural Policy (NAP) (Anon., 1984) and the Rubber Task Force of Experts Report (MRRDB, 1983).

As a result of the various efforts to improve the performance of the plantation sector, there have been some notable successes over the years in the practices of rubber planting and this is seen most clearly through an increase in the productivity of the rubber plantations. In 1980, the estimated yield per hectare of rubber was 1,105 kilos compared with 750 kilos in 1970 (Fourth Malaysia Plan, 1981, p. 37).

Despite these achievements, it is clear that a large proportion of the sector concerned is still under poverty, and many of the rubber smallholders have yet to benefit from the potential improvement in productivity and the poverty eradication projects. As shown in Table 1.2, the incidence of poverty among the rubber smallholders in Peninsular Malaysia had declined from 64.7 % in 1970 to 41.3 % in 1980 as a result partly of higher prices for the second half of this period and partly of productivity improvements in the sector. However, the incidence of poverty in the rubber smallholding sector remained at a high rate of 43.4 % in 1984 (Fifth Malaysia Plan, 1986, p. 86).

In view of the persistent problem of poverty associated with the plantation industry, the question remains open as regards i) the effect of prolonged price instability on rubber and palm oil production, and ii) the effectiveness of national strategies and policies in tackling sectoral development and the poverty eradication problems. In a country such as Malaysia where the climate and infrastructure could allow the profitable cultivation of two or more major crops, the task of the

Table 1.2 Peninsular Malaysia: Incidence of Poverty, 1970, 1975 and 1980

(In thousands unless stated otherwise)

	1970				1975				1980			
	Total households	Total poor households	% poor	% among poor	Total households	Total poor households	% poor	% among poor	Total households	Total poor households	% poor	% among poor
AGRICULTURE:												
Rubber smallholders	350	226.4	64.7	28.6	396.3	233.8	59.0	28.0	425.9	175.9	41.3	26.4
Oil palm smallholders	6.6	2.0	30.3	0.3	9.9	0.9	9.1	0.1	24.6	1.9	7.8	0.3
Coconut smallholders	32.0	16.9	52.8	2.1	34.4	17.5	50.9	2.1	34.2	13.3	38.9	2.0
Padi farmers	140.0	123.4	88.1	15.6	148.5	114.3	77.0	13.7	151.0	83.2	55.1	12.5
Other agriculture	137.5	126.2	91.8	16.0	157.4	124.1	78.8	14.9	172.2	110.5	64.1	16.6
Fishermen	38.4	28.1	73.2	3.5	41.6	26.2	63.0	3.1	42.8	19.4	45.3	2.9
Estate workers	148.4	59.4	40.0	7.5	127.0	59.7	47.0	7.1	112.5	39.5	35.2	5.9
Sub Total	852.9	582.4	68.3	73.6	915.1	576.5	63.0	69.0	963.2	443.7	46.1	66.6
NON-AGRICULTURE:												
Mining	32.4	11.1	34.3	1.4	31.8	10.1	31.8	1.2	32.6	11.1	34.0	1.7
Manufacturing	150.2	48.5	32.3	6.1	206.9	59.6	28.8	7.1	301.1	55.4	18.4	8.3
Construction	35.0	12.8	36.6	1.6	44.0	13.4	30.5	1.6	56.3	12.0	21.3	1.8
Transport/utilities	74.1	27.1	36.6	3.4	108.1	29.0	26.8	3.5	137.2	31.5	23.0	4.7
Trade and services	61.4	109.9	23.8	13.9	595.5	146.5	24.6	17.6	793.6	112.4	14.2	16.9
Sub Total	753.1	209.4	27.8	26.4	986.3	258.6	26.2	31.0	1320.8	222.4	16.8	33.4
TOTAL	1606.0	791.8	49.3	100.0	1901.4	835.1	43.9	100.0	2284.0	666.1	29.2	100.0

Source: Malaysia (1981), Fourth Malaysia Plan, 1980-1985 planners is likely to be more complex. The need for the attainment of multiple national goals, such as maximising of income and eradication of poverty, implies that planners must include among their more important tasks, the formulation of the appropriate optimal policies in crop allocation. This should be carried out within the framework not only of the numerous constraints on scarce resources, but also the externally imposed problems of trade barriers and price instability.

To put these issues into perspectives, they will be discussed in turn first from the view of commodity problems, and then as part of policy and planning strategies in resource allocation in relation to sectoral development at the national level. It will be explained in a later section, the reasons for selecting the methodology employed in this study, and the data required to support the chosen approach.

1.2 Commodity Problems

Many developing countries continue to depend heavily on the export of primary commodities as a means of generating foreign exchange revenue. This has occurred despite the trend that primary products have been making up a falling proportion of world trade while high-skill-and-capital-intensive commodities have been continuously and rapidly raising their share of world trade (Morgan, 1975).

The Less Developed Countries (LDC) which are engaged in the production of primary commodities are usually affected by the external influence of fluctuating demand and price instability for primary commodities resulting from changing levels of manufacturing activities in the consuming industrialised countries. A small (and often temporary) shift in the demand pattern in the consuming countries may have amplified corresponding effects on the economy of the commodity exporting country. These circumstances imply that countries which are heavily dependent on primary commodities have to face the chronic situation of low and fluctuating incomes, and in turn they usually find it difficult to attain their economic goals.

Consequently, the problem associated with the production and trade of primary commodities continues to be a lively topic especially to those concerned with national development planning and policy analysis. The key issue centres on the difficulty faced by the exporting countries from the consequences of fluctuating income due to the problem of commodity price fluctuation and secular decline in terms of trade. Fluctuation of income, it is often claimed, may exacerbate problems in pursuing private and public economic development plans.

The recognition of the commodity problems, as described in detail elsewhere (see Obidegwu and Nziramasanga, 1981; Adams and Behrman, 1982), is based on the assumption that unstable export earnings are unfavourable to the producer countries, allegedly because the benefits of a price increase seldom seem to offset the disadvantages of a decline in prices to the same scale. A fall in income can adversely affect the financing of on-going investment projects while an unexpected rise in income may not initiate a proportionate amount of new investment. Furthermore, an unexpected increase in government revenues results in an increase in public consumption expenditures, but there is no equivalent cutback in a downturn. A decline in government revenues from exports may be accompanied by increased taxation, government borrowing and higher inflation rates. Subsequently, other secondary effects will emerge, including negative balance of payments, and worsening credit standing which may lead to foreign suppliers demanding advance payments for imports, and these in turn lead to more borrowing and so on.

The concept of the 'commodity problem' has recently been reviewed comprehensively by Adams and Behrman (1982). They acknowledged that the main sources of the problem are price fluctuations and the secular declining trend in real prices of primary commodities which eventually result in both income instability and unfavourable terms of trade to the exporting country. They then suggested that the commodity problem is not an isolated phenomenon but one that should be viewed in the context of the economic goals of each exporting country. In this way, the 'commodity problem' is regarded as one of the many major obstacles to the achievement of the desired economic goals of the exporting country. This observation implies the importance of other measures such as resource allocation and production planning which individual countries could consider in countering the adverse impact of the commodity problems while pursuing the attainment of their desired economic goals.

Although the commodity problems were already an important issue raised at various international forums more than three decades ago, the search for the appropriate solutions continues to be a major concern of both the producing countries and the international community at large. There is a considerable controversy, however, on the nature of the commodity problem itself, and therefore, on the most effective remedial solutions.

Firstly, there is a controversy on whether developing countries should diversify into the manufacturing sector or concentrate on producing primary commodities. Given the lack of technical know-how but plentiful supply of cheaper labour, developing economies may have the comparative advantage in the short run in the production of primary commodities provided there exists a liberal system of international trade.

There are those who hold a pessimistic view of trade potential of the LDC. Nurkse (1961) predicted that the demand for LDC raw material would be declining due to the availability of synthetic substitutes and the increasing effective economising of inputs of raw materials in the industrial countries. Furthermore, agricultural protectionism in higher-income countries, though mainly a bar against imports of temperate zone products, is also a bar to entry of products from tropical countries.

Such pessimism was evidenced in the view of Raul Prebisch (United Nations, 1950) who contended that the advantages of technical progress have been mainly concentrated in the industrial centres and not directly extended to the countries making the periphery of the world economic system. He attributed this to the fact that the characteristic lack of organization among workers employed in primary production prevents them from obtaining wage increases in the boom comparable to those of the industrial countries, and from maintaining them to the same extent in depression. A pessimistic view is also projected in the empirical study by Kindleburger (1956) who found that in the European context, the terms of trade favour the developed and run counter to the developing countries.

Although the LDC have some short term comparative advantage in producing and exporting primary commodities, the concept of free trade may not be fully applicable when commodity price fluctuation affects the economic stability of these countries. Under such a situation some form of interference with free trade may become desirable as a means of countering the adverse effect of export fluctuations. Thus, unless commodity price fluctuation problems can be resolved, the developing countries may do better by diversifying into other economic activities where possible.

In the long run, the task of economic diversification is not easy to achieve because i) factors of production are not easily shifted from one sector to another, ii) fluctuation in income from the export of primary commodities affects the planning and decision making process, and this leads to difficulties in importing capital goods. Fluctuation in export revenues also leads in general to instabilities in employment, income and prices in the local economy, iii) free trade may not be achieved because of import tariffs imposed by the importing countries even on primary commodities, and iv) the attainment of the long term comparative advantage in a new industry requires skills which could only be developed by expanding in the relevant sector, but this would be difficult at a time when the immediate comparative advantage would not support such an expansion. Although diversification is a favoured policy in the LDC, the potential costs should also be emphasized. According to Morgan (1975) diversification will lessen the chance of injury from production failures (drought, diseases and so on) or market declines. The cost of diversification is that a country is chronically poorer, through not specializing in accord with comparative advantage. The cost is high where the productivity of second- or third-choice lines is sharply lower than in the most productive lines.

The arguments presented above reflect the difficulty facing the commodity exporting developing countries in trying to diversify away from the production of primary commodities. Furthermore, when the developing country chooses to diversify into other sectors, there is a danger of the traditional primary commodity industries being neglected and denied the development support since there is generally a scarcity of resources. Under such a situation, the production of primary commodities may decline, resulting in a loss to both the consuming and producing countries. A number of primary commodity exporting countries which steered their economy towards an extensive development of petroleum industries in the 1970s have often found some of their primary industries poorly maintained once the petroleum price boom was over.

Although the ultimate options for the commodity producing country are clear, choosing the right one is probably difficult. By continuing to depend on primary commodities, these countries may never achieve an improvement in their long term comparative advantage in other economic activities, while diversifying into other sectors such as production and exports of manufactured goods may or may not provide the desired outcome of increased comparative advantage.

A second approach in viewing the commodity problem involves the recognition that stable and continuing production of certain primary commodities are beneficial to both the producing and the consuming countries and there would be gains to both sides if some measure of stability in the commodity markets can be achieved. Stable prices in the short run help to stabilise the cost of raw materials in the importing countries and stimulate the economies of the commodity exporting countries. In the long run, stability in prices and income may encourage producing countries to re-invest in the production of the commodity and this would benefit the consuming countries through greater assurance of future supply.

A major attempt at finding a solution in this direction has been through the attainment of price stabilization agreements between the producers and consumers. International efforts have centred around the Integrated Commodity Programme (ICP) promoted by the United Nations Conference on Trade and Development (UNCTAD). The UNCTAD ICP involves international buffer stocks to lessen the price fluctuations for ten core nonpetroleum storable commodities of particular importance to the developing countries (these are coffee, tea, cocoa, copper, tin, natural rubber, jute, sisal, cotton and sugar). An integral part of UNCTAD proposal is the establishment of the Common Fund, originally envisaged to have capital of US$ 6 billion, with a first window to finance the core commodity programmes and a second window that would aid other commodities, encourage diversification, and pursue other less well-defined tasks.

Price stabilization is the main focus of UNCTAD commodity programmes, and rubber was the first commodity where internationally ratified agreement has been reached in 1979 (International Natural Rubber Agreements (INRA)); for many of the other core and non-core commodities such as oils and fats, commodity agreements could be difficult to achieve.

Generally, the progress in finding an effective international solution to the commodity problem has been limited. Practical solutions involving stabilization schemes are difficult to implement and getting an international agreement on a particular commodity requires a great deal of political goodwill between both the consuming and producing countries. Since the launching of the Common Fund in 1976, only one price stabilization scheme, for rubber, had been established although there are other previously established commodity agreement schemes such as for cocoa and tin where similar attempts are made to regulate supplies through production quota and other means.

Recent unsatisfactory performances of the price stabilization schemes and the slow rate of progress in negotiations on commodity problems have led to increasing criticisms of the effectiveness of the commodity agreements in defending price fluctuations. Although the focus of UNCTAD ICP is international commodity price stabilization, many saw it as an attempt to alter the secular terms of trade of the primary commodities of interest (Adams and Behrman, 1982, p. 6).

Others hold the view that price stabilization is the wrong approach to solving the commodity problem. It was argued by Professor Ahmad (1985) for example, that the priority given to the problem of the variability of commodity prices on the world markets had tended to focus attention exclusively on the short run, and had thus precluded consideration of more fundamental macroeconomic and sectoral implications of the problem. He argued that

" ...The combination of buffer stocks with price stabilization for exporting unprocessed commodities at agreed prices will only magnify the original problem, i.e. the inability to alter the composition of exports in response to changes in demand and supply. The price stabilization programme may be likened to taking out an insurance against a doubtful risk whose premiums are more onerous than the loss which it is supposed to imdemnify.... Viewed in the light of its probable long run consequences the commodity price stabilization programme may in fact turn out to be no more than a particularly costly error".

Recently, it has been observed for example, that the prices of rubber have continued to fall, despite the operation of the price stabilization scheme. The tin agreement was even more disruptive in its effect when in 1986 a default by the International Tin Council in its contractual commitments led to the suspension of the London Tin Market and a partial collapse of world tin prices. This in turn led to the closure of many tin mines round the world.

Finally, an alternative approach looks at the commodity problem as one which should be tackled from a two-pronged attack. While commodity price fluctuations continue to be a feature of the world commodity markets and internationally acceptable solutions are being pursued, it becomes imperative that individual countries should consider other ways of overcoming their income fluctuation problems. These alternatives, as discussed more elaborately in the following section, refer to measures which the individual countries can carry out independently through optimising the use of their available resources.

1.3 Resource Allocation Problem

It appears that for the foreseeable future, commodity price fluctuations will continue to prevail and while negotiations on price stabilization and other commodity schemes are being pursued at the international front - and this could be a lengthy process - individual countries could examine the productive capacities and allocative efficiencies of commodities in their export sector.

The ability to shift resources between closely related sectors could be easier to achieve than was previously assumed. For example, in the Malaysian plantation industry, oil palm can now be cultivated in areas which in the past could only be planted with rubber. With the increase in transportation and processing facilities, remote areas are becoming accessible, and the use of bulldozers to construct terraces on hilly areas has permitted the cultivation of oil palm on steeply sloped lands which used to be planted only with rubber.

Furthermore technological advancements have reduced some of the inflexibilities associated with the problem of shifting of resources between the sectors concerned. For example, the gestation period for crop rehabilitation is becoming shorter with the advancement in the type of planting materials made available through research and development. With these advanced planting materials, the immaturity period for rubber can be reduced from six to four years. More importantly, a switch of crops from rubber to oil palm enables the planter to reduce the immaturity period from six to three years thus allowing him to reap an earlier return to his investment.

When compared to the time needed to establish an international commodity agreement, rescheduling of resources and reallocation of the appropriate crops may be a much more effective way of optimising a country's export earnings than through the process of international price stabilization agreements.

However, as some countries have only one major commodity as the leading product in their export sector, there is often not much choice. For example, several studies concerning the role of single commodities in certain developing countries have been restricted to analysing ways of protecting the impact of instabilities in income from the commodity on the country's economy (Obidegwu and Nziramasanga, 1981; Lasaga, 1981, for copper in Zambia and Chile respectively). The general outcome of such studies, perhaps rather predictably, is a set of recommendations for government intervention through fiscal and monetary measures to protect the economy from the effect of price instability, and to provide incentives to encourage further investments to develop the sector concerned.

A drawback in single commodity evaluations in relation to a country's economy is that the level of optimal investment is not determined. This is partly due to the fact that the common technique usually employed in such an investigation - macroeconometric simulation - would not provide results related to an optimum investment scenario. Another reason is that comparative opportunities are not evaluated in a single commodity study.

For many other countries, however, there are often more than one major commodity which they can develop for their export sector. Malaysia for example has at least five major commodities, namely rubber, palm oil, tin, timber and cocoa in addition to petroleum. Given these choices, economic planners are confronted with the difficult task of providing an optimal development strategy. There is a need to maintain or expand economic diversification, not only in terms of the commodities per se but also the development of related downstream resource-based manufacturing industries. These considerations must be balanced on the other hand by the need to invest more in the most profitable commodity while bearing in mind the need to achieve certain national goals such as maximising income and eradication of poverty.

1.3.1 Planning for Resource Allocation

The problem of resource allocation has intrigued economists for generations and the literature is quite full with theoretical and empirical exposition of such studies. Indeed, resource allocation is central to economic studies and as noted by Todaro (1985, p. 7):

> "Traditional economics is concerned primarily with the efficient, least cost allocation of scarce productive resources and with the optimal growth of these resources

over time so as to produce an ever expanding range of goods and services."

(Traditional economics refers simply to the classical and neoclassical economics taught in American and British textbooks.)

In the developing countries, part of the economic development process is to plan for the allocation of the resources. This invariably involves "development planning" which has been almost universally accepted as the surest and most direct route to economic progress. Planning has become a way of life in government ministries, and every 5 years or so the latest development plan is paraded out with the greatest of fanfare (Todaro, 1985, p. 463).

According to Killick (1976), the planning process in the developing countries has the following characteristics:-

1) Starting from the political views and goals of the government, planning attempts to define policy objectives, especially as they relate to the future development of the economy.
2) A development plan sets out a strategy by means of which it is intended to achieve these objectives which are normally translated into specific targets.
3) The plan attempts to present a centrally coordinated, internally consistent set of principles and policies, chosen as the optimal means of implementing the strategy and achieving the targets intended to be used as a framework to guide subsequent day to day decisions.

4) It includes the whole economy and hence it is comprehensive in contrast to "colonial" or "public sector" planning.

5) In order to secure optimality and consistency, the comprehensive plan employs a more-or-less formalised macroeconomic model (which, however, will often remain unpublished), and this is employed to project the intended future performance of the economy.

6) A development plan typically covers a period of, say, 5 years and finds physical expressions as a medium term plan document, which may, however, incorporate a longer term perspective plan and be supplemented by annual plans.

The use of macroeconomic models usually becomes the basis of the planning process through which resource allocation problems are evaluated. Such economy-wide models can conveniently be divided into two basic categories: i) aggregate growth models, involving macroeconomic estimates of planned or required changes in principal economic variables; and ii) multi-sector input-output models, which ascertain (among other things) the production, resource, employment, and foreign exchange implications of a given set of final demand targets within an internally consistent framework of inter-industry product flows. Finally, the third and most important component of the plan formulation is the detailed selection of specific investment projects within each sector through the technique of project appraisal and social cost-benefit analysis. These three "stages" of planning have been described by Todaro (1985) as the main intellectual tools for the planning authority.

Although, as suggested by the three stages of planning described above, sectoral evaluation can be based on various techniques of project appraisal and cost-benefit analysis, there has been an interest among analysts in attempting to incorporate models of major sectors of the economy into the main macroeconometric model itself to enable a more consistent plan to be generated (see, Adelman and Kim, 1969, and Basu, 1981).

The choice of whether to use the traditional cost-benefit analysis or a more integrated macromodel for sectoral planning is an issue which will be the focus of the evaluation concerning the crop allocation problem for rubber and oil palm in this study. There are in existence already established quantitative methods for evaluating the crop allocation problems. These can be categorised into three major types: i) direct investment appraisal analysis, ii) econometric analysis of supply response models and commodity market models and their simulation and iii) linear and nonlinear mathematical programming. The integrated macromodel approach that will be followed in this study will thus be an attempt to improve on these existing traditional methods.

The use of the traditional methods of analysis may be inappropriate in the context of the allocation problems for rubber and oil palm. The application of mathematical programming to crop allocation has been well illustrated in the literature but the focus for some of the earlier studies has been on the allocation of annual crops (Heady and Hall, 1969; Sengupta and Fox, 1969). Planning procedures for the allocation of annual crops are in some respects more straightforward as the planning horizon is usually confined to yearly optimization exercises. In contrast, the evaluation of the optimal allocation for perennial crops is made complicated by the need to consider the long gestation period and the high uncertainty of commodity prices.

Many of the earlier studies on perennial crops purporting to deal directly or indirectly with crop allocation problems have been of types (i) and (ii) mentioned above. The first approach needs no elaboration; investment appraisal usually resorts to a direct evaluation of the return to investment on the individual crops and the crop with the highest (internal) rate of return should then be selected for greater level of investment.

The second approach which relies on econometric models usually involves the evaluation of the pattern of demand, supply and price relationship from which crop potential is deduced. Both the investment appraisal and the econometric approaches are usually complementary. The price projections from the econometric model are normally required in the investment appraisal of the first approach.

In Malaysia, the use of the direct investment appraisal method provides individuals and firms with a useful approach for selecting the appropriate crop to be cultivated. A few of such studies for rubber and oil palm have identified the superior returns to investment for oil palm relative to rubber (Ariffin and Chan, 1978; Lim and Chai, 1978). Lim and Chai, for example, showed that the internal rate of return to investment was highest for cocoa-coconut intercropping, at 29.6 %, followed next by oil palm at 23.0 % and then rubber at 15.8 %. The computation was based on future price expectations of M$ 2.00 per kilogramme of rubber, M$ 800 per tonne of palm oil, M$ 3,500 per tonne of cocoa and M$ 650 per tonne of copra. These expectations are still comparable to the present prices of the commodities in question thus suggesting that the evaluation may remain applicable to the Malaysian plantation sector.

However, despite the favourable rates of return for cocoa and oil palm, the crop distribution pattern that emerged in the following years after the study was published did not seem to indicate a significant change in the allocation trend for rubber cultivation especially in the rubber smallholdings. Moreover, the overall national distribution pattern for plantation crops does not reflect the profitability trend suggested by the results of such investment appraisal analysis. The least profitable crop still has the highest share of the cultivated areas in the country.

The disparity between the implication of the investment appraisal and the actual pattern of crop implementation suggests that direct investment analysis alone may not be sufficient for solving the resource and crop allocation problem nationally where multiple goals are usually involved. Despite the prediction of the model, many investors continue to retain an optimistic outlook for rubber.

An interesting feature of the resource allocation problem is that it becomes more complicated as the organization or sector being planned becomes larger. At the macro level where many major economic sectors are involved, planning in the agricultural sector for example, is bound to affect the trade and other sectors. Hence, there is a danger that results obtained from an analysis at the micro level through investment appraisal or using models which do not account for the intersectoral relationships may not be optimal from the macro view point.

It is for these reasons that more interlinked econometric models are often used in policy analysis in general and in crop allocation analysis in particular as in this study. The range of complexities of econometric models for perennial crops varies from the predictive type of supply response models, (see French and Mathews, 1971; and Labys, 1973) to the fully integrated models as suggested in a study for coffee by Ford (1977) as well as that by Adams and Behrman (1982). More importantly, there have been considerable improvements in the techniques of evaluating the contributions of major commodities through macroeconometric models as illustrated in more recent studies (see Obidegwu and Nziramasanga, 1981; and Lasaga, 1981)[3].

1.4 The Scope and Plan to the Study

This study departs from the more common inquiry on the impact of commodity problems associated with price instability and explores instead the potential of production re-scheduling and crop reallocation which could maximise and even stabilise export earnings of the commodity exporting country. The investigation is limited to rubber and palm oil in the context of the Malaysian plantation sector. More specifically, the study aims to investigate the extent to which macromodel simulation and optimal control analysis can be applied in planning for optimal development strategies for the Malaysian rubber and oil palm plantation industry. For reasons explained above, the use of a comprehensive macromodel technique is adopted as opposed to the micro method of investment appraisal analysis to explore the crop allocation problem.

The core of the analysis conducted in this study therefore centres on the macroeconometric model which has been constructed to be used as the consistent framework for carrying out both historical and futuristic policy analyses relating to the palm oil and rubber industries. Hypothetical and tentative policy experiments are carried out through the methods of model simulation and optimal control analysis.

The complementary use of the macroeconometric model simulation and the optimal control techniques forms a major highlight to the study. The aim is to illustrate how the approaches can be used to overcome some of the familiar problems encountered when policy planning is carried out using the conventional simulation procedure alone. Details of these procedures will unfold as the reader proceeds to read Chapter 6 and beyond. However, sufficient salient background information to the Malaysian economy, and some important aspects and characteristics of the rubber and palm oil industries are provided in the next few chapters.

The unique interrelationship existing between the rubber and palm oil sector makes an interesting study. Despite the physical differences of the two products and the contrast in their end-uses, their production processes as well as the market structures are similar. In most instances the land that is suitable for rubber cultivation is also useful for planting oil palm and the establishment costs of the two crops are approximately the same. The high degree of substitutability for land allocation implies that the problem of optimal crop allocation exists not only at the level of the individual investors but also nationally, where a corresponding crop allocation problem can be formulated in relation to optimising a broader set of national goals. For this reason, the use of a macromodel that is responsive in detecting hypothetical policy changes imposed on the rubber and oil palm industry would be a desirable tool for optimising the production of rubber and palm oil in the Malaysian economy.

A review of the literature shows that no previous attempts have been made to study comparatively the allocation problem for perennial crops from a macroeconomic modelling approach. For such a study to be feasible, the crops involved must be sufficiently dominant in the host country's economy in order for the impact of the crop allocation to be measurable in a macromodel analysis. The unique role of rubber and palm oil in the Malaysian economy thus provides an interesting case study to test the usefulness of the analytical tools of macromodel simulation and optimal control analysis.

The presentation of this study is divided into 10 chapters. An overview of the methodology, data requirements and past macroeconomic models of Malaysia is presented in the next chapter. Salient background information on the Malaysian economy and the rubber and palm oil industries is given in Chapters 3 and 4. This is followed in Chapter 5, by a market share analysis of the competitive potential of palm oil and rubber in the context of their world markets.

Model construction, validation and simulation are presented in Chapters 6, 7 and 8. The simulations of historical and forward policy options relating to the rubber and oil palm industry form the basis of examining the effectiveness of past crop allocation policies and the direction of optimal policies for the future. Chapter 9 examines the use of the optimal control technique on the macromodel for complementing the analysis of crop allocation policies. The findings of this study are finally summarised in Chapter 10.

Notes to the Chapter:-

[1] The lack of clear policy on crop allocation prompted the government to introduce the National Agricultural Policy in 1984, and to request an expert group to study the rubber industry in 1983. The results of these studies, as discussed in Chapter 4, give only a qualitative policy on crop allocation ratio for oil palm and rubber, and similar generalised policies are projected in the various Five Year Plan documents of the country.

[2] The prices of RSS1 grade rubber for 1960, 1970, 1980 and 1985 were 184.11, 124.41, 312.35 and 188.60 M cents per kilo respectively. If these are deflated by Consumer Price Indices (CPI) which have increased from 100 in 1960-67 to 179.5 in 1980 and 226 in 1985, real prices of rubber in Malaysia have actually declined by about 50 % between 1960 and 1985. Fortunately, income from rubber has not been as badly affected as there has been an increase in yield for rubber during this period.

[3] See also Tan, C. Suan (1984), p. 68 for a review of some Econometric Studies of Perennial Crop Supply Response.

CHAPTER 2: METHODOLOGY AND THEORETICAL APPROACH

2.1 Introduction

This chapter examines the applicability of the simulation and optimal control techniques in macroeconomic policy analysis. The use of such modelling techniques involves certain assumptions and approximations to simplify the complex real situations, and these must take into account past criticisms, problems and achievements as reported in the literature. These aspects of the approach to the study are reviewed in this chapter.

Model simulation techniques have wide ranging applications in many fields of studies. The popularity of the technique has escalated with the emergence of powerful computers since the 1960s. Problems which are impossible or inconvenient to solve in some other way may be evaluated by the simulation procedure.

The basic principles are simple enough. The analyst builds a model of the system of interest, writes computer programmes which embody the model and employs the computer to imitate the system's behaviour when subject to a variety of operating policies.

There are however, various controversies on the validity of the simulation techniques especially when applied to policy analysis involving macroeconometric models. The criticisms by

Lucas (1976) are worth noting. He argued that because of 'rational expectations', the parameters of a macroeconometric model would change with each policy option and that the assumption that the model coefficients remain invariant with changing policies is theoretically untenable. Others (Gordon, (1976) have refuted the critique and cited various situations in which macroeconometric simulation will continue to be useful for policy analysis. Thus it is necessary to understand the situation in which the method can be applied in the context of analysing the allocation problem for rubber and oil palm in the Malaysian plantation industry.

The emphasis in the methodology to this study lies on the consistency framework provided by the macroeconometric model on which the impact of policy changes can be compared through simulation. The consistency aspect is important in ensuring that the direct and indirect impact of a shock change in an instrument variable can be compared in a consistent manner. Without the consistent framework showing how the major economic variables interact, a policy evaluation might only be partial and can be misleading.

This study has several major objectives and the use of the macroeconometric model framework is judged to be the most appropriate in relation to evaluating these objectives. The multiple objectives are as follows:-

i) The competitive allocation of land for rubber and oil palm in the Malaysian plantation sector should be examined from the macro viewpoint. Despite the known higher returns to investment for oil palm compared to rubber, national distribution of planted areas for rubber and oil palm does not appear to reflect the observed profitability trend effectively. The use of the macroeconometric model provides the framework for assessing the crop allocation problem in the national context, even though many individual units of the sector may have optimal crop allocation schemes through the influence of investment appraisal and other forms of project analysis.

ii) Mostly the applications of macroeconometric model simulation focus on the analysis of national macroeconomic variables related to financial stabilization objectives and rarely is the macroeconometric approach used for sectoral planning of physical allocation of resources. Furthermore, while most related studies in the past have examined the impact of only one commodity, there is an opportunity for comparing the impact of two commodities simultaneously in this study. A comparative approach is desirable in demonstrating the efficiency of allocation of the two major crops at the national level.

iii) The complementary use of macromodel simulation and optimal control analysis for sectoral policy planning is of interest in this study. The usefulness of macroeconometric models has often been criticised as being too dependent on the ability of the planner or decision maker in supplying accurate target growth for the exogenous variables of the model. The derivation of the targets is often subjective and it invites criticisms over the reliability of policies formulated on the basis of the macroeconometric models. Part of these problems can be overcome if the technique of macromodel simulation and optimal control method can be used in a complementary way.

iv) The study also attempts to show that Malaysia has been able to participate sucessfully in exporting palm oil to the highly competitive world market for oils and fats. It is the expansion in the palm oil sector that has enabled the country to overcome its over-dependence in the export of just one major agricultural primary commodity i.e. natural rubber, and hence diversification into palm oil has provided some protection against earning instability from the export of primary commodities. The quantitative evaluation attempted in this study enables the losses from non-optimal crop allocation strategies in the past to be quantified while the hypothetical future policy simulations using the optimal control technique may yield results which could be used to determine future plans for the optimal allocation of rubber and oil palm in the Malaysian plantation sector.

2.2 Comparative Advantage.

An attempt is made in this study to determine the competitive position of rubber and palm oil in their respective markets. Competitiveness, which reflects largely the position of comparative advantage of the producers is regarded as the basis for a country's ability to continue to produce a commodity in the long run, when there are competitions from other countries involved in the exports of similar competing products.

To evaluate further the competitive strength of palm oil, an analysis is presented in Chapter 5, based on the theoretical implications of comparative advantages. Both statistical trend and comparison of production costs methods are presented.

The statistical method is based mainly on the technique of Constant Market Share Analysis (CMS) with the aim of illustrating the competitive strength of palm oil in relation to other oils and fats in the world market. The CMS method can also be employed to show the competitive trends of palm oil as a commodity in the export mix of the Malaysian economy. The details of the CMS analysis are described in Chapter 5. It is noted at this juncture that the results from the Constant Market Share analysis coupled with those from the method of comparing costs of production would contribute towards validating the assumptions to be made regarding the price prospects of palm oil, since these will be employed as inputs to the model simulation experiments in Chapter 8.

The competitive position of natural rubber will also be evaluated in Chapter 5 but the treatment is mostly based on the use of projections made in other studies. This approach has been adopted as a way of limiting the scope of this study and to allow the results of numerous studies on the rubber economy to be fully utilised.

2.3 Modelling Methodology

As mentioned earlier, the sectoral policy evaluation for the rubber and palm oil industry will be evaluated through a macroeconometric framework of the Malaysian economy. A large number of models for the Malaysian economy have been constructed in the past and the model constructed for the present study will draw from the experiences that have accumulated from these past model building efforts (see Section 2.4 for a review of Macroeconometric Models for Malaysia).

However, some digression is appropriate at this juncture to explain two important concepts concerning macroeconometric models. These are :-

i) the macroeconomic aspects especially in terms of the relevance of traditional macroeconomic theory to the less developed country,

ii) the econometric aspects of using macroeconometric models.

2.3.1 The Macroeconomic Perspectives

Macroeconometric models are usually constructed within the Keynesian framework for determination of national income, consumption and investment as well as other macroeconomic variables such as employment, prices, wage rates, interest rates, and production. The nature of the macroeconometric model can be illustrated with a simple prototype example involving the consumption and investment functions which are supplemented by an identity (an equation defining an equality or equilibrium relationship) as follows:-

$$C = a_1 Y + b_1 + e_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots(2.1)$$

$$I = a_2 Y + b_2 Y_{-1} + b_3 + e_2 \quad \ldots\ldots(2.2)$$

$$Y = C + I + G \quad \ldots\ldots\ldots\ldots\ldots\ldots(2.3)$$

The consumption function indicates that consumption (C) is determined by a linear function of current national income(Y). The investment function shows that Investment (I) is jointly determined by current and lagged income. Both equations are stochastic, where the stochastic error term 'e_i' represents the omitted variables influencing consumption and investment including errors due to mis-specification and measurements. The last equation is an identity defining national income as the sum of consumption, investment, and government expenditure. It is therefore non-stochastic. The three equations determine the values of the three current endogenous variables - C, I, and Y - given values of the one lagged endogenous variable Y_{t-1}, the one exogenous variable G and the constant terms b_1 and b_3.

This simplified model is a prototype of macroeconometric models because most macroeconometric models would contain the consumption, investment and income functions or their components except that practical models are more disaggregated and may include other sectors such as production, wages, prices, interest rates, employment and unemployment. The prototype model shown above is linear and can be solved quite easily by matrix inversion methods once the coefficients have been estimated. In practice, nonlinear equations are often used in the specification of the model. In solving the system of nonlinear equations, one of the nonlinear equations techniques, such as the Gauss-Seidel or the Fletcher-Powell algorithm is used, since these methods are often incorporated into computer software packages for solving econometric models.

Although simulating macroeconometric models has become simpler with the advent of powerful computers and the availability of the appropriate software, formulating a macroeconometric model is still a difficult process. A major question is whether the traditional neo-classical or neo-Keynesian economic theories are applicable and relevant when applied to characterise situations in the developing countries. Already, many development economists agree that what has come to be known as traditional or Western neo-classical and neo-Keynesian economic theory is in itself of limited relevance for understanding the characteristic features of the economies and economic progress of the Third World.

Traditional economic theories are based on the assumptions of consumer sovereignty, perfect competition and profit maximization all of which are hypothesised to operate within an environment of equilibrium and stability that is assumed to exist in the developed industrialised countries. These features are often not attainable in the developing economies which are instead characterised by disequilibrium and instability. The microeconomic theory on production which is based on profit maximization, consumer sovereignty, and perfect competition, may not fully apply in the developing countries because competitive markets do not exist, nor are they fully desirable.

Consumers sovereignty applies only in so far as prices of goods are to be dictated by the international primary commodity markets. As asserted by Todaro (1985, p. 13), perfect competition remains an ideal with little relation to reality in the developing economies, and the role of the famous Adam Smith's notion of "invisible hand " simply seems to promote the rich to be richer and the poor to be much worse off.

The irrelevance of microeconomic theory to the developing country is similarly applicable in macroeconomic aspects. Macroeconomic theory, whether in its "Keynesian" or "monetarist" form, also views the economy through competitive equilibrium, supply and demand spectacles. Keynesian policies on employment for example, usually prescribe for increasing aggregate demand so that the government can generate a higher rate of economic activity and consequently induce a higher level of employment.

In the developing countries, however, markets for product, resource and financial transsactions are often poorly organised, and such market situation results in the dual coexistence of modern and traditional sectors in both agriculture and industry. The situation is further compounded by inadequate and malfunctioning credit systems and a general vulnerability of LDC to powerful foreign economic influence. There is underemployment in the labour force in addition to the usual unemployment problem especially in the traditional sector and the application of Keynesian type fiscal policy may not be expected to result in as much stimulation of economic expansion and increased employment as would be expected when such policies are applied in the developed economies.

Economic policies in the developing countries are thus concerned more with trying not only for efficient resource allocation and steady growth of aggregate output over time, but also on achieving a mechanism for bringing about rapid and large scale improvements in the standard of living for the masses of the poor. This often necessitates the formulation of appropriate public policies designed to affect major economic, institutional and social transformation of the entire societies in the shortest possible time (Todaro, 1985). Some of these assertions will be further described more specifically in Chapter 3, when the salient features of the Malaysian economy are examined. An attempt will be made to include such special features of the developing economies in the construction of the macromodel of Malaysia in Chapter 6.

2.3.2 The Econometric Aspects of Macroeconometric Models

The use of macroeconometric models for policy analysis has been well established. Macroeconometric models became one of the most important applications of econometrics, and the rate of progress in macroeconometric modelling is directly influenced by the advancement in econometric science in addition to the impetus given to its development due to advancement in computer technology and programming.

Over a span of about half a century since the first major macroeconometric model of the U.S.A. was constructed by Tinbergen in 1936, there has been a boom in model building efforts not only in the U.S.A. but also in almost all the industrialised countries and many of the developing countries as well. Equally, there have been numerous reviews on macroeconometric modelling including those by Tinbergen (1967), Nerlove (1966), Hickman and Lau (1976) and Intriligator (1978).

The major features of the development trends in macroeconometric model building can be listed as follows:-

i) The number of equations contained in the model has increased significantly. The U.S. model by Tinbergen in 1936 contained 50 endogenous variables and 14 exogenous, with 32 of the 52 equations stochastic and 18 non-stochastic. By the early 1970s a family of macroeconometric models had emerged for the U.S.A. with the Brookings model, Wharton model and Chase Econometric model being among the most well known. Some of these models contain more than 700 equations, and today, macroeconometric models with over 100 equations may be considered small.

ii) The computation techniques for simulating (solving) the equations of the model have improved considerably. This has influenced not only the size of the model but also the specification of the equations. The Wharton model (Evans and Klein, 1968), for example, was made up of mainly linear equations or when an equation was not linear, a linearization procedure had to be used. Most modern macroeconometric models contain a significant proportion of nonlinear equations, and nonlinear solution techniques are used in their simulation. Many econometric programming packages are available to assist the model builder in such simulation procedures.

iii) There appears to be a trend that in the case of planning, the Leontief static or dynamic input-output macromodel has been the accepted approach, while the use of macroeconometric models for medium to long range planning has been rare, even in the case of the developed countries (see Basu, 1981). In the developing country, the reason may be that the model builder has no choice but to rely on input-output tables as the only source of coherent and consistent data. The use of macroeconometric models in policy analysis in the developed countries, on the other hand has mainly been confined to financial stabilization analysis.

Econometric techniques allow for several methods of estimating the coefficients of the equations of the model. Most models in practice use the OLS method of estimation by which the benefits of more accurate estimates from using more detailed techniques such as the 2SLS, 3SLS etc are sacrificed for computational simplicity. Usually the level of error in macro aggregated variables does not justify the accuracy from improvement obtained through better estimation technique for the equations. Detailed treatment of estimation procedures are provided in most econometric textbooks; readers interested in econometric modelling may find extensive coverage of the subject in Fair (1984), Chow (1983), Intriligator (1978), Maddala (1976) and

Pindyck and Rubinfeld (1981). Some of the more recent policy planning studies based on using macromodels for assessing the role of major commodities have been reviewed by Adams and Behrman (1982).

When the model is fully linear, the economy, which was earlier represented by a simple prototype model, can be written more concisely in matrix notation as

$$y_t = A_0 y_t + A_1 y_{t-1} + \dots + A_m y_{t-m} + C_0 x_t + C_1 x_{t-1} + \dots + C_{t-n} x_{t-n} + b_0 z_t + b_1 z_{t-1} + \dots + b_k z_{t-k}. \tag{2.4}$$

where y is a vector representing the endogenous variables of the model, x is a vector of exogenous variables selected for use as instruments in later application of the model for analysis, and z represents the vector of exogenous variables including the intercepts for each equation.

The construction of the macroeconomic model involves the estimations of the coefficients A, C, and b, while simulation of the model refers to solving the system of equations simultaneously given the values of the exogenous as well as the lagged endogenous variables of the model. By experimenting with different input values of the instrument variables, the model builder can examine the effect of various policies on the economy as represented by the model. This forms the basis of analysing the historical and future outcome of various policy scenarios applied to the evaluation of the crop allocation policy for rubber and palm oil in this study.

Two main assumptions in accepting the simulation procedure are that the coefficients of the model remain stable over the period of forecast and that the Lucas critique (see Lucas, 1976) is not entirely applicable. Menges and Diehl (1964) had tested the time stability of econometric model parameters and they found mixed results. Depending on the country and the sector being modelled, the coefficients of the regression may vary with time. In this study the coefficients are estimated from a data series of 24 years, and the forecast period is for twelve years. It is assumed that the data base is sufficiently long to provide a more accurate estimate of the coefficients, and the forecast period is sufficiently short so as to imply that the structural coefficients of the model will remain stable and relevant for the duration of the planning period.

Furthermore, both the Lucas critique and the time stability tests refer to situations in the developed countries where for the former, the assumption of the existence of optimising agents or 'rational expectations' is important. For the developing countries, such an assumption may not fully apply since price mechanisms and markets do not function in an efficient way. In addition, the significant influence of external factors on the economy may imply that the variants of the model parameters over time and over policy change may be smaller. For example, in this study, prices of commodities are determined outside the model and it follows that their coefficients should remain unaffected by policy changes in the allocation for rubber and oil palm. In addition, appropriate modifications to the relevant coefficients of the model will be introduced to account for known simultaneous effects of introducing a policy change to the planted areas for rubber and oil palm. This is to improve the responsiveness of the model. Such modifications concur with the suggestion by Gordon (1976) in his reply to the Lucas critique that shifts in the parameter values may be deduced on a priori grounds.

There are other considerations which must be included as part of the routine in the process of model construction. The level of complexity for example, is determined firstly by the intended application, and secondly by the need to keep the structure simple and the model size as small as possible. A large model is likely to require more time to build and will use a larger amount of computing resource to simulate, and it is bound to have more accidental errors which in turn will require more time to eliminate. Larger models however, may be more accurate in representing the economy being modelled and may be more responsive in the sense that they allow the impact of sectoral changes to be better detected. These requirements call for a balanced approach in designing the complexity and size of the model to be built.

Models are only at best an approximate representation of the entity being studied. There are bound to be imperfections and rigidities in the response of the model when simulated. The rigidity in the model structure however, may be overcome by augmenting the model using additional external information. The use of external information as inputs in model analysis requires an understanding of the mechanism of the sector being studied. Assumptions have to be made, and to provide further evidence in support of some of these assumptions, especially on the future viability of palm oil, an evaluation of the competitive aspects of palm oil is presented in Chapter 5. The aim is to show that there is a sufficient potential demand for palm oil and this should indicate intuitively the range of price trends which could be used in the futuristic simulation analysis of the macromodel.

More generally, this study emphasises the simulation aspects of the exercise as this will provide the planner with a quantitative understanding of the future situation of the economy. Viewed in this way, the result of a simulation is only one of many possible scenarios that could prevail and thus it should not be regarded as definitive and fully predictive of the future.

Simulation will help the planners to quantify the interactions of the economy in their planning assumptions. After all, planners do take into account the reactions between different sectors of the economy in making decisions however imperfect their knowledge of these reactions may be. Chow (1975) has asserted that " It is more dangerous for planners to hide their assumptions of the economy on which policies are based than to state them explicitly in quantitative form". Of course, the poorest alternative is to avoid making decisions and make no plans at all.

The full extent of the applicability of the model for predicting the future impact of policies is known only through the comparison of the performance of the model in practice. However, even when certain assumptions made in the model simulation may become invalid with unforeseen changes in the particular variables, the model may still be useful for indicating the direction of change under the new scenario after allowing for the unforeseen changes. In this respect, the robustness of the simulation approach is being tested, i.e to what extent can it provide useful results given the approximations which have been introduced to allow the feasible computation of the model. Although econometric model builders have to come to grip with the Lucas critique, which by its extreme implication, invalidates the simulation procedure altogether, econometric models can be useful for evaluating policies where perhaps rational expectations are not so dominant (see also Sheffrin, 1985, p. 108).

On the other hand, attempts to improve the construction and simulation response of macroeconometric models have continued to provide encouraging results, especially for the developing countries (UNITED NATIONS, 1982). Thus, a brief review of the progress in macroeconomic modelling efforts in Malaysia is in order and this will be presented in a later section. More detailed description of the actual construction of the model is presented in Chapter 6. Some of the data problems will be discussed in the section on data sources below.

2.3.2 Optimal Control Technique.

The use of the optimal control technique in this study is aimed at two major objectives. The first is to demonstrate how the use of this technique enhances the usefulness of the macromodel in policy analysis. The second is to use the technique to explain more thoroughly the direction of optimal crop allocation policy in the Malaysian plantation sector for the future.

The description of the optimal control technique, besides being well documented in the literature, (Sengupta and Fox, 1969; Pindyck, 1973; Chow, 1975; and Fair, 1984) is briefly presented in Chapter 8. It is sufficient to indicate at this juncture that it is one of the more recently developed techniques for policy analysis as evidenced by the quotations in Chow (1975) "... Optimal Control: A Mathematical Supertool...", which suggests the initial excitement attached to the use of the technique in the seventies.

On the other hand the survey by a British Committee of Policy Optimization, (Johanson, 1979) shows that the technique is less applicable to the day to day planners of the Treasury although it could provide an interesting approach to complement macroeconomic simulation analysis.

Control theory originates in the engineering sciences, and it assumes the existence of a law of motion for the system being controlled. The law establishes the relationship that the next period's position of state y_{t+1} depends on the current position y_t, the action of the controller x_t and independent shock z_t.

$$y_{t+1} = F(y_t, x_t, z_t) \qquad (2.5)$$

As in the simulation approach, the debate over the use of control theory in economic stabilization policy analysis centres on the premiss that there exist stable coefficients of the model parameters i.e. the existence of a fixed law of motion which is invariant to the way a policy is selected (Prescott, 1977). In macroeconomic application the fixed law of motion would be represented by the function F which is the reduced form of the econometric model (2.4).

Thus, the arguments for supporting the use of the macroeconometric simulation apply equally to justify the use of the optimal control technique. In some respects, the investigation on the use of the optimal control technique in this study is aimed at investigating some of the above controversies.

The idea of fixing targets in macroeconomic planning was first introduced by Tinbergen (1956). In his scheme, a set of target variables and an equal number of instruments are selected. These instruments are controlled to keep the target variables on the desired path. When there are more targets than instruments, or if there are costs in adjusting instruments, there will be a trade-off and an objective function must be introduced. Simon (1956) and Theil (1957) developed computationally feasible techniques when the law of motion was controlled. The law establishes the relationship that the next period's position of state y_{t+1} depends on the current position y_t, the action of the controller x_t and independent shock z_t.

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As in the simulation approach, the debate over the use of control theory in economic stabilization policy analysis centres on the premiss that there exist stable coefficients of the model parameters i.e. the existence of a fixed law of motion which is invariant to the way a policy is selected (Prescott, 1977). In macroeconomic application the fixed law of motion would be represented by the function F which is the reduced form of the econometric model (2.4).

Thus, the arguments for supporting the use of the macroeconometric simulation apply equally to justify the use of the optimal control technique. In some respects, the investigation on the use of the optimal control technique in this study is aimed at investigating some of the above controversies.

The idea of fixing targets in macroeconomic planning was first introduced by Tinbergen (1956). In his scheme, a set of target variables and an equal number of instruments are selected. These instruments are controlled to keep the target variables on the desired path. When there are more targets than instruments, or if there are costs in adjusting instruments, there will be a trade-off and an objective function must be introduced. Simon (1956) and Theil (1957) developed computationally feasible techniques when the law of motion was linear, and the objective function quadratic. These methods were first applied to production scheduling and inventory control (Holt, Modigliani, Muth, and Simon, 1960). Subsequently, Theil (1964) advocated that they be used for macroeconomic planning.

The applications of the optimal control technique for macroeconomic policy analysis have been taken up by Pindyck (1973) and developed further by Chow (1975). Kendrick (1976) surveyed over 90 applications of the technique, and more recently further developments on the topic have been described by Chow (1983) and Fair (1984). Two major applications related to physical planning are illustrated by Anandalingam (1983) and Basu (1981).

To employ the optimal control technique, the macroeconometric model has to be recast into its state-variable form. This involves firstly converting higher order terms and including them into first order equations which are added to the model, and then using the reduced first order system of equations for the computation of the optimal control algorithm. Thus the structural equations of (2.4) are transformed into their state-variable form which can be written as follows:-

$$y_t = A\, y_{t-1} + C\, x_t + b_t \qquad (2.7)$$

where in this special deterministic form the error terms have been eliminated through the usual assumption that their mean equals zero. The instrument variables x_t are also understood to be already included in the vector y_t to simplify the representation and the derivation of the solutions to the optimal control problem. The time subscript for x and b have been modified to account for the different form of relationship in macroeconomic models when compared to the law of motion derived from the engineering application as represented by equation (2.2) (see Pindyck, 1973; and Chow, 1975).

The quadratic objective function (W) is usually formulated as follows:-

$$W = \sum_{t=1}^{T} (y_t - a_t)' K_t (y_t - a_t) \qquad (2.8)$$

The performance of the system is thus measured from the deviation of y_t as defined in (2.8) from the target vectors a_t (t=1,...,T), with the initial condition y_0; and K_t are the weight matrices. An optimal control problem is to minimise the expected objective function (2.8) subject to the reduced form of the econometric model (2.7). The matrix K is usually a diagonal matrix. Thus variables which are given non-zero elements in the K matrix are explicitly included as target variables in the objective function. These variables will be steered to track their target values as close as possible by the effects of the instrument variables when subjected to the minimization algorithm.

The details of the algorithms are discussed in Chapter 9. Readers can anticipate that given certain targets which are initially determined by systematic evaluations via the simulation approach, the optimal control technique can be employed to determine the optimal paths of the control variables with respect to optimal paths of certain targeted state variables. Thus the optimal paths of planted areas for rubber and oil palm in the Malaysian economy could be studied in this way given some desired and feasible growth targets for GDP and export revenue in the objective function.

2.4 An Overview of Some Past Macroeconomic Models of Malaysia.

The literature on macroeconomic models of Malaysia has grown considerably since 1968 when the first econometric model for West Malaysia was constructed by Niebhur (1968). His model and the next to follow which was built at ECAFE (1973) were designed for internal use by the respective U.N. organizations. The first published work of a real sector macromodel was presented by Cheong (1974). This and other models at that time (Cheong and Tillman, 1976) were constructed under various constraints of computing limitations and data unavailability. Some of these early models were structured as a system of linear equations to simplify the simulation procedure, and many covered only West Malaysia. The Eastern states of Sabah and Sarawak were not included because of unavailability of accurate data.

Modelling the Malaysian economy was not an easy task. It must be remembered that Malaysia was formed only in 1963 through the unification of Malaya, Singapore, Sabah and Sarawak. Two years later Singapore left to become an independent Republic. These changes require major reorganisation in data collection and collation efforts. Time was needed to allow the aggregated data series to evolve either through the usual statistical sources or through specific exercises of compiling and aggregating data from the component states.

In view of these data limitations, which have been widely noted as a common problem in modelling the developing economy (Bos, 1982), it is not surprising to find that many of the earlier models of Malaysia were exploratory in nature. Some of the modelling efforts were only partially completed with further work, especially the results, being promised but the final installments were often never disclosed (Cheong, 1974; Hayes, 1977). The period for which modelling of the Malaysian economy continues to be difficult extends well into the 1980s.

It is also noted that modelling efforts are still an ongoing process especially in the major centres such as the Economic Planning Unit (EPU), the Treasury and Bank Negara Malaysia (Central Bank). These organizations are directly involved in national policy planning and they are keen to see an improvement in the application of macroeconometric models in financial and national planning.

Nevertheless, there are some interesting observations that could be drawn from these past models. Cheong (1974) had established the foundation to the approach for modelling the Malaysian economy, and his model had inspired other workers. (See for example, Semudram, 1980). Cheong's model was based on 6 sectors which included the blocks for consumption, income, investment, tax, and foreign trade. There was an elaborate demographic sector to assist in the determination of the pattern of labour supply and other per capita variables.

The objective of his model was for forecasting and policy analysis. However, the model was not solved and the simulation properties were not revealed. In addition, the coverage was limited to West Malaysia only, and important sectors such as prices and monetary sector were ignored. The model was rather small and too aggregative for practical application in policy analysis. The technique for solving nonlinear equations appeared to be unavailable to the author at that time, and the model was formulated to be linear apparently for this reason.[1]

The exploratory nature of macromodels of the period was reflected in the model constructed by Raja Lope (1975), Hayes (1977) and Jaafar Ahmad (1977). Raja Lope developed a highly aggregative model consisting of 9 equations, seven of which were stochastic and two were identities. The model was meant for forecasting aggregated macro variables. A two stage least square estimation procedure was used and though the model seemed to perform well, the highly aggregative nature of the variables would not make it a suitable model for policy analysis.

The model constructed by Hayes for the Central Bank was a much improved version designed to assist in short term forecasting and aggregate stabilization policy analysis. Annual time series data from 1960-1976 were used and the monetary sector was incorporated exogenously. By introducing the appropriate level of disaggregation, Hayes was able to introduce more specific theoretical reasonings in the estimation of the individual components of each sector.

Lack of adequate data series was discussed in some detail. Data on some endogenous variables were weak and they had to be constructed. Such an approach had the drawback that the resultant estimated equations merely reflected the method of construction of the endogenous data series.

Hayes's model finally turned out to be largely demand determined except for the export sector. Thus the effects of supply constraints such as shortages of capital and other factors of production were not evaluated. Results of the model simulation were not reported and thus the performance of the model could not be fully assessed.

The model by Jaafar Ahmad, and other models which emerged in the following few years (Sakurai, 1978; Ahluwalia and Lysy, 1979; Semudram, 1980) were illustrations of some real attempts, from both the practitioners and academical approaches, at applying the econometric model for policy and planning analysis of the Malaysian economy.

The models available at this stage were still affected by lack of data on certain sectors such as wage rates and sectoral investment and it appeared that alternative approaches to overcome these problems were attempted. For example, the EPU attempted to develop a fix coefficient type model which relies on the input-output tables as the data base (Karim et al, 1977). In an alternative approach adopted by Semudram (1980), the role of money was emphasised and the money multiplier approach was adopted. In the traditional monetarist approach, the production sector was not included, and as such, the model could not be regarded as fully representing the Malaysian economy.

A number of medium scale models of the Malaysian economy were reported in the subsequent years, (Abe, 1982; Lin, 1983). By this time, the approximate form of the macroeconomic model that could be appropriate for modelling and conducting policy analysis of the Malaysian economy was becoming clear. Such a model must represent the major economic blocks including the finance sector, and within each block there should be an adequate level of disaggregation of the components subsectors.[2]

More recently, improved versions of the macromodels for Malaysia were constructed by Ho (1983) and Gulbrandson (1984). Ho's model was inspired by the earlier work of Hayes as well as by the well-developed approach adopted by researchers at the University of Pennsylvania (Obidegwu and Nziramasanga, 1981; Lasaga, 1981; Priovolos, 1981). In his model, Ho employed seven inter-related economic blocks with sufficient level of disaggregation in each block. Ho observed that many of the Keynesian type macroeconomic models for developing economies failed to incorporate the special conditions and features of the developing economies. Some of the more serious shortcomings included the following:

i) as national income is determined only by aggregate demand in a pure Keynesian model, constraints due to lack of capital stock, land and other production factors were often ignored.

ii) a distinction between agriculture and non-agriculture is seldom made clear.

iii) the level of aggregation was generally too high for meaningful analysis on policies to be possible.

To meet these requirements, Ho attempted in his model to combine demand and supply factors in the determination of sectoral outputs. The model was employed for policy analysis and price stabilization experiments for the Malaysian economy. The short term contribution of the financial sector to the economy was also investigated in detail. Where data were inadequate a constructed data series was used. The estimation period was from 1960 to 1980.

A validation exercise carried out on the model showed a good fit, and overall the model seems to perform adequately for the intended application as a tool for price stabilization policy analysis relating to the Malaysian economy.

The model constructed by Gulbrandson (1984) was sponsored by the Economic Planning Unit (EPU) within the framework of the LINK project [2], and it was designed mainly to generate short to medium term forecast of the Malaysian economy. The EPU had previously worked on a number of macromodels (Lin, 1983; Karim, 1977) to facilitate national planning work especially in the preparation of the country's Five Year Plans. Unsatisfactory performance of a previous model built by Lin (1983) led Gulbrandson to develop an improved version called the EPU model. The model contained 259 equations from 10 interrelated blocks including world prices, exports, imports, balance of payments, production, employment, macroeconomic aggregates, public finance, prices and money, capital flows and debts. The data series and the period of historical simulation were from 1970 to 1982 and the projection period was from 1983 to 1995.

To enhance its forecasting capability, the EPU model was designed with minimal use of exogenous data, and sufficiently detailed level of disaggregation was introduced especially in the trade and production sectors. This was to reflect the heavy dependence of the Malaysian economy on the exports of commodities. Scarcity of data on wages and sectoral investment forced the production functions to be formulated as demand-determined equations.

Although the EPU model produced some reasonable results, there were also a number of weaknesses. The short time series used in the model allowed only a few variables to be used in the structural specifications of the equations. Of the 93 stochastic equations, 64 were formulated with only one explanatory variable in each equation. While it was possible to obtain acceptably high t values for the variable in these single variable equations, the degree of explanatory power as a whole was often low, and while the model would be very responsive to changes in the explanatory variables, it might also tend to be unstable due to the low level of causal relationships in some of the equations. To improve the simulation stability of the model, some of the equations estimated in the logarithmic forms were changed into the corresponding linear structure.

The EPU model (Gulbrandson, 1984) demonstrated a number of useful properties as well as providing some contrasts to the model constructed by Ho (1983). Firstly, the objective of the model building exercise clearly dictates its structural formulation. A model intended for forecasting, as in the EPU model, emphasises the accuracy of the forecast while the one intended for policy analysis as in the model developed by Ho (1983) gives more importance to model simulation response and adequacy of structural representation.

Secondly, a model intended for evaluating the economies of the developing countries may be different from those that could be appropriate for the developed economy. The use of supply rather than demand-determined models may be more appropriate to reflect the constraints on lack of capital and other factors of production in the developing countries.

Thirdly, there are various trade-offs to be considered in terms of the model complexity and predictive ability. A very detailed model may be difficult to handle while a very small model may not allow the application of the model for sectoral policy analysis. The length of the data series may also determine the structure of the equations in the model formulation.

2.5 Data Requirements

The amount of data required for the macroeconometric model is primarily determined by the model size. For a model with about 200 variables and an annual data series spanning 24 years from 1960 to 1983, as in this study, some 4800 data points are required. These are relatively small in terms of computer handling and storage but they are not necessarily easy to compile.

The types of data are determined by the way that the macroeconomic model is specified. In this study, the macro-model consists of seven economic blocks:- output, trade, aggregate demand, government, financial flows, income and employment, and prices. Most of the data set needed to model these sectors are obtainable from the National Accounts and External Trade Statistics published by the Department of Statistics. The publications of the Treasury (Economic Report, various issues) and the Central Bank also contain macroeconomic data series in a more processed form. In recognising the need for generating consistent macroeconomic data series, there has been a conscious attempt by the Central Bank to publish macroeconomic data series which are consistent back to the year 1960 (Bank Negara Bulletin, various issues).

The above sources do not provide all the data needed for building the macroeconometric model. Other sources have to be used to obtain data for prices and the production sector. Where world price and related indices are involved the standard sources are the International Financial Statistics published by the International Monetary Fund (IMF), and Trade Year Books of the Food and Agricultural Organization (FAO), and the Commodity Price Bulletin published by UNCTAD.

Some early series of the data set are not available. In the data gathering stage to this study the Treasury was approached for some of these data. Subsequently some unprocessed data set were obtained from the Treasury and these were used to supplement various gaps in the data base for the model. The alternative is to use a shorter data series from 1970 to 1983 which are more readily available from the above published sources but this would restrict the structural specification of the model and might not be appropriate for a model meant for policy simulation analysis (see the review of Gulbrandson (1984) model which was based on a short data set).

In deciding to use the longer series data set, the following views are adopted:-

i) The data set from the Treasury are first checked for consistency and accuracy. As the Treasury is also the source of published macroeconomic data for the more recent years, this checking is quite simple, except that the published data are themselves inconsistent between the various issues of the Economic Report. In such a situation, the Treasury unpublished data set is used as a first preference.

ii) The use of the Treasury data set enables the attainment of consistency and comparability with the official source of information on the Malaysian economy. Even if some of the data turn out to be weak, this will be reflected in this study, and it will serve to explore the extent that existing data set can support macroeconometric model building effort. An attempt to reconstruct the older data set (1960 to 1969) was both unproductive and riddled with data inconsistency problems. To begin with, the Statistic Department changed its accounting system in 1969 and published a new form of internationally compatible Systems of National Accounts (SNA). Thus the data from 1960 to 1969 are affected by two major changes. The first is in relation to changes in the national boundaries when the country was united in 1963, and secondly the data sets were affected when the system of national accounting was changed in 1969.

In the rubber and oil palm sector, the data quality is much better and there are adequate data going back to the 1950s. These are contained in the Rubber Statistical Bulletin published by the International Rubber Study Group, and in publications on these commodities from the Statistic Department. Data on palm oil are also published by the newly established Palm Oil Registration and Licensing Authority (PORLA) while market data for oil and fats are obtainable from the more established publications of the Oil World produced by ISTA Hamburg.

Notes to Chapter 2

[1] The technique of solving nonlinear models was not generally available as ready to use computer software until the mid 1970s. Before this, the cumbersome method of linearising nonlinear models was the approach adopted by earlier researchers as shown by Theil (1964), Evans and Klein (1968). Numerical techniques for solving nonlinear systems of equations were already established by 1970 (Ortega, 1970) but it took a further few more years before efficient computing packages for dealing with econometric models became available to most researchers (see Drud, 1983 where the releases of the various econometric simulation programmes are reported).

[2] Note that Malaysia has participated in an international collaboration in constructing an interlinked project executed through the United Nations Economic Commission for Asia and the Pacific (ESCAP) to form part of the LINK project headed by Nobel Prize laurate Professor L. R. Klein. The Central Bank (BNM) has also participated in a number of interbank seminars for the countries of the region where modelling studies have been regularly discussed. The exchanges of modelling ideas and critical evaluation of models presented at these conferences had significantly influenced the structure of macromodels constructed for the Malaysian economy.

CHAPTER 3: SALIENT FEATURES OF THE MALAYSIAN ECONOMY

3.1 Introduction

The object of this chapter is to provide some background information on Malaysia in order to show the evolution of the economic structure, the influence of the export sector, and the roles of public policies and strategies in the development of the country. More specifically, this chapter will examine how various development policies had influenced the agricultural, manufacturing and export sectors which have all been closely linked to the development of the rubber and palm oil industry. Other quantitative aspects of the main macroeconomic sectors will be described in Chapter 6 as they arise in conjunction with the construction of the macroecomometric model. However, readers interested in more elaborate studies of the economic development of the country may find adequate coverage in past work reported elsewhere by Lim Chong Yah (1967), David Lim (1973), Lee Hock Lock (1978), Snodgrass (1980) and Young, Bussik and Hassan (1980).

Malaysia is a federation of thirteen states, plus a Federal Territory which was formed to administer the capital city Kuala Lumpur; two of these states, namely Sabah and Sarawak, are situated in the north-western part of the island of Kalimantan (Borneo). The country has a total land area of 127,316 square miles which is slightly larger than the area of the UK (94,222 square miles). About 40 % of the land area is in the Peninsular while the eastern states of Sabah and Sarawak, which are separated by more than 400 miles of the South China Sea, account for the remaining 60 %.

The formation of the country as an independent sovereign nation occurred in stages. The Peninsular States (formerly Federation of Malaya) achieved independence on 31st August 1957. Malaysia was formed some six years later on 16th September 1963 when the British colonies of Sabah, Sarawak and Singapore joined the Federation of Malaya. Singapore subsequently left Malaysia to become an independent Republic in 1965.

In 1983, the country had a population of about 14.8 million and an annual GNP of M$ 65.5 billion (equivalent to about 8.1 % of the corresponding GNP for the UK or 0.56 % that of the U.S.A.). The per capita income of about US$ 2,000 compares as one of the highest among the developing countries in Asia (Table 3.1).

Table 3.1: Per Capita Incomes of Selected Asian Countries (US$)

Country	1970	1975	1980	1984	1985
Japan	1895	4311	10128	9837	10681
Singapore	919	2362	4621	6923	6842
Malaysia	380	706	1635	2017	2113
South Korea	262	541	1479	1947	n.a.
Thailand	180	342	701	701	739
Philippines	175	357	720	513	615
Indonesia	74	207	473	489	n.a.

Source: Economic Report,1985/86, Treasury, Kuala Lumpur.
International Financial Statistics, various issues.

The wealth comes from a proportionally large export sector comprising mainly rubber, tin, petroleum, palm oil, timber and manufactured goods. A combination of factors have accounted for the development of the present state of prosperity and the evolution of the Malaysian economic structure.

Firstly, both the country's geographical location and past colonialization appeared to affect the pattern of economic development which could be pursued after the country became independent. Development was physically difficult as a large part of the country especially in Sabah and Sarawak is either mountainous or under thick tropical forest. For these reasons plus the fact that attainment of independence was late, the two eastern states of Sabah and Sarawak lag the rest of the country in development; and despite occupying 60 % of the total land area, they only have 17.1 % of the total population and contributed 14.2 % towards the total GDP in 1983.

Secondly, the socio-political situation arising from the multiracial nature of the population, as will be described later, adds further to the unique economic system which has evolved. The majority of the population, constituting 58.6 % of the total in 1983 are the Malays and other indigenous groups; the Chinese represent 31 percent and the remaining 10.4 percent are Indians and other races. Most of the people are engaged in the agricultural sector and in 1985 more than 62 % percent were still living in the rural areas. The capital city Kuala Lumpur has close to one million people and is the focal centre of business activities and financial market for the nation.

The country is ruled through a parliamentary system of democracy involving the (Lower) House of Representatives and (an Upper House) the Senate, with the "Agung"(Supreme Head of State) as the constitutional monarch. The political party elected to form the government commands the confidence of the house of Representatives which is the law making body. The Senate, known locally as the "Dewan Negara", can also initiate legislations but its main role is to complement the task of the lower house through its rectificationary powers.

Thirdly, a major source of strength to the country's economy comes from its endowment of natural resources such as tin, petroleum and other minerals while the tropical climate has given rise to large areas of rain forest which in turn supports a flourishing timber industry. Over the years, some of the rain forests have been cleared to give way to agriculture. However, a large proportion of the country is mountainous and therefore non-arable, and the soil is generally poor as top soils are easily washed away by the heavy rain which characterises the tropical monsoonal climate of the country. Furthermore, the high level of rainfall enables only certain types of agricultural crops to grow and overall, only about 12 % of the country is under permanent cultivation, though this conceals the fact that the proportion of cultivated area in the Peninsular States is much higher than that in the eastern states of Sabah and Sarawak.

In the distant past, the source of wealth for the country came from the exploitation and exports of tin, other minerals and forestry products. The economic base however, was strengthened by the establishment of the plantation industry early this century. Crops such as rubber, oil palm and cocoa were found to adapt well to Malaysian climatic and soil conditions, provided there were adequate management and technical inputs in the cultivation process.

Agriculture has thus become the traditional major sector of the economy but in the last two decades, there have been increasing contributions from the manufacturing and services sectors. The process of transition from an economy which was based essentially on exports of rubber and tin to one that is more diversified has occurred mostly through programmes of development that have been carried out since the end of the Second World War. Furthermore, after the country became independent in 1957, development was speeded up and expanded into new areas so that the present economy operates from a much broader and more diversified base.

From a modest beginning after the war, Malaysia has been able to expand its economy while remaining the world's largest exporter of rubber and tin. It has since become a major exporter of palm oil, pepper and tropical timber, while its exports of petroleum and manufactured goods have increased significantly. In addition, there has been diversification in terms of destinations and types of goods and commodities exported. These changes have transformed the economic structure from a position of heavy dependence on exports of rubber and tin to one that is more diversified.

As in many less developed countries, formal planning for economic growth is based on the country's official Five Year Plans. The first two Five Year Plans for 1956-60 and 1961-65 were for Peninsular Malaysia only and they were referred to as the First and Second Malaya Plan respectively. With the formation of Malaysia in 1963 the planning coverage was revised to include the states of Sabah and Sarawak and the First Malaysia Plan (1966-70) was subsequently introduced. Since then, there have been four other Five Year Plans and Malaysia is now implementing its Fifth Malaysia Plan for the 1986-90 period.

Despite the impressive quantum of changes introduced by the different Five Year Plans, the development of the Malaysian economy for the period under review can be conveniently divided into just two distinct phases. The first phase covers the post-independence years up to 1970 during which the country was actively engaged in the process of "nation building". The beginning of the second phase coincides with the introduction of the New Economic Policy (NEP) which was first introduced in the Second Malaysia Plan (1971-76). The implementation of the NEP has been the object of the country's various five year development plans since 1971.

3.2 <u>The First Phase of Economic Development, 1957-1970</u>

The first official economic development plan for Peninsular Malaysia was prepared in 1950 when the country was still under British rule. In those days, the approach to the formulation of the country's development strategy had to take into account both the local and colonial interests. The economic development policy was to build upon the country's rubber and tin industry and promote free trade using the earnings from the exports to finance the import of consumer and capital goods. This called for an expansion in the production and exports of rubber and tin which were in demand as important raw materials to the manufacturing industries in Europe and America.

In the process of developing these resources, roads and other infrastructural facilities needed to service the industries had to be built and these indirectly benefited the country as a whole. This maintenance or "good husbandry" approach to development planning did not have provisions for industrial development (see Draft Development Plan: Malaya, 1950). There was not much allocation for creating financial facilities which could propagate the expansion of economic activities in sectors other than those designated to promote the maintenance of the tin and rubber industries. Many analysts have criticised the development plan as indirectly discriminating against the expansion of the manufacturing sector. Such plans steered the economy towards the specialization in the production of only a few commodities while the country remained a captive market for manufactured goods mostly from the developed countries.

Consequently, the economic conditions in Malaysia were largely exogenously determined. The absence of domestic manufacturing activities meant that even relatively simple manufactured consumer items had to be imported. The lack of industrial development also made it difficult to modernise the other sectors of the economy. Thus, the over-concentration on exports of rubber and tin made the economy vulnerable to external fluctuations in commodity demand and prices, and the heavy reliance on imports increased the degree of vulnerability.

The development of rubber and tin industries provided little interactions with the traditional agricultural sector existing throughout the country. This was because of the fact that the major rubber estates and tin mining companies were foreign owned, and rubber and tin were themselves destined for consumption outside the country. The transfer of skills from this "modern" sector to the traditional agricultural sector was almost non-existent. Consequently the effect of modernization brought about by the development of rubber and tin were largely confined to a small section of the economy and restricted to areas where these industries were located. The existence of this dualistic economic structure meant that the bulk of the population who were engaged in traditional agriculture were unaffected by modernization, except for those (mostly Chinese and Indians) who were engaged in the modern sector. This situation was regarded as one of the major causal factors which gave rise subsequently to serious regional as well as racial economic disparities.

When the country became independent and began its nation building programmes more intensively, the potential for economic development was judged to be enormous, even though there were the threats of communist insurgence and socio-economic problems to be resolved. The main strengths and weaknesses of the country at the time just after independence were summarised by Snodgrass (1980) in terms of assets and liabilities as follows:-

Liabilities

i) There existed a pattern of ethnic cleavage, in which the two largest groups (the Malays, with 50 % of the population, and the Chinese, with 37 %) differed sharply in culture, occupational pattern and income level; these groups, which had formerly co-existed peacefully under the umbrella of the Pax Britannica, would now be interacting more and would be forced to work out the terms of the interaction for themselves.

ii) There existed an over-specialised economy, subject to strong export-induced fluctuations and too dependent on single crops whose continued viability was being threatened by competition from a synthetic substitute.

iii) There existed an explosive demographic potential which had already raised the rate of national increase above 3 % per annum and threatened to keep it there indefinitely.

Assets

i) There existed the beginnings of a political system in which Malay, Chinese and Indian representatives participated in the Alliance Party, a permanent coalition aimed at resolving conflicts of group interest through elite bargaining, based on the 'bargain of 1957', which specified that the Chinese would be given free reign for their entrepreneurial talents (subjects to provisions of special programmes to aid the economic advance of the Malays) while the Malays would be allowed to dominate the government (subject to citizenship rights and junior partner participation for the Chinese, the Indians and several much smaller minorities.

ii) There existed a strong heritage of physical and administrative infrastructure.

iii) There existed a favourable ratio of land and other natural resources to population, which offered generally promising chances to raise income per head despite the high rate of population increase.

The post-independence period also saw the implementations of the First Malaya Plan, (1956-60), the Second Malaya Plan, (1961-65), and the First Malaysia Plan, (1966-70). The thrusts of these plans were essentially on nation building through expansion of the economy, modernization of the rural sector and socio-economic improvement for the population. In the course of the implementation of these programmes, the government established many statutory bodies to take over the task of promoting sectoral development. These statutory bodies feature prominently in the Malaysian economic structure as they later developed to become the main agencies for implementing development targets for the country.

3.2.1 Policies and Development Strategies

Two main policies were formulated in the early part of this period. These were i) rubber replanting, and ii) economic diversification. The programmes for implementation of these policies were embodied in all the Five Year Plans which were implemented during the period under review.

The replanting policy was formulated as a result of a detailed study by a UK Mission (Mudie) in 1954 (see Allen, 1972) which found that more than half of the rubber plantations were over thirty years old and had to be replanted without delay. The task of overseeing the implementation of the replanting policy was given to RIDA which was renamed as RISDA in 1973.

Similarly, the need to diversify the economy was identified through another study by a World Bank team in 1955. They (IBRD, 1955) concluded among other things that natural rubber was under threats of competition from the synthetics, and the way to protect the economy from the decline in income from rubber was to rehabilitate the rubber industry and to develop other industries including investment into the planting of other crops. In particular they suggested a pilot scheme for oil palm cultivation which was to be organised through a public sector agency.

Consequently, the Federal Land Development Authority (FELDA) was established in 1956 to undertake a programme of land development through which alternative crops such as oil palm could be grown on a large scale.

In the other non-rubber sectors, a programme of self sufficiency in food production was intensified and a range of supporting services from irrigation projects to banking and marketing facilities were established. In the manufacturing sector, more incentives and assistance were provided to attract both local and foreign investors to set up industries in the country.

In the implementation of these plans, the lack of trained man power and technical know-how was a problem. The high level of concentration and specialization of the economy on the exports of rubber and tin meant that other services and sectors were underdeveloped at the time of independence in 1957. There were initially no capital markets or a central bank. There was a need to invest in infrastructural facilities and to set up training programmes to develop the necessary skills and for all these capital was needed. This was partly achieved by means of attracting foreign investment into the country.

Growth and development had to be achieved without upsetting the expansion programmes of the rubber and tin industries in view of their importance to the economy. The land development scheme was appropriate for this requirement in that the newly opened land could be allocated with alternative crops whereas the uprooting of the existing rubber plantation for new crops might have a de-stabilising effect on employment and income. This strategy however called for a policy of rapid growth such that Malaysia could continue to be the world's largest exporter of tin and rubber, while other commodities were added to the list.

To facilitate investment especially in the manufacturing sector, there was a need to improve the financial facilities. A Central Bank was established in 1959 and the Malaysian Industrial Development Finance was set up in 1960 as an agency to provide credit facilities for medium to long term industrial projects.

Thus, during the decades of the 1950s and 1960s, the foundations and vehicles for promoting growth were established. It is noted that the state of emergency which endured for 12 years, was ended in 1960, and in the absence of the immediate threats of communist terrorisms, the implementation of the plans proceeded more vigorously during the Second Malaya Plan from 1961 to 1965 and the First Malaysia Plan, 1966 to 1970.

3.2.2 Economic Diversification

The implementation of the policy of diversification involves developments in the agricultural and non-agricultural sectors. The main focus of agricultural development had been on land development and modernization programmes including rubber replanting which had been formulated into a major policy on its own. Non-agricultural development was directed at stimulating growth in the manufacturing sector and development of the services facilities and other infrastructures.

The intensity of the implementation for the economic diversification programme is reflected in the growth in investment. During the 1960s private investment rose by 8.6 % per annum from M$ 663 million in 1960 to M$ 1,514 in 1970. In the public sector, investment almost trebled from M$ 269 in 1960 to M$ 732 in 1965 although there was a slowing in public investment in the late 1960s. This is reflected in the lower growth of government development expenditure from M$ 651 million in 1966 to M$ 725 million in 1970. These trends indicated the more dominant role of the private sector in the development process as government development expenditure and public investment in general were initially relatively small. This situation is to be contrasted with the period of the 1970s when the government became actively involved in financing various development projects.

3.2.3 Agricultural Development

Agricultural development was mostly in land settlement projects and rubber replanting. Three quarters of the public development expenditure was directed at land development, drainage and irrigation, and rubber replanting.

i) Land Development

Expenditure on land development in Peninsular Malaysia surged from M$ 17 million during 1956-60 to M$ 130 million during 1961-65 and M$ 310 million under the First Malaysia Plan. More than 800,000 acres were developed under public sector programmes during the decade under review.

FELDA was the main agency for land development. From 10,500 acres opened in 1960, the annual rate of land development was steadily increased to 51,500 acres in 1970. Up to 1970, the authority had developed 308,400 acres and settled 29,700 families on 90 separate land schemes. About 60 % of the land developed by FELDA was allocated to oil palm and 30 % to rubber and 10 % other crops.

Crop diversification was achieved through planting of oil palm as an alternative to rubber in the estate sector as well as on new land opened up by FELDA. This contributed to a rapid growth in the contribution from the oil palm sector.

Output of rice also increased rapidly from better irrigation and improved production through double cropping and use of elite strains. Expansion in rice cultivation was considered a priority area in the development strategy as the country strived to become self-sufficient in rice production.

ii) <u>Rubber Replanting</u>

Under the agricultural modernization programme, rubber replanting was successfully carried out and this led to increased productivity. The smallholders production of rubber increased rapidly, at twice the rate of the estate sector.

During 1960-70, about 304,000 acres of smallholdings were replanted in Peninsular Malaysia while more than 1,200 acres were planted in Sabah and Sarawak. Smallholding output rose by about 5 % per year during 1960-65 and by 11 % during 1966-70 reflecting the benefit of the replanting programme. The average yield of the smallholdings, estimated at about 676 lbs per acre was still far below the average of about 1016 lbs per acre on the estates. The lower average yield is explained by the fact that by 1970 only about 63 % of smallholders' acreage was under high yielding rubber, compared to about 92 % in the estate sector.

3.2.4 Non-Agricultural Development

The importance of rubber and tin to the economy was steadily declining as a result of the rapid expansion in the production and exports of timber, palm oil and manufactured goods. This was achieved while the production and exports of rubber and tin continued to increase in absolute tonnages during the 1960s.

i) Manufacturing

As can be seen from Table 3.2, the exports of manufactured goods, though small, grew rapidly during the period from 1.6 % share of the total exports in 1960 to 4.1 % in 1970. The exports of 'other goods' which comprised mostly of industrial products, also grew steadily at 4.4 % per year during 1960-65 and at 4.5 % per annum during 1966-1970 in line with an overall rate of growth in total merchandised exports of 3.6 % during the same ten year period.

These statistics conceal the strong underlying growth trend in the manufacturing and other industrial sectors, thus suggesting the initial success of economic diversification policy. Net output of the manufacturing sector, when defined more broadly to include machinery, chemical, food and beverage production actually rose at 9.9 % per annum for 1961-65 and at 10.4 % during 1966-70. Consequently, the share of manufactured goods in GDP rose from 8.5 % to 10.4 % in 1965 and about 13 % in 1970

Table 3.2 : Malaysian Exports of Major Commodities, M$ million

Commodities	1960	(%) share	1965	(%) share	1970	(%) share	%pa Growth 1960-70
Rubber	2001	55.1	1462	38.6	1724	33.4	- 1.5
Palm oil	61	1.7	107	2.8	264	5.1	15.8
Sawlogs	119	3.3	263	7.0	644	12.5	18.4
Sawn timber	75	2.1	97	2.6	206	4.0	10.6
Tin	508	14.0	872	23.1	1006	19.5	7.1
Petroleum	147	4.0	87	2.3	203	3.9	3.3
Manufactured goods	57	1.6	87	2.3	213	4.1	14.1
Other goods[a]	665	18.3	808	21.4	903	17.5	3.1
Total Exports	3633	100.0	3783	100.0	5163	100.0	3.6

Source : Quarterly Economic Bulletin, Bank Negara Malaysia, Vol. 18, No 4, 1985.
Note:[a] Includes machinery and transport equipment, chemicals, beverages and tobacco and food and live animals.

The growth in manufacturing was oriented towards the home market and substantial import substitution had taken place in foodstuffs, beverage, tobacco products, petroleum products, cement, rubber and plastic goods, fertilizers and textiles and steel bars.

It was also evident from Table 3.2 that industries were increasingly turning to the export market. Exports of manufactured goods, although small, grew steadily at an average of 14.1 % per year during the decade under review.

ii) Other Sectors and Services

The mining sector remained confined to tin production. Tin accounted for almost 20 % of export revenue in 1970 (Table 3.2) and employed about 3 % of the labour force.

Towards the end of the sixties, some exploration of petroleum was carried out and this contributed to the expansion of the Malaysian petroleum industry in the seventies.

3.2.5 Macroeconomic Performance, 1960-70

The growth in GDP for the decade of the sixties was 6.6 % per annum, and this was beyond the targeted figures in the Government Five Year Plans. The decline in prices for rubber and tin made some recovery toward the end of the 1960s, and together with expansion with other sectors, a reasonably high growth rate was thus achieved. The share of exports in the GNP decreased from 57.3 % in 1960 to 47.7 % in 1970, indicating the rapid expansion of the non-export sector of the economy in line with the government policy of economic diversification.

Unemployment was contained at a low level, and inflation remained at an average rate of less than 1 % during the 1960-70 period. With the growth in the export sector, Malaysia continued to enjoy a strong merchandise trade surplus but the current account had frequently been in deficit. During the period, the surplus in current account occurred only during the boom years 1965-66 and 1968-70. The services account continued to be in deficit, indicating that this sector, which was represented mainly by the freight and insurance business, had remained largely underdeveloped.

Industrial development was growing at a rapid rate as the government tried to attract foreign investors through a variety of promotional efforts including the encouragement of investment through joint ventures. There were many incentive schemes to attract investors including the establishment of free trade zones, and the granting of pioneer status to qualified companies. The shift in emphasis towards promoting industrialization was partly created by the threat of instability in the prices of rubber and tin.

The large foreign investment in Malaysia meant that a substantial amount of investment income had to be paid abroad yearly. The combination of the deficit in the services account and the transfer payment more than offset the surplus in the merchandise account. However, due to the long term private capital inflows the overall balance was often in surplus, which in turn allowed the Central Bank to build up a large portfolio of external assets over time. At the end of 1957, official net external reserves amounted to M$ 1,485 million but this rose to M$ 2,402 by the end of 1969.

3.3 Second Phase of Development, 1971-Present

The second phase in the development of the Malaysian economy began with the implementation of the New Economic Policy (NEP) which was introduced in 1971 in conjunction with the launching of the Second Malaysia Plan (1971-75). It is the significant influence of the NEP on the macroeconomic policies and sectoral development of the economy which distinguishes this second phase of development from the first. Thus, a slight digression is necessary to describe the circumstances leading to the formulation of the New Economic Policy and the approach adopted by the government in its implementation.

The policy of economic diversification and rural modernization pursued during the 1960s had brought substantial growth to the economy. Between 1960 and 1970, the GDP grew at a rate of 6.6 % per annum while the export sector registered a moderate rate of growth of 3.6 % per annum, despite low prices of commodities. As a result, the country enjoyed a strong balance of trade position with relatively low level of inflation, unemployment and foreign debt position. Yet these modest achievements were looked upon by some sectors of the population with a sense of disappointment. The economy seemed to be potentially unstable for a number of reasons. Economically, the policy of rapid growth alone appeared to be insufficient as a strategy for the development of the country since such a policy contributed invariably to disparity between the have and have-nots, and in the case of Malaysia, the have-nots were identified with race.

In particular there was discontent over the economic distribution of income and wealth ownership.

The development policies pursued during the 1960s which focused on growth in the modern sector had not only failed to redistribute income to the traditional agricultural sector but also aggravated the relative income disparity between the racial groups. Without the benefit of hindsight, it would have been difficult for planners at that time to appreciate the severity of the problem as the economy was expanding above the targetted rate of growth. Furthermore, the imbalance in ownership pattern was partly inherited from the situation before the country became independent.

The pattern of income distribution is shown in Table 3.3. The Malays and other indigenous population (known officially as Bumiputras), who were mainly fishermen, rubber smallholders and government employees, were earning at less than half that of the Chinese. Moreover, they were badly affected by depressed agricultural commodity prices while the Chinese and Indians who were engaged in manufacturing and commerce were less affected as conditions in the manufacturing activities were more favourable. There was a growing sense of helplessness among the Bumiputra community in seeing their economic position being eroded away by the rapid expansion of the modern sector in which they had little opportunity to participate fully.

When the general election in 1969 returned a reduced majority for the Malay-dominated ruling party, the Malays felt that their strong political position was also in jeopardy. The fragile balance and mounting racial tension gave way in May 1969 to an outbreak of racial violent when political party supporters reacted emotionally to the election results.

The circumstances leading to the racial riots in May 1969 have been widely documented (see Snodgrass, 1980) including a book written by the present Prime Minister, Dr. Mahathir Mohammad (1970). For a brief period after the riots, the country was under emergency rule, but the most urgent task was for the government to reexamine the past development policies and make a comprehensive assessment of the economic problems of the nation.

The cause of the conflict was eventually diagnosed to be the existence of significant disparities in the economic position of the Bumiputras and the Non-Bumiputras. Furthermore, the existence of extreme skewness of income, wealth ownership and employment opportunities was identified as the root cause of racial discontent. The identification of occupation with race was thought to be undesirable in a multiracial society and unless these fundamental economic imbalances were resolved, future racial conflicts would not be averted.

3.3.1 The New Economic Policy

To correct the imbalances, it was necessary for the government to seek a new development strategy. The overiding task was to achieve national unity and racial harmony, and the restructuring was to take place over a reasonably extended period. It was in response to these tasks that the New Economic Policy (NEP) was formulated and incorporated for the first time into the Second Malaysia Plan (Malaysia, 1971) with the two-pronged objectives of

i) eradicating poverty irrespective of race, and

ii) restructuring society so as to eradicate identification of race with economic functions.

Table 3.3 Percentage Distribution of Households by Income[a] and Race in Peninsular Malaysia, 1970

Income per Month	Malay	Chinese	Indians	Others	Total
$ 1-99	22.9	2.6	1.3	0.2	27.1
$ 100-199	19.1	7.8	4.4	0.1	31.4
$ 200-399	10.4	11.9	35	0.1	25.9
$ 400-699	3.0	5.3	1.2	0.1	9.6
$ 700-1499	1.1	2.9	0.6	0.1	4.7
$ 1500-2999	0.2	0.7	0.1	0.1	1.1
$ 3000 and above	neg[b]	0.1	0.1	0.1	0.3
Total	56.7	31.3	11.2	0.8	100.0

Source : The Mid-term Review of the Second Malaysia Plan, 1971-75 (Malaysia, 1973).

Note: [a] Income includes cash, imputed income from earnings in kind plus transfer receipts;

[b] The percentage is negligible in relation to the total.

Imbalances become more pronounced when one takes into account the ownership of equity capital in the corporate sector of the economy. This is not surprising because the business sector in particular and the private sector in general, have been owned predominantly by foreign establishments and local Chinese interests. In 1969, the share of the Bumiputras in corporate ownership was only 0.3 % in the modern agricultural sector and 0.9 % in the industry sector (see Table 3.4).

Although it was clear that the benefits of growth have not been successfully spread to the poor in the community, it was also important to find ways and means of redistributing income without damaging the competitive structure of the economy.

Table 3.4 : Ownership of Assets in Modern Agriculture and Industry, Peninsular Malaysia, 1970

	Modern Agriculture				Industry(fixed assets)			
Ownership	Corporate (000 acres)	(%)	Non-corporate (000 acres)	(%)	Corporate $ (million)	(%)	non-corporate $ (Million)	(%)
Malaysians	515.0	29.2	697.6	94.1	559.7	42.8	167.2	97.6
Malay	5.0	0.3	349.3	47.1	11.2	0.9	3.9	2.3
Chinese	457.0	25.9	243.3	32.8	342.3	26.2	158.0	92.2
Indian	4.9	0.3	74.8	10.1	1.5	0.1	3.9	2.3
Other	48.1	2.7	13.2	1.8	187.2	14.3	1.4	0.8
Government	-	-	17.0	2.3	17.5	1.3	-	-
Non-Malaysians	1249.6	70.8	44.0	5.9	747.3	57.2	4.1	2.4
Total	1764.6	100	741.6	100	1307.0	100	171.3	100
% of Total	-	70.4	-	29.6	-	87.4	-	12.6

Source: Mid-term Review of the Second Malaysia Plan, 1971-75

A long term implementation strategy was needed to achieve the structural changes desired. Thus, in the Mid-term Review of the Second Malaysia Plan (Malaysia, 1973), the Government presented its Outline Perspective Plan (OPP), 1970-1990. In this plan, the programmes and targets of the NEP were spelt out and the implementation period of twenty years, equivalent to one generation, was envisaged.

3.3.2 <u>Programmes and Strategies.</u>

The development strategy of the previous decade was still the principle route toward achieving growth but more was needed to incorporate the requirements of the New Economic Policy.
A number of changes in strategy had to be introduced:-

i) Eradicating poverty was to be achieved by raising the income levels and increasing employment opportunities for all Malaysians, irrespective of race. This required programmes aimed at raising the productivity and income of those in low productivity occupations, the expansion of opportunities for inter-sectoral movements from low productivity to higher productivity and the provision of a wide range of social services designed to raise the living standards of the low-income groups.

ii) A high rate of growth was needed to allow the process of redistribution to be implemented so as to ensure that no particular group experiences any loss or feels any sense of deprivation in the process.

iii) A target for Malay and other indigenous groups was set up so that the ownership of corporate assets can be increased from a share of 1.5 % in 1970 to 30 % by 1990.

iv) There was to be greater involvement by the government in commerce and industries to create the climate to allow the Bumiputras to participate in these sectors. Programmes for this purpose included the modernization of rural life, the rapid and balanced development of urban activities, the establishment of new growth centres and the creation of a Malay commercial and industrial community in all categories and at all levels of operation. The objective was to ensure that the Malays and other indigenous people will become partners in all aspects of the economic life of the nation.

The long period of transformation envisaged in the implementation of the restructuring process implies that the Five Year Plans of the country beginning with the Second Malaysia Plan, 1971-75, will have these targets as the part of their main objectives. Malaysia is currently implementing its fifth Five Year Plan, 1986-1990 corresponding to the last phase of the implementation of the Outline Prospective Plan.

3.3.3 Agricultural Development

During this second phase of economic development, the share of the agricultural sector in the GDP declined from 30.8 % in 1970 to 23.9 % in 1980 and 19.8 % in 1985. This reflected two main structural changes in the economy. Firstly, the policy of diversification has caused a greater rate of expansion in the non-agricultural sector. Secondly, the policy of agricultural modernization, spearheaded by rubber replanting was only moderately successful due to the sluggish growth in the replanted area and prices for rubber.

The strategy for the rubber industry was to modernise by introducing high yielding clones and improved grading schemes to enhance the marketability of natural rubber. A total of 302,900 hectares were replanted with rubber and other crops by RISDA and other agencies compared with 393,000 hectares targeted during the 1970-80 period. A further 131,800 hectares were replanted during the subsequent five years against 141,500 hectares targeted for the period. The overall position of crop hectarage in Malaysia is shown in Table 3.5.

Table 3.5 : Malaysian Agricultural Crops by Hectarage ('000 hectares)

Crop	1980	1981	1982	1983	1984	1985
Rubber	2004.7	2006.1	2005.8	1971.2	1978.6	1999.0
Oil Palm	1023.3	1117.9	1182.8	1253.0	1349.2	1464.9
Paddy	735.2	767.6	758.4	764.2	769.8	775.2
Coconut	349.4	318.0	319.0	324.0	298.0	274.0
Cocoa	123.8	158.8	193.5	215.1	242.0	258.0
Pepper	12.7	13.4	12.8	11.4	10.6	10.0
Pineapple	12.2	11.6	10.6	11.1	10.6	10.3
Vegetables	12.8	12.5	7.5	7.6	7.8	8.0
Orchards	93.0	87.8	89.0	90.0	92.0	94.0
Tobacco	12.4	14.3	9.6	9.4	9.3	9.2

Source : Malaysia (1986), Fifth Malaysia Plan, 1986-1990.
Note: Figures for vegetables and Orchards refer to Peninsular Malaysia only.

Table 3.5 shows that oil palm and cocoa are the two main crops which expanded in the 1980-85 period while hectarages for rubber, coconut and paddy have either stagnated or declined.

Timber production which expanded rapidly during the seventies had stagnated by 1985, partly as a result of more stringent emphasis on conservation as spelt out in the National Forestry Policy implemented in 1981.

In paddy production, a significant progress was made through increased acreage and the introduction of double cropping. By 1970 production had reached 1.5 million tonnes. Over the next 5 years, the production increased 25 % to 2 million tonnes. As in the 1960s, this rapid increase in production was also due to the introduction of high yielding strains and improved water management practices. Throughout this period the prices for paddy were guaranteed to the farmers under a guaranteed minimum price scheme and this contributed to a large extent towards the growth and stability of the rice sector. In 1974, 87 % of total consumption in Malaysia was met by domestic production. However, frequent prolonged droughts and outbreaks of diseases had impeded the expansion in rice production. By 1984, the country has achieved only 76.5 % self sufficiency in rice production compared with 80 to 85 % targeted for the National Agricultural Policy (Fifth Malaysia Plan, p. 304).

Rubber remained the major export revenue earner up 1983, but by 1984, palm oil was the largest single commodity sector in terms of export revenue overtaking not only earnings from rubber but also that from timber. Large scale shifts in investment from rubber to oil palm by the estates sector, and the continued weakness of commodity prices led to the decline in the contribution of rubber. Without the rapid growth of palm oil production, the agricultural sector would have registered a much lower growth rate than the 4.3 % attained during the 1970-80 period.

The declining role of the agricultural sector affected a wide section of the community. The processes of transition from rubber to oil palm and from agriculture to industrial sectors appeared to occur haphazardly, and this was compounded by labour migration to the cities causing many rubber smallholdings to be abandoned. In view of these problems, the government attempted to rationalise its strategies and priorities by introducing the National Agricultural Policy in 1984 and the Industrial Masterplan in 1985. The NAP recommended that the rubber industry should expand through increasing productivity on existing acreage while growth in palm oil production is encouraged through expansion in planted area. The policy however, had still to be formulated into various strategies for implementation. The pessimistic outlook for the rubber industry also led to the appointment of a rubber task force to review the strategy to be followed up to the year 2000. The outcome of the review is summarised in Chapter 4.

The Industrial Master Plan attempted to develop the potential opportunities existing in the various sectors not only as a way of promoting the growth of the industrial sector but also to evaluate the areas where investment and flow of foreign capital could be encouraged.

3.3.4 Non-Agricultural Development

The successful expansion of the manufacturing sector has been an important part of the development programme. Manufacturing has been stressed as one of the ways of diversifying the economy.

Table 3.6: Contribution of the Manufacturing Sector to GDP

Year	Contribution of the GDP
1957	8.0 %
1970	13.4 %
1975	16.4 %
1980	20.5 %
1985	19.1 %

Sources: Economic Report, Treasury; and National Accounts, Statistics Department, various issues.

The initial rapid growth in the manufacturing sector was primarily due to the expansion of import substitution and processing industries in the 1960s. In the 1970s there was a greater shift towards export orientated industries. The main items were electrical machinery, appliances and parts, and textiles, food and beverages and chemical and petroleum products. As more of export oriented manufacturing industries were established, there was greater level of competition, and when the recession affected the economy in the 1980s, the newly acquired competitive position of the Malaysian manufacturers was put to the test. By 1985, there was a slowing down in the growth of the manufacturing sector; manufacturing accounted for 19.5 % share of the GDP compared to 22 % target for the period as stipulated in the Fourth Malaysia Plan.

Nevertheless, the initial momentum of development through the government diversification policy had helped the manufacturing sector to establish a strong base in the economy. The various schemes of incentives appear to be effective in attracting foreign investors to establish manufacturing industries in Malaysia. For example, the manufacturing sector received a big impetus with the introduction of the Pioneer Industries Policy which allow companies established under this scheme to enjoy a grace period of up to 5 years before paying company's tax.

3.3.5 Macroeconomic Performance, 1971-85

The objective of attaining a high rate of economic growth has largely been achieved. Between 1950-60, the average annual rate of growth of GDP was 3.5 % compared with 6.6 % between 1960-1970. The rate of growth has accelerated since 1970. Between 1971-1975, the economy grew at 7.4 % per annum and from 1976 to 1980 the growth rate was 7.6 %. Except for the 1981-85 period when the economy grew at 5 % because of world wide recession, the growth rates have exceeded the original planned targets.

With the growth of various sectors and as a result of successes in diversification, export instability, as measured by the coefficient of variation, has decreased especially in the early phase of diversification. This coefficient declined from 21 % to 16 % in the period between 1948 and 1967 (Lim, 1975). The export earning instability, as measured in terms of standard deviation from the mean of export earnings (see Pollak, 1980, p. 257), was 25.4 % for total exports of the country from 1960-74. This was much smaller than the deviation of the earnings from most of the individual commodities such as petroleum, sawn timber, palm oil and rubber.

The reduction in export instability was achieved by diversifying the types and destination of exports. Higher level of production aimed at domestic consumption has also contributed towards a reduction in the degree of economic instability. Although the growth of local production of manufactured goods resulted in increased local activity, the dependent of the Malaysian economy on trade is still evident. In 1955 exports amounted to 50 % of GDP but this proportion has fallen to 41 % by 1975 but the ratio increased again to 52 % in 1985. The Malaysian government has intensified efforts to diversify its trading partners and its products especially by strengthening trade relation with neighbouring Asean countries. Because many of these countries are producing similar goods, the level of bilateral trade is still low. Thus, for the foreseeable future, Malaysia would continue to depend on OECD countries for its exports.

The contribution of rubber and tin has clearly declined indicating the success in the diversification policy. In 1957, rubber and tin accounted for 70 % of export revenue but the two commodities only accounted for 20.0 % of the total export of commodities in 1985.

The distribution of income and wealth among the races have improved appreciably from the skewed position in 1970. Assets ownership by the Malays and other indigenous groups had increased from 1.5 % in 1970 to 15.0 % in 1985. This may appear much too low from the 30 % target to be reached by 1990, but there have been considerable improvements in the distribution of income, thus minimising the potential source of discontent. Through the eradication of poverty strategy, the overall incidence of poverty has been reduced during the period 1970-84 from 36.6 % in 1970 to 18.4 % in 1984.

Growth had also brought along other benefits as well as problems. There have been increased employment opportunities to accommodate the rapidly growing labour force. However, employment statistics indicate that open unemployment increased from 2 % in 1957 to 8 % in 1970. In 1975, the level of unemployment was 7.5 % and it has since remained at slightly below 7 %. However these figures do not reflect the seriousness of the unemployment problem because they only refer to those unemployed who are actively seeking employment. The passively unemployed are not accounted for in these figures as rural under employment is not represented and thus the overall unemployment picture is unlikely to improve. Migration of workers to the urban areas and other social problems associated indicating the success in the diversification policy. In 1957, rubber and tin accounted for 70 % of export revenue but the two commodities only accounted for 20.0 % of the total export of commodities in 1985.

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Finally, there are environmental problems as well; this is often referred to as the price to be paid for pursuing a rapid development strategy. Rapid expansion in palm oil and rubber processing had caused major pollution of rivers and waterways and these have still to be fully brought under control.

3.4 Current Policies and Strategies

The government had played an active role in the development process during the 1970s. This was partly to provide the opportunities for the process of economic distribution as stipulated in the New Economic Policy to be attained. With the implementation of the Fourth Malaysia Plan from 1981-1985, the strategy was to reduce the government involvement in favour of greater level of private sector participation. The contribution of the private sector in national development is further emphasised in the implementation of the Fifth Malaysia Plan. A policy of privatization has been adopted and to date, major government bodies such as the Telecoms have been scheduled to be completely run by the private sector.

In its endeavour to meet the objectives of the development plans, the government has financed its development expenditures by various means - taxation, domestic and foreign borrowing. Private investment continued to be encouraged by providing fiscal incentives and improved infrastructural facilities, (roads, railways and other services) which are required for the further development of agriculture, commerce, industry and services. To assist in the restructuring of assets ownership, special loans were set aside so that a government appointed National Trust could acquire corporate shares which can be held in trust for the Bumiputras to buy at a later period.

3.4.1 The Balance of Payments

In the early 1960s the balance of payments was given great weight in policy formulation because of its potentially adverse effect on the development programme. The government maintained a conservative policy in its budgeting process by not spending at a rate higher than the revenue that it could raise. However, the programme of rapid development introduced during the 1970s, required more savings, borrowing and capital inflow into the country, in addition to the need to increase export earnings to finance imports.

Rapid expansion in the export sector provided a high rate of savings. The average level of national savings rose from 15 % of GNP in 1960-65 period to 22 % during 1971-75, and to 33 % by 1980-85. The high rate of national development caused public expenditure to grow to about 35 % of GNP during the period 1971-75. This was relatively high in comparison with other developing countries. To finance the gap between expenditure and available revenue, the government increased its foreign borrowing.

During the 1970s, the balance of payments continued to be in surplus for a number of reasons. Firstly, commodity prices were higher resulting in a strong positive trade balance. Secondly, despite the continued deficit in the services account plus the outflow of fund as investment income paid abroad, there was a surplus in the capital account. This was possible through the good credit rating position of the country, which allows the country to obtain loans more easily from the international market. Furthermore, since 1973, Malaysia floated its exchange rate, to allow the exchange values of the Ringgit to be directly determined by the market, and leaves the Central Bank to manage the occasional imbalance in money supply rather than worry about managing the balance of payments.

The balance of payments position deteriorated during the early 1980s. The current account recorded a deficit of M$ 620 million or 1.2 % of GNP in 1980, and continued to deteriorate to reach M$ 8,409 million or an unprecedented 14.1 % of GNP in 1982. With the recovery since 1983 of the merchandise account, the current account position improved substantially (Table 3.7). By 1985, the decline in imports has more than offset that of exports to result in a surplus of M$ 628 million. Overall the merchandise account netted a cumulative surplus of $14,633 million during the Fourth Malaysia Plan period.

The traditional deficit in the services account continued to worsen during the Fourth Malaysia Plan period. In 1985, the deficit almost doubled to M$ 10,728 million from M$ 5,813 million in 1980. Larger outflow of investment income, especially for interest payment, and higher payments for freight and insurance accounted for the major portion of the deficit.

With the large deficit in the current account, Malaysia continued to be a net importer of capital. During the period, the cumulative net inflow of long term capital amounted to M$ 34,811 million of which M$ 20,111 million were official market loans, M$ 2,254 million were official project loans, and M$ 13,111 million were corporate investment. The large official loans were partly to finance the investment of the special loans for the NEP.

The substantial net inflow of long-term capital was able to offset the large current account deficit and net outflow of short term capital. Consequently, the overall balance of payment position recorded a cumulative surplus of M$ 1,759 million which led to an accumulation of reserves. External reserves of the Central Bank amounted to M$ 12,457 million at the end of 1985, sufficient to finance 4.9 months of retained imports.

3.4.2 Macroeconomic Prospects

The prospects for the next five years have been chartered out in the Fifth Malaysia Plan. In the past, the planned targets have generally been achieved, and even exceeded for the years when prices of commodities were favourable. Even during the difficult period of the first half of the 1980s, the actual growth had been close to the targeted figures.

The Malaysian economy is projected to grow at 5 % per annum and in view of the depressed market conditions for tin and petroleum, a significant portion of the growth is projected to come form domestic activities. A general consolidation of the financial and fiscal policies was envisaged and private sector investment at rates well past that of the Fourth Malaysia Plan was to be the key factor underlying the growth prospects for the Fifth Malaysia Plan.

Sectoral development will focus more on the development of the secondary sector which will increase its share slightly from the 24.3 % in 1985 to 25.8 % in 1990; the share of the primary sector will decline from 30.4 to 27.4 percent during the same period while the tertiary sector will increase from 44.0 to 46.3 percent.

In the primary sector, the production of rubber will increase marginally by 0.8 % per annum from 1.45 million tonnes to 1.511 million tonnes in 1990 attributed mainly to the projected increase in yield. The planted area for rubber is expected to decline to 1,908,000 hectares from 1,959,000 in 1985. The total area of the rubber smallholding sector is projected to increase by 34,000 hectares largely through new planting through organised smallholdings to reach 1,537,000 hectares in 1990. The rubber area for the estate sector is expected to decline due to the continued conversion of estates mainly to oil palm. It was estimated that about 95,000 hectares of rubber estates will be converted to oil palm and to other uses. Only about 10,000 hectares of new planting of rubber will occur in the estate sector.

Palm oil production is projected to expand by 6.7 % per annum to reach 5.7 million tonnes by 1990 compared with 9.9 % during the Fourth Malaysia Plan. The slowing in rate of growth is projected for the planting of oil palm. Planted area is projected to grow by 3.8 % per annum rising from 1.5 million hectares in 1985 to 1.8 million by 1990.

The Fifth Malaysia Plan represents the last part of the implementation of the OPP. The achievement attained during the preceding five year plans had been satisfactory despite the difficult period of depression in the early 1980s. This has trimmed the implementation machinery, and would have no doubt strengthened the economic structure for the future, and with the moderate rate of growth projected for the next five years, the country should continue to grow according to plan.

Table 3.7 Malaysia: Balance of Payments, 1980-85

(M$ million)

Item	1980	1981	1982	1983	1984	1985	1981-85	Fourth Plan
Goods and Services	-575	-5555	-8334	-8005	-3653	-2100	-27647	-29354
Merchandised account	5238	-243	-1758	1093	6913	8628	14633	9890
Exports	28013	26900	27946	31853	38452	37905	163056	-
Imports	22775	27143	29704	30760	31539	29277	148423	-
Services account	-5813	-5312	-6576	-9098	-10566	-10728	-422280	-39244
of which								
Freight and insurance	-1781	-2008	-2154	-2132	-1986	-1753	-10033	-
Investment income	-1820	-1836	-2679	-4208	-5205	-5692	-19620	-
Transfers	-45	-78	-75	-21	-90	-130	-394	-310
Current account	-620	-5633	-8409	-8026	-3743	-2230	-28041	-29664
Capital account	1622	4540	7795	7971	4055	5439	29800	-
Official	180	3017	5169	6284	4364	2866	21700	-
of which:								
Federal govn. loans	309	2909	4622	3768	3152	1074	15525	-
Loans for NEPEs	n.a.	769	736	2028	2007	1500	7040	-
Corporate investment	2033	2914	3263	2926	2138	1870	13111	-
Errors and Omissions	-1493	-1488	-963	-976	-2159	-300	-5866	-
Overall Balance	1002	-1093	-614	-55	312	3209	1759	-
Change in reserves allocation of SDRs and drawing on IMF	-1002	1093	614	55	-312	-3209	-1759	-

Source: Malaysia (1986) Fifth Malaysia Plan, 1986-90, p. 58.

CHAPTER 4: AN OVERVIEW OF THE MALAYSIAN RUBBER AND PALM OIL INDUSTRY

4.1 Introduction

This chapter - and the next - will describe the main features of the rubber and palm oil industry with the intention of giving a general impression of the basic production and consumption structures and the competitive positions of the two commodities within their respective markets. An understanding of the economic interrelationships between supply, demand and prices under which the commodities are produced and marketed will be a useful foundation to have before proceeding to evaluate in later chapters the crop allocation policy in the Malaysian plantation sector.

The emergence of rubber and palm oil as industrial commodities is reviewed first in Section 4.2. Details of rubber production and marketing systems are presented subsequently, while the sections that follow will describe similarly the salient economic features of the palm oil industry. The emphasis in this overview is to highlight the strengths and weaknesses of the two industries and to relate these to the economic aspects and policy options which have influenced the development of rubber and oil palm cultivation in Malaysia. The role of joint policies is also examined in view of the possibility, at least for planning purposes, of regarding rubber and oil palm as part of a coherent plantation industry.

4.2 The Emergence of Rubber and Palm Oil as Industrial Commodities

It is important to note at the outset that rubber and palm oil, when looked upon as industrial commodities, have many features in common. Both are tropical products derived from perennial tree crops which have been successfully introduced into Malaysia and neighbouring South East Asian countries during the last century when these regions were under the British and Dutch colonial powers. Rubber originated from the Amazon area of Brazil and the oil palm came originally from West Africa.

4.2.1 Rubber as a Commodity

The emergence of rubber as an important industrial commodity can be traced back to the discovery of vulcanization in 1839 by Charles Goodyear and the development of pneumatic tyres in 1888 by J. B. Dunlop. The discovery of vulcanization was a revolutionary breakthrough as it enabled rubber to be moulded into useful products and the elastic properties of raw rubber to be stabilised. Vulcanization enabled rubber to become an industrial material with predictable strength and technical properties. Previously, rubber remained an item of curiosity because of its special properties such as its ability to erase pencil marks - from which the name rubber was derived - as discovered by an eminent English chemist, Joseph Priestley, in 1770 (Allen, 1972, p. 34).

Most of the technological processes needed to promote industrial utilization of rubber were already established during the nineteenth century. For example, the revolutionary method of processing and softening raw rubber using the masticator was pioneered by Thomas Hancock in 1820. When tyres for use by motor vehicles were invented, rubber became an indispensible raw material, and when its supply from wild trees in the Amazon jungle became insufficient, expensive and unreliable, production of rubber through cultivation of the crop became inevitable.

The challenge to cultivate rubber trees was taken up by the India Office of the UK government who ordered various expeditions to collect rubber specimens during the 1860s, and following feasibility studies it was recommended that Peninsular Malaysia, Borneo and Ceylon would be among the most suitable countries where rubber could be cultivated. Subsequently, several attempts were made to collect and ship rubber seeds from Brazil and one of the most successful missions by Sir Henry Wickham in 1876 resulted in some 70,000 seeds being brought back to Kew Gardens in the UK for germination. Just over 2,000 of the seeds germinated and most of them were shipped to Ceylon and 50 were sent to Singapore. Further consignments of seedlings followed from subsequent expeditions and by 1877/78 rubber seeds were already widely distributed. The first Hevea rubber plantation was established in Ceylon in 1890 and this was soon followed with the establishment in Malaya of the first rubber estate of about 20 hectares in 1896.

Two main problems impeded the early development of the rubber industry. First, there was a need to develop an efficient means of latex extraction. Secondly, an efficient way had to be found to coagulate the latex. The first problem was solved by the invention of the tapping knife by H. N. Ridley in 1889. The use of the tapping knife, unlike the slashing cuts method practised by harvesters of wild rubber in the Brazilian Amazon, resulted in less damage to the bark of the tree and output was increased. In the same year, John Parkin demonstrated the use of acids as coagulating agents and thus he was able to solve the problem of the inefficient smoke coagulation technique used hitherto in Brazil.

In the following few decades, production of plantation rubber grew rapidly as world demand and prices for rubber escalated (see Drable, 1973, who studied extensively the early growth of the rubber industry in Malaya from 1876 to 1922). As the main use for rubber was for making tyres for the emerging motor car industry at that time, the growth pattern of the early development of the rubber industry was closely linked to the growth of the car industry.

Subsequent expansion of the rubber industry was closely correlated with the expansion not only of the motor car industry but also industrial production in the developed countries as the uses of rubber expanded into many other industrial products such as hoses, matresses, footware etc. The relationship is often illustrated graphically to yield the usual logistic curves of per capita income and per capita rubber demand ranging for countries with low income to those with high income (see, Smit, 1982; and Allen, 1972). Today, tyre and tyre products are still the main end-uses of raw rubber. As shown in Table 4.1, tyre products accounted for 58 % the total rubber consumption in 1978 and the share has been stable in the subsequent years.

In the rubber literature, the word "rubber" refers nowadays to both synthetic (SR) and natural rubber (NR). Synthetic rubbers were first introduced in the 1930s in Germany when a shortage of foreign exchange necessitated the development of alternative materials but the chief impetus to its development took place in the U.S.A. during the Second World War when rubber supplies were interrupted because of Japanese occupation of the NR producing countries of South East Asia.

With the rapid growth in the production of synthetic rubber, especially after the Korean War in 1950, the share of NR in the world market began to decline rapidly. Between 1960 and 1978, the share of NR has declined from 48 % to 32 % (Table 4.1), despite the growth of 280 % in the total rubber consumption during that period. It is interesting to note that the pattern of consumption has stabilised. In 1984, the world consumed around 13.23 million tonnes of NR + SR; the share of NR of about 4.24 million tonnes represents 32 % of the total consumption indicating the stable trend in the shares for the last ten years.

Table 4.1 Pattern of Elastomer Usage in Selected Countries*.

Year	Usage in tyres as % (SR+NR) Total	NR as % of (SR+NR) Total	NR as % of (SR+NR) in Tyres only	NR in Non-tyres as % of NR+SR Total	World NR usage as % World NR+SR Consumption
1960	59.4	47.9	43.7	21.9	47.4
1961	58.8	45.3	41.1	21.1	45.7
1962	58.5	43.3	39.4	20.3	44.3
1963	58.3	41.7	37.7	19.7	42.9
1964	58.3	40.0	35.5	19.3	40.9
1965	59.3	38.9	35.3	18.0	39.5
1966	58.1	37.4	34.8	17.2	38.2
1967	58.5	36.4	32.8	17.2	37.3
1968	59.5	35.3	31.4	16.6	36.3
1969	59.8	34.0	31.3	15.3	35.2
1970	58.3	33.9	31.7	15.4	34.7
1971	60.0	32.9	31.2	14.2	33.4
1972	59.9	32.5	30.9	14.0	32.4
1973	57.5	31.3	31.6	13.1	31.0
1974	60.4	33.1	33.2	12.7	32.1
1975	60.1	34.9	34.1	14.4	32.4
1976	56.7	32.8	33.8	13.6	30.7
1977	59.6	33.0	33.9	12.8	30.1
1978	57.7	32.4	34.4	12.6	29.8
1979	57.4	27.1	34.8	7.1	29.8

* Brazil, Canada, France Germany, Italy, Japan, UK, U.S.A. for which only data series up to 1979 are available.

Sources: Report of Rubber Task Force (MRRDB, 1983); Rubber Statistical Bulletin, Various issues.

The universal demand for natural rubber and its numerous sources of supply contribute to it being regarded as one of the most actively traded commodities in the world commodity market. Many terminal markets have been established including in New

York, London, Tokyo and Kobe while the primary markets dealing mainly with physical trading of rubber are based in Kuala Lumpur and Singapore. Recently, the Kuala Lumpur Commodities Exchange has also started "futures trading" on rubber.

4.2.2 Palm Oil as a Commodity

The classification of palm oil as a commodity is only justified as a definitional simplification. As will be shown later, a significant proportion of Malaysian palm oil products is exported in the refined form ready to be consumed by consumers in the importing countries. In this respect, palm oil can be more appropriately described as a consumer product rather than a primary commodity although traditionally, palm oil has been exported in its crude form.

Crude palm oil is a reddish brown semi-solid fat produced by extraction of oil from the mesocarp or flesh of the oil palm fruit. The oil contains carotenoids and tocopherols as the main non-oil minor components. The carotenoids which are rich in vitamin A are responsible for the reddish colour in crude palm oil while the tocopherols, besides being useful nutritionally as a source of vitamin E, are natural antioxidants which protect the oil against oxidative deterioration. It is interesting to note that modern consumers prefer the oil to be refined before it is used in food products. Unfortunately, the refining process also destroys the nutritionally useful carotenoids and tocopherols.

Nevertheless, crude palm oil has long been a traditional source of food fats for many African countries. Archeological findings from the sepulchral vaults of an Egyptian tomb showed that one of the vases to serve as provision for the deceased contained a substance which under examination was proven to be palm oil (Lanagan, 1977; Hartley, 1967). Today, the tradition of consuming palm oil in its unrefined crude form still continues in some countries in Africa and South America but the majority of total output is consumed after the oil has been refined and processed into fat or oil products.

It was the early eighteen century European traders who found that palm oil could be imported to Europe for use in fat based products such as hand cream, medicines and soaps. Thus trade in palm oil began when the commodity was exported from Africa to Europe and later to the United States not only as a raw material for fat products but also for its well known use as an excellent lubricant for the tin plating industry.

Most palm oil today is consumed for edible purposes especially in shortenings and margarine, while in the warmer climates, the liquid fraction of palm oil, known in the trade as palm olein, is widely used as frying and salad oils. In the Middle East and Indian Sub-continent, palm oil is used mainly as a substitute for ghee (a fat product derived from cow's milk).

The most notable development in the palm oil industry is the rapid growth of its production in Malaysia and Indonesia during the second half of this century. Though the oil palm was already introduced to these countries during the nineteen century, its commercial importance was not initially exploited. Instead the palms were regarded as ornamental plants popularly grown for decorating avenues and gardens.

According to Hartley (1967), the oil palm plantation industry in the Far East began with the introduction of four palms for planting in Bogor Botanical Gardens in Java in 1848. The origin of these four seeds and their link to the African palm were not clear as two of the Bogor seedlings came from Mauritius and the other two were from Amsterdam. From Bogor, progenies were planted in Deli in Sumatra, and offsprings from the Deli palm known as the Deli Dura (yielding fruits of the thick shelled variety) were soon adopted for wide-scale planting in South East Asia.

The foundation of the industry in the Far East is generally attributed to M. Adrien Hallet, a Belgian , who planted palms of the Deli origin in 1911 in the first large commercial plantation in Sumatra. The first oil palm plantation in Malaysia was established in 1917 at Tenamaran Estate not far from Kuala Lumpur, although as noted by Hartley (1967), some palms of the Deli Dura variety were already planted by M. H. Fauconnier during 1911 and 1912 in Rantau Panjang also near Kuala Lumpur.

Until the late fifties, the expansion in production of palm oil in Malaysia grew only at a slow rate, unlike the more rapid increase in rubber production. The main reason for the slow growth is partly the lack of market opportunities and partly the low yield of the Dura palms which were widely planted at that time.

As in the rubber sector, innovations and research breakthroughs also played an important role in the early years of the establishment of the palm oil industry. Cross breeding of 'Dura' palms (thick shelled fruits) with the 'Pisifera' palms (no shell) imported from South America produced the Tenera variety (of medium shell thickness, see Figure 4.1) which led to more than doubling of the yield. This enhanced the economic viability of oil palm cultivation and provided the impetus for the expansion of palm oil production during the sixties and seventies. By 1966, Malaysia and Indonesia together had surpassed Africa's total exports and this marked the end of Africa's domination of palm oil trade even though Nigeria, the leading producer (but consuming most of its output) alone produced more that year than Malaysia and Indonesia combined.

In an important respect, palm oil trade is similar to the rubber trade in that it faces stiff competition from close substitutes. Because of the large variety in the types of oils and the wide distribution of the sources of supply, trade in oils and fats is highly complex. Exports can be in the form of crude or refined oils and fats or they can be in the form of oil seeds which are crushed to produce both the oil and meal in the importing countries. Altogether, some 33 % of world production of 76 million tonnes of oil equivalent enters world trade in 1983.

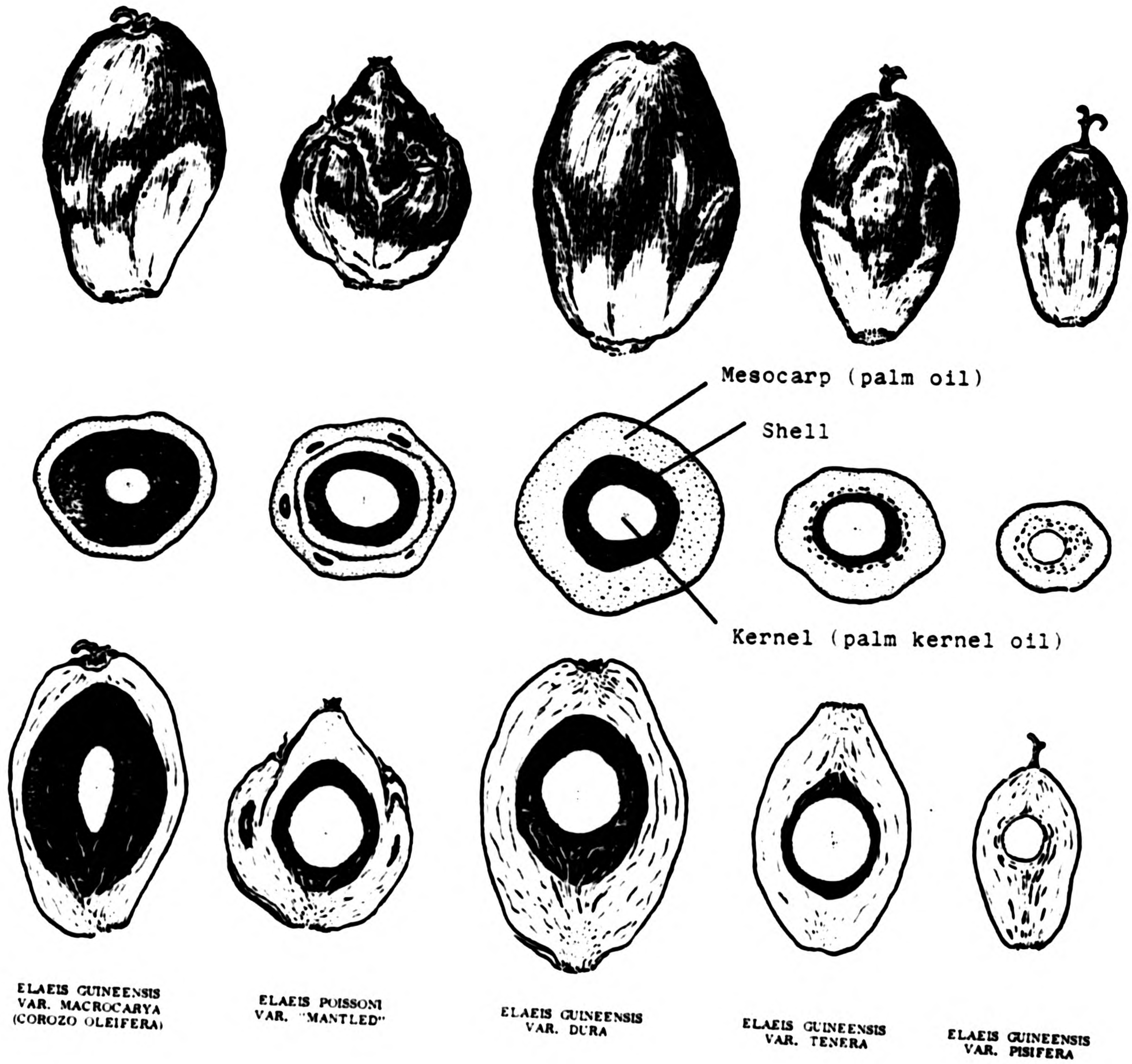

Figure 4.1: OIL PALM FRUIT TYPES

(Adapted from Ministry of Agriculture "The Oil Palm")

To service the distribution of such large quantities of oils, fats and oilseeds, efficient market system must exist and adequate shipping and handling facilities are required. Bulk oil shipment and storage facilities are required in both the importing and exporting countries.

The above description on the early processes of the development of the two crops provides an insight into the historical economic circumstances which led to the establishment of the two commodities as major international commodities. It has been shown that both crops have a very narrow genetic base, at least as far as Malaysian plantations are concerned, and to the plant breeders it means that there is a great potential for discovering better yielding varieties if prospection work to broaden the genetic base is carried out. This explains the continual efforts by both the rubber and oil palm growers to send teams to collect seeds in South America and Africa for the purposes of developing a genetic pool for these crops.

The establishment of rubber and oil palm cultivation in Malaysia demonstrated the viability of organised planting of tropical crops even though Malaysia is not the native habitat of the two crops in question. Not surprisingly, following the success in oil palm cultivation in Malaysia, there has been a rapid growth in oil palm hectarage in Indonesia, and there is a revival of interest in Africa and South America to cultivate the crop.

The question of crop diversification however, remains an important issue facing present investors in the Malaysian plantation industry. The crop allocation problem, which is the key objective to be evaluated in this study, requires that the past, present and future pattern of crop development and their competitive position internationally be taken into consideration.

With the firm establishment of the production and marketing systems for rubber and palm oil, their status as major international commodities is clear and unquestioned. Both rubber and palm oil are widely traded to all parts of the world and the prices of these commodities for instance are quoted daily in commercially popular newspapers in the UK such as the "Financial Times" and "Public Ledger". The question of interest at this juncture is how well these commodities will face the challenges from their respective competitors in the future. This question will be partly evaluated by examining in the next few sections the past and present performances of the two commodities, in terms of the strengths and weaknesses of their production, marketing, end-uses and technical properties.

4.3 Rubber Production

The world is now accustomed to the existence of two main types of rubber: natural and the synthetics. The growth of natural rubber production has to occur within the pattern of competition where a natural product which is traditionally exported by the developing countries is being substituted by synthetic products produced through technological innovation by the more developed countries. Many other examples can be quoted where traditional commodities are being threatened by newly invented substitutes. These include jute, silk and cotton which are affected by synthetic fibres, and tin, timber and bricks which are often substituted for by aluminium and plastic materials.

In these situations, it is important to recognise that although natural rubber and the synthetics are two close substitutes, they have different production cost structures, pattern of ownership and linkages between producers and consumers and in turn these will have different implications on the marketing system, prices and competitiveness for the two commodities.

Natural rubber is derived from the latex which is extracted from the rubber tree by a 'tapping' operation (making a continuous stretch of sloping incision) on the bark of the rubber tree (Hevea braziliensis). The latex is collected from the daily or alternate day tapping operations, and coagulation of the latex is achieved by the addition of formic acid. The coagulates, after undergoing intermediate processes of mangling and drying to remove most of the water, is finally dried in smoke houses to yield the exportable ribbed smoked sheet rubber (RSS). The processing can be carried out either on a small scale by the individual smallholder or by factory type operations as usually practised in the larger plantations.

Other processes such as the production of "heveacrum" to produce the more technically specified Standard Malaysian

Rubber (SMR) require factory processing of the latex where, in combination with other coagulates collected from the field such as cup lumps and laces from the tapping groves, different grades of SMR can be produced. The production of SMR involves the use of a series of rollers and hammer mills to masticate the coagulates to produce the rubber crums. These are washed and then dried in hot air continuous dryers to remove dirt and water respectively from the rubber before packing into bales and crates for export.

Major producers of NR are Malaysia, Indonesia, Thailand and Sri Lanka. Some small quantities are produced in West African countries. In Brazil however, the rubber industry has remained underdeveloped because of the presence of a lethal leaf blight disease which defoliates rubber plants.

Of the 4.26 million tonnes of NR produced in 1984, Malaysia accounted for 35.9 %. The South East Asian countries and other minor producers in Asia together accounted for 92.9 % of the total while African and South American countries occupied shares of 4.7 % and 1.4 % of the total NR output respectively.

Rubber is a perennial crop and the trees take 5 to 6 years to mature. A substantial investment is thus required during the establishment phase before any returns can be expected. This burden is often borne by the poorest of peasants as more than 75 % of world production of NR is through smallholdings. Very often, in the smallholding sector, the maintenance of the plantations and fertilising of trees are affected by lack of funds and rubber yields are ultimately lower than that achievable in the estates. Earnings from rubber production in the smallholdings vary from a low of US$ 1 to about US$ 5 per day typically, and it is from these humble contributions of villagers and smallholders that enable most of the tyres to be produced for the cars and lorries all over the world.

4.3.1 Malaysian Rubber Production

The growth pattern for Malaysian rubber planted areas has been summarised in Table 3.5 of the previous chapter. Readers interested in detailed development history of the industry may refer to the excellent book by Drable (1973). More recent developments have been studied by Barlow (1978), and Ani and Pee (1976).

The establishment of rubber plantations in Malaysia has to a large extent been enhanced by the improvements in yield. This is achieved primarily through intensive breeding research. Early work by the Dutch in Indonesia and later by the Malaysian Rubber Research Institute (RRIM) led to a dramatic increase in rubber yield. The initial imported hevea yielded only about 500 kilogrammes per hectare per year while today there are special breeds capable of producing well over 3,000 kilogrammes per hectare per year. Optimists in the natural rubber industry have often cited the biological yield limit for Hevea at around 10,000 kilogrammes per hectare per year as estimated by Templeton (1969). Of course the industry is a long way from achieving this target figure because the agronomic ideal conditions would not be easily obtainable.

Although the original thrust of past research efforts was for improving the productivity of rubber cultivations in the larger plantations, the results of research such as the use of high yielding clones, could be applicable and easily adaptable to rubber production by the small farmers on a much smaller scale of 1 to 5 hectares compared with 1000 to 5000 hectares usually observed in the estates. In this way the structure of rubber production has evolved into the dual sectors of ownership: the smallholdings and the estates. The distinction between the estates and the smallholdings is rather arbitrary. An estate is a plantation of more than 100 acres or 40.7 hectares.

The proportion of rubber smallholdings in the Malaysian rubber industry had increased from 40 % at the end of the war to 75 % in 1982. This shift arises from three main developments. Firstly, the government promoted a programme of rubber replanting by providing a replanting grant to sustain the smallholders' income during the period of crop reestablishment. Secondly, the proportion of the estate rubber areas had declined mainly by default as the estate sector began to diversify extensively into oil palm planting. Thirdly, organised rubber planting schemes were introduced by the government. Land development agencies such as FELDA and FELCRA had been established to introduce organised systems of rubber production on a scale approaching that of the estate sector. Often, the sector under the land development schemes is referred to as the organised smallholders sector.

Although there is no convincing reason to support the contention that the estate is superior to the smallholdings in rubber production, it is generally recognised in practice that the estate can be managed more efficiently. Estates are essentially commercial enterprises. Their better level of management practices is evidenced by the observation that rubber yields from the estates are 1.5 to 2 times those of the smallholdings.

Initially most of the large estates in Malaysia belonged to the major plantation companies owned by foreign groups which were mostly registered in London. British agency houses or merchant firms such as Guthrie & Company Limited, Barlow and Company and Harrisons & Crossfield Limited played a major role in channelling capital from the United Kingdom to Malaya to finance the planting of rubber. In 1953, foreign shareholders owned 83 % of the equity of plantation companies. After independence in 1957, there was no real effort to correct the imbalance in the ownership pattern. By 1968, only about 29 % of the equity of the plantation companies was held by Malaysians. Today, about 90 % of the plantation hectarage is Malaysian owned. The change in the ownership structure was achieved through gradual acquisition of the shares of these foreign rubber companies in the equity market. The move was encouraged by the Malaysian Government as part of the implementation of the country's New Economic Policy as discussed in Chapter 3.

Another striking and most important feature of the ownership pattern for the estate sector is the historically low level of ownership by rubber manufacturing companies, thus reflecting minimum vertical integration within the rubber producing and consuming sectors, unlike the pattern existing in the synthetic rubber industry (see page 132). The main reason is probably that rubber manufacturers may not wish to diversify and develop the necessary expertise required to operate the rubber plantation business. Another reason is that NR can be more efficiently obtained from the open market. Most rubber manufacturers which have their own plantations prefer to dispose of the NR produced from their own plantations through the rubber market, and their manufacturing units will in turn purchase from the market any rubber they need for their manufacturing processes.

4.3.2 Policies Influencing Rubber Production

As explained in Chapter 3, a major task of the Malaysian government after independence in 1957 was to ensure that the country can develop a self-sustaining economy. The country was then heavily dependent on the rubber industry which accounted for some 40 % of the export revenue but the rubber plantation sector was in need of rejuvenation. Even before independence, a UK government (Mudie) mission in 1954 had pointed out that more than 50 % of the rubber planted area was at least 30 years old, and ought to be replanted without delay. These events signalled the start of the replanting policy.

In addition to rubber replanting, a policy of agricultural diversification was also set into motion as a result of a study by a World Bank team in 1955. The study noted that the viability of natural rubber production was under the threat of price erosion due to increasing synthetic rubber production. The planting of alternative crops principally oil palm was thus recommended to ensure that the economy would be well diversified.

To implement these policies, the government set up two agencies:- i) The Rubber Smallholders Replanting Authority (RISDA), and ii) The Federal Land Development Authority (FELDA). RISDA was set up mainly to undertake the task of promoting the replanting of rubber lands. A "replanting cess" was levied for every unit of rubber exported, and RISDA was empowered to manage the accumulated fund and to supervise the award of grants to those participating successfully in rubber replanting.

The impact of rubber replanting can be seen in the greatly increased output of rubber from the smallholdings sector. Apart from the expansion in the areas of younger and more productive rubber plantations, replanting also enabled better clones to be introduced and this contributed to the overall increase in rubber production.

The land development scheme was proven to be highly successful. FELDA was able to develop large areas of virgin jungles into oil palm or rubber plantations using funds borrowed from the

Government and international development banks. The development process normally begins with the clearing of the land and planting the crop concerned. This phase is usually carried out by contractors. Once the field has been planted, the settlers are brought in to maintain the young plantations while FELDA provides them with a minimum subsistence family allowance. Each family is usually given a right to own about 4.2 hectares, or a right to a share ownership of an equivalent area of the plantation. When the plantation comes into production, the settlers are required to pay back the development costs. In the mean time, the management rights remain with FELDA. In this way, the large scale of operation is preserved and the supervision of plantation maintenance and marketing of the products continue to be centrally managed by FELDA management teams.

The success of the land development schemes can be seen from Tables 4.2 and 4.3. By 1984, Felda had developed some 300,000 hectares of oil palm plantations and some 200,000 hectares of rubber in the smallholding sector. It is often asserted that FELDA, when regarded as a unit, represents the world's largest single producer of both rubber and palm oil. By retaining management rights on the smallholders lands, FELDA is able to provide centralised services and research inputs to improve the efficiency of production and marketing of the products from smallholders operations. This contributed to the success of the FELDA settlers when compared with the performance of independent smallholders.

Table 4.2 Outputs of Rubber and Oil Palm in Peninsular Malaysia

Year	Rubber			Oil Palm		
	Area('000ha)		Production	Area(000'ha)		Production
	Estates	Small-holdings	('000 t.)	Estates	Small-holdings	Palm oil ('000 t)
1960	750.7	802.6	694.4	54.6	-	91.7
1970	646.6	1077.3	1215.7	193.4	67.5	419.5
1980	491.6	1205.7	1463.9	495.4	488.8	2058.6

Sources: Rubber Task Force Report, MRRDB (1983); Statistical Handbook, and Updates, PORLA (1980, and 1982)

Table 4.3: Smallholding Rubber Areas in Peninsular Malaysia ('000 ha)

Year	Individual holdings		Group planting schemes			
	Replanted	Others	Felda	Felcra	State	Total
1960	155.2	570.1	5.9	-	34.4	765.6
1970	436.0	429.7	59.8	5.7	146.1	1077.3
1980	612.3	190.0	168.9	41.8	192.7	1205.7

Source: Rubber Task Force Report, MRRDB (1983).

Rubber replanting and crop diversification are without doubt the two main policies that have influenced the development of the Malaysian plantation sector up to the present time. To enhance the implementation of these policies, other supporting policies were also introduced. Many agencies were established to assist in the implementation process. These include the establishment or expansion of

i) FELCRA to rehabilitate land not successfully developed previously;

ii) MARDEC to assist in the processing and marketing of smallholders rubber

iii) RRIM and MRELB to promote research, promotion and marketing of rubber

iv) KLCE to provide futures trading facilities.

These supporting organizations assume the task of consolidating the development and the implementation of the main policies of the rubber industry. Evaluation of the country's various five year plans shows that these agencies are depended upon to carry out policies for the development of the rubber industry and in turn the agencies have introduced various operation strategies and implementation slogans to carry out their respective tasks. These slogans such as "replant or die", "dynamic production policy" and "dynamic productivity policy" reflect the philosophies and the approaches adopted by the agencies in improving the competitive position of the rubber industry.

Up to 1980, and before the Fourth Malaysia Plan came into operation, the planning strategies of the government as indicated in various Five Year Plans were to continue to encourage the expansion in rubber production through an increase in replanting and new planting. After 1980 there was a slight shift in the emphasis of the policy pertaining to rubber. Increasing in productivity was emphasised as an important target rather than an increase in planted area for rubber. The reasons and circumstances which brought about these changes in policy are detailed below.

i) Slow rate of change: The process of implementing changes in the structure of the rubber industry could only be introduced gradually owing to two main reasons. Firstly, it was important to preserve the stability in employment and revenue offered by the rubber industry which was still a major source of income and employment to the economy. Secondly, even if rapid changes in production structure were desired it would be difficult to implement them immediately owing to the fragmented nature of ownership and the problem of dealing with a perennial crop which has an economic life of more than 25 years. Any policy changes to the rubber industry had to be introduced after careful consideration to the economic implications, and would in any case require time in their implementation.

ii) Lower profitability for Rubber: The lack of any permanent increase in the prices of rubber over the previous twenty years meant that rubber production had become less profitable or outright non-viable in areas where labour was scarce. Whilst the plantation companies were fully capable of reallocating their land to other crops such as the oil palm, the smallholders would not be able to convert their plantations rapidly because of the small size of their plot of land, the long life of the existing rubber and the different technology needed in the production of the alternative crop. Consequently, the estate sector had shifted into oil palm cultivation in a big way while the smallholders remained stuck with rubber cultivation. Given that palm oil had been more profitable than rubber for the last two decades, the lower participation of the smallholders is seen as a loss, and this in some way appears to contradict the policy of poverty eradication of the government.

iii) Inefficiency of Smallholdings: Replanting assistance provided by RISDA was often seen to be insufficient and replanting of smallholders land was only partially successful. The model to be followed was to introduce large scale operations using high yielding planting material, as shown by the success of the FELDA's schemes. This target could not be easily attained through RISDA's earlier operations. The transfer of technology to the smallholders was slow and thus the high yielding material was not reaching the smallholders effectively. The organizational structure needed to enhance the efficiency of the smallholders could not be achieved. It was estimated that Malaysia could double its rubber production without increasing the rubber hectarage if it were possible to increase the productivity of the smallholdings to the level achieved in the estate sector.

iv) Labour shortages and migration: There were problems of labour shortages in the estate as well as the smallholding sectors. Rubber was losing credibility as the income from rubber production remained relatively low. The younger generations, as in most developing countries, were migrating to the cities to seek better employment or they could join the services of the government such as in the armed forces which were all experiencing a rapid phase of expansion. This compounded the problem of RISDA in its attempt to promote smallholding rubber development. As the prospects for remunerative occupation in rubber smallholdings diminished, more of the rubber smallholding became neglected and abandoned.

v) Lower income from rubber relative to palm oil: During the Fourth Malaysia Plan, (1981-85), the country saw the export revenue from palm oil exceeding that of rubber for the first time even though the planted area for rubber was nearly twice that for oil palm. Rubber exports were declining and prices remained depressed. Of some 800,000 hectares of smallholdings in operation, only about 50 % were capable of supporting an economic wage; in the remaining areas, smallholders were not able to derive economic wage levels and an increasing trend was for the smallholders to abandon their rubber plantation and seek other forms of income (Task Force Report, MRRDB, 1983).

v) Mixed prospects for rubber: The rubber future hangs in the balance. On the one hand, rubber has a good future as a renewable resource in competing against the synthetics which depend on exhaustible petroleum. Even the demand for NR in the medium term appears to be greater than the projected supply. On the other, it is recognised that current profitability on rubber production is much lower than other crops. To promote rubber cultivation to the smallholders through the traditional policy of rubber replanting would be to perpetuate poverty given that the smallholders were less efficient in rubber production and rubber production was itself less profitable than the major alternative crops.

vi) Price Stabilization: The government had supported the international price stabilization agreement for rubber (INRA) and had to pay substantially towards the rubber stockpiling fund. Despite the existence of the price stabilization scheme, prices of rubber continued to remain low and a large amount of rubber stocks had accumulated. The outlook for the rubber industry was therefore not very encouraging and this signalled for some actions and the introduction of policy changes if necessary.

The above-mentioned situation reflects the deteriorating circumstances facing the rubber industry. While past performances have favoured increased production of palm oil relative to rubber, the future of palm oil is also uncertain and while the original crop diversification policy was successful, the same policy dictates that there is a limit to the extent of replacement of rubber by oil palm. However, the amount of oil palm to be planted and the extent of involvement for the different sectors in cultivating the alternative crops are questions which are not so easily resolved. These have been the focus of recent studies by the government and the outcomes of these studies are discussed later in the end of this chapter after the positions of synthetic rubber and palm oil have been examined in the next few sections.

4.4 Synthetic Rubber Production

Between 1950 and the first oil price hike in 1973, world total consumption of synthetic and natural rubber grew by 6.6 % per annum while the supply of NR registered an annual growth rate of only 3.0 %. The disparity in growth rates resulted in an apparent NR supply gap which had to be filled by the synthetics. NR was said to be losing its market share by default. The competitive position of NR was considerably weaker as consumers were able to substitute NR with one of the synthetics. In the period subsequent to the oil crisis, the growth in demand for total rubber was slightly lower (less than 2 % per annum) and the gap with respect to NR supply was smaller, but the future prospects of NR remained uncertain as by then large production capacities for SR had been established and NR demand and prices continue to be threatened by the increasing supply of the synthetics.

The process of NR substitution by the synthetics is fairly complex, as it depends on many factors including the relative prices, technical properties, pattern of ownership linkages etc. These factors are in turn related to the production structure for synthetic rubber. Thus, the extent of the substitution process and the future prospects for NR can be better understood if one examines the production structure for synthetic rubber. This is the object of the next section.

Synthetic rubbers are produced from polymerizaton processes where petroleum based monomers such as styrene and butadiene are combined to produce longer chain polymeric materials which, like NR, can be vulcanised to produce rubber products. There are some fifteen chemically distinct types of synthetic rubbers competing in the world market thus indicating the numerous possibilities of combining and modifying the monomers to produce a variety of synthetic rubbers with different properties.

The most important synthetic rubber is the styrene butadiene rubber (SBR), and besides having the largest production tonnage, it is also one of the cheapest. The more specialised rubbers such as silicon rubbers are produced in smaller quantities to meet the smaller world demand and consequently, they are more expensive. Butyl rubber (BR) and isoprene rubber (IR) are the next two important large tonnage rubbers competing in the world market. IR is the synthetic chemical equivalent of natural rubber.

The different types of synthetic rubber display a wide range of properties and usually, the individual synthetic rubbers have both good and poor properties with respect to a particular application. For example, a particular synthetic rubber may be better than NR in certain properties but may be poor in some other aspects. The importance of these rubbers has been extensively compared in the literature and will not be repeated here (see Grilli et al, 1978; Allen, 1972; Tan, 1984; and Smit, 1982)

The production of SR in 1950 was only 34,000 tonnes. In the U.S.A., many of the government owned factories producing SR during the Second World War were sold to private rubber companies but despite these developments, production grew slowly up to 1950. It was the Korean War in 1950-51 which stimulated SR production as the US began to stock pile rubber.

Since then the capacities for SR production have increased tremendously.

Most of the developed countries have established their own factories to produce synthetic rubbers. Up to recently, the production data of the individual synthetic rubbers, were not published, and an estimate by Allen et al (1973), based on published capacities, showed that world production of rubber may be divided as follow: 30 % NR and IR; 50 % SBR+ BR; and 20 % Specialties rubber. This pattern is still applicable today as can be judged from the production of various types of synthetic rubber for the U.S.A. where data are more readily available (Table 4.4).

Table 4.4 Production of Synthetic Rubber by Types, in the U.S.A. ('000 tonnes)

Year	SBR	BR	EPR	N-type	IR	Others	Total
1980	1120	314	143	69		569	2215
1981	1085	343	178	70		558	2234
1982	876	288	123	45		497	1829
1983	905	333	175	55		510	1978
1984	958	359	215	67		495	2095
1985	805	330	215	55		504	1907

Source: IRSG, Rubber Statistical Bulletin, Vol. 40, June 1986

The development of the synthetic rubber industry has been geared to meet the demand of the tyre market which is the main consumer of rubber. Rubbers for tyre construction are required to have good 'green' strength to assist in the construction phase; they must also have good resistance to wear, heat buildup, air permeability and damage when in contact with oil.

No single rubber can have good attributes in all these properties. Thus, in tyre construction, different rubbers are used to provide the different properties needed in the various parts of the tyre. For example, SBR is useful for the tread section of tyres because of its high resistance to wear and tear. Butyl rubber may be included in the inner lining as this allows the tubeless tyres to retain their air pressure for a long time, while chloroprene rubber may be used in the outer sidewall of the tyre to increase its resistance to damage by oil.

NR on the other hand is preferred for its good properties with respect to flex, resilience, 'green' strength and heat resistance. The latter property is especially useful for construction of heavy vehicle tyres. Aeroplane tyres, and heavy tractor tyres which are prone to heat build-up problems, are usually made of natural rubber, while lorry tyres may contain more than 50 % NR. Passenger car tyres in comparison may contain only 15 % NR as most of the good properties of NR are not really required for passenger car tyres.

The construction of non-tyre products is less demanding in relation to technical properties, and usually the cheapest suitable rubber is used. In this sector, the share of NR is lower.

The main strengths of the synthetic rubber producing industry are summarised as follows:

i) vertical integration in the production with end-users provides a distinct advantage in the control of supply and perhaps price arrangement

ii) the ability of SR to be tailor-made to the desired properties may enable it to replace NR.

iii) the attractiveness of marketing arrangement, such as short transportation distance, stable prices and good presentation and packaging of products may favour SR to NR.

The main disadvantages are that

i) the SR feedstock comes from petroleum products, and although petroleum prices have fallen in recent years, the supply of petroleum is not inexhaustible. Over the very long term, the cost of feedstock is likely to increase as supplies become scarce.

ii) Some synthetic rubbers are particularly expensive. Isoprene rubber (IR) for example, costs almost twice the price of NR.

The main question to be posed at this juncture is how the world will respond to the situation of depression such as in recent years when both the demand for SR and NR is low. The synthetic rubber factories were reported to be operating at below capacity. Total world SR consumption in 1984 was 8.990 million tonnes which was only 75 % of total reported capacity of 11.973 million tonnes.

One could anticipate increased competition within the SR industry as factories tended to produce in excess of demand in order to cover operating costs. In addition, the inelastic supply structure for NR (see Smit, 1982; and Tan, 1984) tends to put pressure on the synthetic rubber producers to reduce supply during times of slackening demand. In these circumstances, three main possibilities in the direction of change for the consumption pattern could be expected. Firstly, natural rubber consumption may decline as consumers who are closely linked to the supply process in synthetic rubber production may elect to use more synthetic rubber because of ownership linkages. Secondly, the share of NR may remain constant if demand pattern is based on consideration of technical limits in rubber products. Thirdly, NR consumption share may increase if its inelastic supply has caused prices to fall relative to SR and makes NR to appear cheaper to the consumers. These possible developments in consumption trends will be examined further in the following section.

4.5 Demand for Natural and Synthetic Rubbers

The demand for rubber is a derived demand arising from the use of rubber in tyres, engineering components and other industrial products. In the transportation sector, the rubber component in the final product is only a small fraction of the total value of the manufactured item such as the car. Many past attempts to estimate the demand for rubber made use of the high correlation between rubber consumption and the growth of demand for motor vehicles. Population growth is also an important determinant as well as the level of income.

Rubber consumption can be classified into usage for tyre and non-tyres. The main factors affecting future usages in tyres in turn depend on the development of the transportation sector. These include:

i) vehicle population and new vehicles production

ii) Tyre production

iii) Changes in the tyre replacement market and

iv) Structural and technical changes affecting the tyre industry

It is not sufficient to determine the extent of tyre production in response to growth in car population alone. Changes in the tyre industry are also important. For example, the shift in popularity of radial tyres from cross-ply tyres caused a shift in the relative amount of NR consumption as the tyres use different amount of NR and they have different rates of wear. There is also a trend that tyre size may become smaller as smaller cars are increasingly produced (Basiron, 1978).

A study by the Rubber Task Force (MRRDB, 1983) shows that the world production of cars and tyres tended to have levelled off during the period after the oil crisis in 1973 compared to the much steeper growth rate for the preceding period. Taking these and the effect of changing tyre structure into account, the Rubber Task Force arrived at the following demand projections:-

- 1982 12.0 million tonnes of NR + SR
- 1985 13.6 million tonnes of NR + SR
- 1990 15.5 million tonnes of NR + SR
- 2000 18.0 million tonnes of NR + SR

The forecasts are much lower than those made earlier by Smit (1982) and by other centres such as the World Bank, and the IRSG (see MRRDB, 1983). This indicated the pessimistic outlook that existed for the rubber industry as a whole as the result of the depressions in the first half of the 1980s.

In an attempt to assess the share of NR in the overall consumption of rubber for the future, many methods of estimation have been used. Allen et al (1973) tried the accounting method by estimating the potential loss in market shares due to certain disadvantages such as inferior properties, marketing arrangements etc. Smit (1982) and Grilli et al (1978) used various demand models which were estimated econometrically and conditional forecasts are then produced. It is however not too difficult to extrapolate the trend line in the pattern of rubber consumption in order to arrive at a forecast of NR consumption. These studies tended to show that the share of NR has stabilised over the last decade suggesting that some balance in the consumption pattern has been achieved.

Forecasting the share of NR in the world rubber market is simpler when the inelastic supply structure of NR is taken into consideration. This means that the future production of NR may be related to the growth in its planted area. Since the rubber areas are already established, future production is therefore largely determined by the areas coming into maturity.

Based on these arguments, the NR Task Force of Experts, for example, has concluded that

"while nationalistic and captive market influences in some important consuming countries will continue the use of SR, particularly SBR, the competitive strength of NR and the higher than average proportional consumption of NR in other fast developing Asian countries will at least sustain the overall NR/(SR+NR) ratio at 32 % till the year 2000".

Translated accordingly, the estimation suggests that total NR demand may reach 5.0 to 6.0 million tonnes by the year 2000. When compared with current production of NR of 4.0 million tonnes, it is perhaps a tall order for production to increase by 2 million tonnes by the year 2000. It means bringing into production some 1 million hectares of rubber.

If Malaysia were to maintain its rubber production share, this means bringing into production some 350,000 hectares of rubber plantation. When this is compared with the planned expansion in planted area and the trend in investment, it is clear that such development will not be achieved as investors may continue to invest more in the planting of oil palm.

In trying to match the supply against demand, at every stage right down to the individual country's level, it is clear that NR supply will be short of demand. The question of losing market share by default will prevail again. The alternative which is not well explored is the implication on price levels if the predicted amount of NR supply is made available. Smit (1982) concluded that under such circumstances, price would fall and thus planting of rubber may not be an optimal strategy for the rubber planter as he could have planted his land with another more profitable crop.

It is seen that increasingly, the synthetic rubber industry has been able to match NR prices, and this situation is worsened by the trend that rubber supply viability is undermined by the superior profitability of crops such as the oil palm. Thus the expansion of both synthetic rubber and palm oil production will impinge on the future growth of the rubber plantation sector and details of these aspects are discussed in a later section, after the production structure of the palm oil industry has been examined.

4.6 Palm Oil Production

A measure of the importance of palm oil as a commodity is that its growth rate of about 6.0 % during the last twenty years has been much higher than that for the total world's production of oils and fats (3.4 %). Consequently, palm oil's share of world oils and fats production grew from 5 % in 1975 to 8.3 % in 1980 and to 14 % in 1984 (Table 4.5). Most of the increase came from the rapid expansion in the production of palm oil in Malaysia and Indonesia. The pattern of production for palm oil is shown in Table 4.7. The South East Asian countries including Indonesia and Papua New Guinea produced some 80 % of world's palm oil production while the African and South American countries produced 10 % and 5 % respectively.

The modern method of palm oil production is based on large scale cultivation of the oil palm as a perennial plantation crop. The large scale operation is necessary because of the need to set up the palm oil mill; a typical mill with 30 tonnes of fresh fruit bunches (ffb) per hour capacity costs more than M$ 10 million to build, and anything smaller may be less viable. Given that per hectare of the oil palm yields 20 tonnes of ffb per year and the mill operates for 330 days annually, a simple calculation would show that a mill with a capacity of 30 tonne ffb per hour would need to secure a source of fruits from a neighbouring production area of about 10,000 hectares.

Table 4.5: World Production of Oils and Fats, 1970-1980
('000 tonnes)

Type of Oil/ Year	1970	% share	1975	% share	1980	% share
Soya bean oil	6381	17.17	8025	18.51	13320	24.06
Cotton Oil	2511	6.76	2929	6.76	3043	5.50
Ground nut oil	2730	7.35	2672	6.16	2583	4.67
Sunflower oil	3491	9.39	3900	9.00	5040	9.10
Rapeseed oil	1778	4.78	2392	5.52	3528	6.37
Olive Oil	1388	3.73	1562	3.60	1566	2.83
Coconut oil	2019	5.43	2593	5.98	2768	5.00
Palm kernel oil	393	1.06	474	1.09	637	1.15
Palm oil	1796	4.83	2858	6.59	4619	8.34
Butter, as fat	4793	12.90	5346	12.33	5734	10.36
Lard	3901	10.50	4268	9.85	4981	9.00
Fish Oil	1078	2.90	1059	2.44	1187	2.14
Tallow and Grease	4907	13.20	5270	12.16	6361	11.49
Total	37166	100.00	43348	100.00	55367	100.00

Source: "Oil World" Monograph, see Mielke (1983).

The establishment of the oil palm crop is similar to that of rubber. After the land has been cleared and the field prepared, seedlings which have been grown in polybags for about 12 months, are transplanted from the nursery to the fields usually during the rainy part of the year. The use of the polybags and the correct timing for the transplanting ensure uninterrupted growth and up to two months of immaturity period can be saved (Pike, 1980). The young palms are fertilised about twice a year, and the maintenance of the crop is based on providing good nitrogen-fixing ground cover crop which, besides preventing the growth of weeds, also prevents soil erosion while simultaneously providing nitrogenous nutrients to the soil.

The palm will take three years before yielding harvestable fruits. Harvesting is carried out manually by cutting the stock of the fruit bunch using a chisel or a sickle attached to a long pole, the latter being applied mostly in harvesting tall palms. The normal practice is to organise a harvesting round every ten days throughout the year. Various systems of harvesting teams and infield machanical or manual transportation techniques have been introduced. Plantation labour is always scarce, and proper harvesting management is critical as it is necessary to optimise the use of scarce labour to ensure that harvesting is complete and only fruits of the right ripeness are harvested to obtain maximum oil yield.

The fresh fruit bunches (ffb), each weighing about 15 kilo-grammes, are transported expediently to the mill for oil extraction as the fruits that have been harvested must be processed within a day to prevent a build-up of free fatty acid (ffa) in the oil contained in the flesh of the fruitlets. At the mill, the fruit bunches are sterilised by using high pressure steam. This prevents oil deterioration as the steam inactivates the enzyme "lipase" which catalyses the hydrolysis of the oil thus causing an increase in the free fatty acid content and the deterioration in oil quality.

The steam also softens the fruitlets which are subsequently separated from the bunch stock and then sent to a digester where the fruits are prepared for oil extraction using the screw press. The crude oil from the press is further treated to remove impurities and water and the oil is then sent to storage ready for subsequent shipment as crude palm oil.

Clearly, in managing the plantation and the operation of the mill, the yield of oil becomes an important measure of efficiency. Good agronomic practices in the field, efficient harvesting system and mill operations will improve yield.

The yield of palm oil from the plantation is affected by the number of fresh fruit bunches and the oil content of the ffb. The age of the palm will affect both the yield of the ffb and, to some extent, the oil extraction rate. Typically, the yield profile for oil palm shows that the amount of ffb produced will initially continue to rise until the peak is reached when the palms are about 8 to 10 years old (Table 4.6). After that the yield will decline slightly and stabilise within a range of

20 to 25 tonnes per hectare per year until the palm is considered too tall to be economically harvested when they reach 20 to 25 years old. Oil extraction rates are less affected by age structure of the palm but it depends more on the type of palm. The fruit from the Tenera palm contains about 21 % oil while the Dura has 12 %.

Table 4.6 Mean ffb yield (tonne/hectare) of Dura x Dura, Dura x Tenera and Dura x Pisifera palms on inland loam (L) and coastal clay (C) soil types in West Malaysia

Years from	Dura x Dura		Dura x Tenera		Dura x Pisifera	
Planting	(L)	(C)	(L)	(C)	(L)	(C)
2-3	-	-	1.8	n.a.	6.2	11.0
3-4	2.3	7.5	8.9	11.9	15.0	19.3
4-5	5.8	11.3	16.0	19.4	20.5	22.5
5-6	9.0	14.5	16.7	22.5	23.3	24.5
6-7	11.6	17.5	20.4	25.0	24.5	25.7
7-8	13.8	20.0	n.a.	25.8	25.5	26.5
8-9	15.6	21.3	n.a.	26.1	26.4	27.0
9-10	16.9	22.5	n.a.	26.3	25.5	27.5
10-11	17.8	22.0	n.a.	n.a.	25.0	27.5

Source: Turner and Gillbanks (1974), p. 278.

It is noted that the Tenera is a hybrid between the Dura and the Pisifera (refer to Figure 4.1). The Pisifera is female sterile as the fruit contains little kernel (seed) component and thus it could not be economically propagated. A good quality Deli Dura may have 60-70 % of the fruit as the oil bearing mesocarp and around 25 % shell (kernel). In contrast, the Tenera material now being grown commercially in Malaysia may have 80 % of the fruit as the oil bearing mesocarp and 18 %

shell (kernel).

Despite the complex production processes, the economics of large scale palm oil production probably have the same cost structure as the production of other oilseeds. Large scale production of palm oil may be influenced by changes in labour wage rates, costs of capital equipment, fertilizer and herbicide just as production of groundnut, soyabean or rapeseed are affected by these factors. Thus, in contrast to the situation (see Section 4.4) where natural rubber competes with the synthetics from different cost bases, the cost structures in palm oil production are comparable to those of competing oils and fats. Even the production of tallow, the fat derived for the beef industry is indirectly linked to the agricultural sector. The importance of comparability in production costs is that there is more certainty in future relative positions of the individual oils competing in the world market as the increase in the input costs of fertilizers for example, may be expected to affect the costs of production of the oils similarly.

4.6.1 Production of Palm Oil in Malaysia

The past development of the palm oil industry in Malaysia can be categorised into four phases. The first phase refers to the establishment era between 1876 when oil palm was first introduced into the country and 1917 when the crop was first planted commercially. Between 1917 and 1960 - considered as the second phase in the development - the expansion of the palm oil

Table 4.7: World Palm Oil Situation ('000tonnes)

Country	Production	Imports	Exports	Total Domestic Use
Cameroon				
1979	81	0	6	75
1982	105	0	12	93
1984	90	0	10	80
China				
1979	93	42	0	135
1982	112	19	0	131
1984	110	15	0	125
Colombia				
1979	70	0	0	70
1982	87	0	0	87
1984	110	0	0	111
West Germany				
1979	0	175	14	156
1982	0	142	21	123
1984	0	192	20	172
India				
1979	0	398	4	374
1982	0	435	0	435
1984	0	370	0	370
Indonesia				
1979	641	0	351	297
1982	838	0	240	576
1984	950	0	300	660
Iraq				
1979	0	140	0	141
1982	0	186	0	186
1984	0	160	0	168
Ivory Coast				
1979	124	0	49	75
1982	157	0	62	95
1984	170	0	55	115
Japan				
1979	0	139	0	139
1982	0	148	0	142
1984	0	170	0	170
Malaysia				
1979	2189	0	1901	214
1982	3512	0	2829	428
1984	3800	0	3090	480
Netherland				
1979	0	167	57	107
1982	0	151	56	90
1984	0	190	70	120
Nigeria				
1979	500	13	0	513
1982	525	153	0	678
1984	535	175	0	710

Table 4.7 (continued)

Pakistan				
1979	0	203	0	203
1982	0	220	0	230
1984	0	335	0	355
Singapore				
1979	0	518	492	26
1982	0	541	502	39
1984	0	415	395	20
United Kingdom				
1979	0	229	1	228
1982	0	186	0	186
1984	0	225	0	225
United States				
1979	0	142	1	133
1982	0	113	0	113
1984	0	160	0	178
USSR				
1979	0	105	0	103
1982	0	354	0	354
1984	0	310	0	310
Zaire				
1979	173	0	0	173
1982	175	0	5	170
1984	157	0	4	153
Others				
1979	396	598	82	915
1982	495	816	235	1318
1984	671	1144	156	1541
World				
1979	4267	2869	2935	4077
1982	6006	3689	3962	5474
1984	6483	3861	4100	6063

Sources: Journal of American Oil Chemists Society, Vol. 61, No.5, (May 1984); "Oil World" Monograph, Mielke (1983).

industry was very gradual and slow. Most of the production came from the estates sectors established by well-known plantation companies such as Socfin and Gutherie.

The third phase refers to the period 1960 to 1975 which saw Malaysia expanding its palm oil production rapidly. Output grew from 92,000 tonnes to 1,257,000 tonnes during that period. Most of the production was exported as crude palm oil mainly to Europe, U.S.A. and Japan. The impetus for the rapid development of palm oil output came from the policy of crop diversification and the successful land development schemes of FELDA.

The fourth phase saw the consolidation of palm oil production industry in Malaysia. Local processing of crude palm oil was encouraged through the government 'Agro-based Industrialization' policy, and increasingly, more of the exports of palm oil were in the form of processed products. The diversification in the form of palm oil exports led to the expansion of world market of palm oil. Countries in the Middle East began to increase their imports of processed palm oil from Malaysia. Previously, such products were only available from Europe. Imports of processed palm oil also supplemented the limited processing capacities in countries of the Indian Sub-continent where there have been a shortage of oil refining capacities. This enabled them to increase their oil consumption without having to immediately increase refining capacity.

The policies of crop diversification and agro-based industrialization appear to have stimulated the production of palm oil in Malaysia. Expansion in oil palm cultivation however, was achieved at the expense of rubber production as by 1983 some 100,000 hectares of rubber lands have been replanted with oil palm. The reallocation of perennial crops involves decisions which will affect future production over many years. This demonstrates the complexity in the crop allocation problem. The crops make an enormous contribution to the country's economy and the planning for future crop allocation ought to seek the best crop distribution for oil palm and rubber after taking into account the future prospects of the two crops. As will be emphasised in this chapter, evaluation of the future prospects for the two crops is a difficult and challenging task for the planners.

4.7 Trade in Palm Oil

The pattern of trade in oils and fats is based on the consumption habits which exist in the different countries. Differences in taste preferences for fats are greatly influenced by the type of local oils available traditionally. For example, the colder regions in the temperate countries were used to consuming solid fats such as lard and beef dripping while the tropical countries were consuming coconut, groundnut and palm oil. When supplies for the preferred oils and fats were insufficient substitute oils and fats were imported.

The pattern of oils and fats consumption has been further influenced by a number of recent developments as follows:-

i) Soya Bean Meal Industry.

The expansion of soyabean production was based on the feed meal industry as the meal is required to produce meat and dairy products to meet an ever increasing world demand. The crushing of soyabean for the meal also produces the oil which has to be disposed of into the world market. The main producers of soyabean are the U.S.A., Brazil and China but the latter is a net importer of oils and fats.

In addition to soyabean, there is an increasing production and exports of rapeseed from Canada and the EEC, and sunflowerseed from the U.S.A. and Argentina. Production levels of other oils and fats are either experiencing a slow rate of growth or they have been declining.

ii) The rapid development of soyabean production in the U.S.A. had stimulated innovations and development in the processing of oils and fats particularly soyabean oil. This has brought about progress in the technology of oils and fat processing, market promotion as well as the introduction of many new findings including some controversial issues such as the nutritional aspects of oils and fats consumption. These factors have brought major changes in the pattern of oils and fats consumption.

Technical advancement in fats processing has improved the usability and interchangeability between oils and fats. Hydrogenation processes for instance, have enabled oils to be hardened into fat products while the processes of fractionation, winterization and interesterification can modify the state of the oil or fat product into a more desired consistency.

With competition between oils and fats intensifying, the influence of promotional activities may have an important impact on the pattern of oils and fats consumption. Health awareness has often influenced the buyers, even if the scientific evidences are still surrounded by controversies and tainted by vested interest.

iii) The availability of foreign exchange is also an important determinant of oils and fats consumption pattern especially in the poorer countries. When a country is forced to import some of its oils and fats requirement, it is usually desirable to import the most suitable oil based on price and usability rather than taste preferences, and in this way soyabean and palm oil have been able to gain a growing share of the world market.

The overall trend in the pattern of oils and fats consumption is likely to depend on the fact that oils and fats will continue to be an important component of food and the increase in population and per capita income will increase oils and fats consumption. The health problem associated with fat consumption will arise more from excessive usage rather than the type of fat or oil used. For the less developed countries where per capita consumption is still below the recommended nutritional level, the pattern of oils and fats consumption is likely to be determined by the availability of foreign exchange.

4.7.1 Malaysian Palm Oil Exports

The rapidly expanding production of palm oil in Malaysia throughout the 1970s necessitated an equally rapid rate of expansion in the market outlets for palm oil products. As more than 90 % of palm oil products produced by Malaysia were finally exported, it was necessary to export these in the form most readily accepted by the consumers. One method was to export processed palm oil products. Refineries for processing crude palm oil had to be established, and with encouragement from the government through lower export taxes on the exports of refined palm oil, the number of refineries in Malaysia increased rapidly from 8 in 1975 to 42 in 1983.

With the rapid increase in refining capacity, the majority of palm oil is now exported in the processed form. This has generally increased the usability of palm oil in countries where the processed oil can be consumed directly as a consumer product. Consequently, new market outlets have been developed as the processed oil offers a number of technical and economic advantages.

The increasing supply of cheaper processed palm oil from Malaysia has led on the one hand to greater availability of oils to countries which depend on imported oils and fats, but on the other hand there has been increased competition in countries where Malaysian palm oil could compete with locally produced oils and fats. In the EEC, various forms of protective measures and subsidies have been introduced to enhance the viability of local oilseed production and these measures help to reduce at the same time the competitive advantage of imported palm oil. To some extent Malaysian refiners have competed directly with the EEC refiners in supplying processed palm oil to the lucrative Middle East market. The cost situation is such that it works out to the effect that even in the EEC, refined palm oil products from Malaysia could be competitively priced if there are no discriminative import tariffs on such products and no subsidies on the locally produced oils.

The main effect of protective measures against imported palm oil is that sales of palm oil in the EEC have stagnated, and the higher cost of subsidy to support local production and crushing of oilseeds is finally passed on to the consumers.

4.8 End-Uses of Palm Oil

An understanding of the end-uses of palm oil and other oils and fats is important in providing a clearer indication of the pattern of demand for palm oil and the possibility of substitution among these commodities. Food applications account for about 90 % of total consumption of oils and fats while non-edible uses which account for the remaining 10 % are mainly as fatty acids and oleochemicals, soaps and detergents. About half of the fats used for edible applications is in the form of solid fats and the rest as liquid oils.

The liquid oils are usually used in various frying and salad oil applications while the solid fats are consumed in the form of traditional fat products such as margarines, shortenings, bakery fats, and vegetable ghee known as "vanaspati" which is extensively used in the Indian sub-continent and the Middle East.

Palm oil is semi-solid at room temperature and this is an important property which contributes to its competitive strength. Palm oil can also be separated by a fractionation process to yield a 65:35 split of liquid component- palm olein- and a solid part - palm stearin. Palm olein in turn can be used as liquid frying oil while palm stearin is used in fat products formulation such as in bakery margarines and shortenings.

By establishing refining and fractionation facilities, Malaysia could export the three products to the right destinations where they are most required. Each of the palm oil products is exported in quantities comparable to that of the competitors. The tonnages of palm olein exported are comparable to those of groundnut while exports of palm stearin are as significant as the exports of lard and edible tallow. Viewed in this way, palm oil is seen to be a truly general purpose oil competing in all areas of the oils and fats market and this in turn enhances its competitive position.

There are other interesting technical advantages of palm oil products. For example, in the manufacture of solid fat products, palm oil is already in semi-solid form and very little hardening process needs be carried out. In contrast, to turn liquid oil into fat products such as margarines and shortenings, it is necessary to hydrogenate the oil and this will increase the cost (see Moolayil, 1978).

The demand pattern of palm oil is also affected by two other technical properties. In industrial applications, where customers are aware of the techno-economic performance of the individual oils and fats, the stability of the oil is of paramount importance. Oils that are stable against oxidative deterioration are economical to use as the lower rate of oxidation enables the oil to be used many times in deep frying applications before it becomes rancid and has to be thrown away. More importantly, stable oil will yield food products with stable shelf-life. In applications where the fried food is packed for sales at a later period, such as potato crips and instant noodles, the stability of the oil is very important as these products are usually required to have a shelf-life of up to six months.

As most of oils and fats are used for edible purposes, the nutritional aspects of their consumption are important in influencing the consumption pattern. It should be noted that fats are rich in energy; a gramme of fat contains 9 kilo calories of energy compared to 4.5 and 4.3 kilo calories per gramme for carbohydrate and protein respectively. Nutritionally, fats could play a crucial role in preventing energy malnutrition in the poorer countries where often the problem of food shortage leads to energy rather than protein malnutrition. Oil also contains the essential fatty acids (linoleic and linolenic acids) which are important to the development of the cells of the body. The WHO/FAO recommendations stipulate that at least 3 % of the fatty acids in the total intake of oils and fats must be essential fatty acids. Most oils and fats including palm oil have sufficient essential fatty acids in them to meet the minimum nutritional requirement.

On the other hand in the Western countries, it is the excess consumption of oils and fats that have contributed to an increase in health problem. However, the complexity of untangling causes and effects relating health problems such as heart attack with that of oils and fats consumption has led to various controversies. At the bottom of the scientific investigation, there is no certainty on the effect of fat on heart attack. Many studies ended with very cautious conclusion with "may perhaps" statement to qualify possible effects. In the commercial world, however, where promotional strategies and vested interests rather than health problems are the final objectives, such "may perhaps" statements are made definitive, and this leads to confusion.

Two aspect of fats properties are being debated. The first is the cholesterol content of fats where the consumption of fats with a high cholesterol content is assumed to increase the cholesterol level of the blood directly. Increased levels of cholesterol have been regularly detected in patients suffering heart attacks and the possibility of directly increasing the cholesterol content of the blood through fats consumption is thus to be avoided. In this respect, vegetable oils including palm oil, do not contain cholesterol, and the cholesterol issue is one which causes difficulty to promoters of the animal fats products such as butter, tallow and lard.

The second issue concerns the proportion of saturated fats in the product. Oils and fats are made of 99 % triglycerides, which are compounds of glycerols and fatty acids. The fatty acids have an even number of carbon atoms in their molecular chain ranging mostly from 12 to 22 carbon atoms per molecule. The most common fatty acids occurring in nature are palmitic (16:0), stearic (18:0), oleic (18:1), lenoleic (18:2) and linolenic acid (18:3) where the figures in brackets indicate first the length of the carbon chain and second the number of double bonds or degree of unsaturation in the fatty acids.

The seed oils generally have high unsaturated fatty levels. Palm oil has a balanced composition of 50 % saturated and 50 % unsaturated fatty acids. Coconut oil has 90 % saturated fatty acids. However, when the liquid oil is hydrogenated to form a solid product, the level of saturation is increased and for practical purposes the oil is considered equivalent to one of the moderately saturated products such as palm oil.

Experiments where animals samples are subjected to intense feeding with oils rich in certain types of fatty acids have been a major field of nutritional research, and such experiments have been responsible for delineating the health effects of saturated against unsaturated fatty acids. Saturated fats are said to cause a higher rate of mortality and artherio sclerosis tendency in experimental animals compared to unsaturated fats.

The subject of how fats affect the build up of fatty deposits to cause blocking of arteries (artherio sclerosis) is still a wide open field of scientific study. New theories and evidences are being reported regularly. Honstra and Lussenburg (1975) for example has found that palm oil behaves differently in a more favourable way which runs counter to the expected behaviour based on its saturated fatty acid contents. This only demonstrates the incomplete nature of present knowledge relating fat nutrition to health problems.

The above properties of palm oil are some of its strengths but there are also a number of weaknesses. The liquid fraction of palm oil is not as low melting as some of the competing oils. Palm olein would begin to solidify at 0^0 C while soyabean or rapeseed oils will still remain a clear liquid at that temperature. Commercially, the appearance of the competing oils are important features in enhancing sales and many sales strategies are based on these properties even if the oils with the poorer appearance are better technically. Image and identification are other aspects of marketing in which palm oil has to improve in the future.

4.9 Demand Trend for Oils and Fats

The usual route to estimating demand trend for oils and fats is to relate consumption to per capita income. Agusto and Pollak (1978), for example, used a formula relating per capita income to total fat demand. In a recent forecast of demand for oils and fats, Mielke (1982) estimated that demand for oils and fats would increase at a rate of 3.4 % annually to reach 113 million tonnes by the year 2007; the estimate was based on the projected composite effects of lower prices, lower rates of are being reported regularly. Honstra and Lussenburg (1975) for example has found that palm oil behaves differently in a more favourable way which runs counter to the expected behaviour based on its saturated fatty acid contents. This only demonstrates the incomplete nature of present knowledge relating fat nutrition to health problems.

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Table 4.8 Projected Worlds Share of Palm Oil (%)

	Share in 1978-1982	Share in 2003-2007
Palm oil	8	22
Soyabean oil	22	22
Other oils and fats	70	56

Source: Oil World Monograph, Mielke (1983)

Given that the projected demand for oils and fats in the 2003-2007 period is more than double the 56.2 million tonnes consumed during the 1978-1982 period, it is clear that palm oil represents one of the most promissing oils with a rapidly expanding supply in the world's oils and fats market.

In the past, the projections by the World Bank tended to show that a proportionately higher demand for soyameal would lead to an imbalance in the supply and demand of oils and fats, and this would result in excess supply situations and lower prices for the latter commodities. Unlike rubber, it is not too difficult to project the demand for palm oil. Given the high interchangeability of oils and fats and the close correlation in their prices, there would be less discrimination in the use of one oil over another unlike the situation found in natural and synthetic rubber as described earlier. Thus, the share of an oil such as palm oil will be dictated more by availability. For palm oil, supply is inelastic because of the perennial nature of the crop and thus availability is directly related to planted area.

In turn, investment in oil palm cultivation is based on future price expectations of oils and fats and the price of competing crops such as rubber. Price forecasts are often inaccurate, and investors have to rely on an assessment of the competitive strength of palm oil relative to other oils and fats. As was shown above, palm oil has been relatively competitive in the past and this contributed to its optimistic outlook for the future. This in turn has led to an increase in its cultivation in Malaysia and other countries.

The uncertainty in palm oil demand for the future arises mainly from prediction of excess supply and depressed prices. There is very little that the small producing countries such as Malaysia can do to influence future price pattern. Planners responsible for the future development of the palm oil industry may have to introduce policies to influence the investment pattern. In the past, Malaysian policies relating to palm oil production have been adequate but for the future the policy must be directed at tackling the problem of possible excess supply of palm oil in view of increasing production of other oils and fats in the world market.

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One approach that has been evaluated for some years is to convert palm oil to palm diesel for use as fuel. Preliminary research at PORIM has shown that palm diesel can fully substitute petroleum diesel as fuel and its production can be viable if palm oil costs below M$ 760 per tonne and petroleum diesel cost M$ 650 per tonne. The calculations show that palm oil could be viably converted into diesel and there is ample flexibility for the government to manipulate diesel price structure if it is desired to improve the viability of palm diesel production.

With the potential possibility of converting palm oil to diesel, there is scope for designing a new palm oil policy that could tackle the problem of excess supply. For instance, it may be possible to use low quality palm oil as the feedstock to a nationalised palm diesel industry. The advantages of such schemes are:-

i) to ensure that only high quality palm oil would be exported from Malaysia,

ii) excess supply of palm oil is potentially minimised

iii) foreign exchange is saved as less of diesel has to be imported.

There is possibly a social cost of having to subsidise the diesel project if such a national policy on palm diesel is implemented, especially if diesel price is low. But the benefits are quite valuable to the country overall, and thus a nationalised production unit may be appropriate.

4.10 Conclusions and Policy Implications

This chapter has reviewed the salient features of the rubber and oil palm industries with a view to assessing their relative positions among competing products in their respective markets. It would have been most interesting if the future scenarios for the supply and demand for palm oil and rubber are derived from models for their respective markets but such forecasts fall outside the scope of this study. Instead, past results of various forecasting studies by others have been reviewed and compared and these were found to be sufficient as a basis for evaluating the future trends in the developments of natural rubber and palm oil.

i) Prospects for NR

In the very long term natural rubber has bright prospects as a renewable resource when compared to synthetic rubbers which rely on petroleum as their feedstock. In another 100 years, petroleum may become a scarce commodity, while rubber has only completed its second century of cultivation. Such a duration represents only four planting cycles for the natural rubber industry.

In the short term, however, rubber is under pressure from both the synthetic and the oil palm. On the demand side, synthetic products are competing in every application. The individual properties of synthetic rubbers may be better than that of NR but the latter appears to retain certain technical properties which are not easily or cheaply substituted for by the synthetics. This in turn has helped NR to retard the erosion of its market share.

It is observed that at times of economic depression, the share of NR in world rubber consumption has increased or stabilised. This stability appears to come not from supply but more from demand considerations. If loyalty linkages are important, one would have expected that during period of depressions, imports of NR may decline as the SR producers could saturate the market in view of the large excess capacity present in the consuming countries. Lack of evidence to support this trend shows that the transition in the process of substitution of NR by SR based on technical properties may have been completed and it could be deduced that the present levels of uses of NR for various applications are techno-economically desirable relative to the synthetics.

On the supply side, the prevailing low prices of natural rubber have forced planters either to switch crops or abandon their rubber tapping occupations for better jobs in the cities. In Malaysia, the more efficient estate sector of the plantation industry has tended to increase its planting of oil palm while the less efficient smallholding sector, unable to choose oil palm planting due to lack of resources and know-how, has opted for employment in other areas of the economy. These developments have resulted in the decline in rubber planted areas in the last 15 years with most of the decline contributed by the decreasing rubber areas of the estate sector. The rubber industry thus faces the dual threats of market erosion from the synthetics and erosion in planted area due to an increase in the planting of oil palm.

The plantation industry in Malaysia has attempted to review the situation in 1983 with a view to recommending strategies for the rubber industry. The main recommendation was to consolidate the rubber industry by improving productivity. In the smallholding sector, this means attempting to form viable groupings to achieve an economic size; in other areas such as processing, marketing, and price stability management, the provision of supporting facilities are recommended to promote the competitive position of natural rubber. However, some of the policies are partly ill-founded. Firstly, rubber production is not remunerative enough to justify investment to increase productivity. Secondly, the approach of forming organised grouping of smallholders is not self-consistent; a successfully organised group of smallholders would not likely plant rubber when planting oil of palm is apparently more profitable.

ii) Prospects for Palm Oil

The exports of palm oil especially from Malaysia have expanded at an average rate which exceeds the rate of growth of oils and fats exports in general. This signifies the expansion in the palm oil market and the ability of palm oil to compete effectively. In the short run, palm oil appears to have been a more profitable crop to plant but over the long term demand will be affected firstly by the saturation in consumption in the developed countries, and secondly by the lack of foreign exchange in the developing importing countries.

The potential demand for palm oil however, can be quite large. Because of its competitiveness it could continue to displace other high costs oils from the market. Groundnut oil is perhaps one that can be affected by increasing availability of palm oil and palm olein. A second major outlet that can be developed is to convert palm oil into diesel substitute.

The practicality of palm oil diesel is already proven for example by the Palm Oil Research Institute of Malaysia. The economics of converting palm oil into diesel depends on the cost of palm oil relative to petroleum diesel, and the cost of glycerine which is the by-product. A policy of removing the excess supply of palm oil through conversion to diesel merits a deeper evaluation. It may perhaps provide the safety net against future fall of palm oil prices. Such a scheme may be comparable or even serve as a better example to the rubber price stabilization scheme which so far has displayed a dubious degree of effectiveness.

Finally, the output of palm oil and rubber is relatively small by the standard of the developed countries. Although palm oil export is the country's largest export earning sector, total export revenue is only equivalent to total sales of the Jaguar Company of the U.K. In this respect, Malaysia can ill-afford to have divergent policies within fragmented industries for rubber and oil palm. Such policies could result if the individual sectors are looked at in isolation. Thus, there exists a clear role for quantitative evaluation of sectoral policies in development planning for Malaysia especially for rubber and palm oil to allow land and other resources to be utilised to maximum advantage. The existing National Agricultural Policy is a step in the right direction, but it lacks the details and in-depth analysis needed to make it a suitable basis for joint policies and their effective implementation. The use of a macroeconometric model therefore provides an opportunity to explore quantitatively the relative contributions of the two sectors in question and consequently, the possibility of evaluating joint policies can be investigated.

CHAPTER 5: COMPETITIVENESS AND EXPORT PERFORMANCE OF RUBBER AND PALM OIL

5.1 Introduction

The objective of this chapter is to evaluate the relative competitive positions of palm oil and rubber in their role as major export commodities for Malaysia. The investigation will

i) emphasize the export performances of these commodities within their respective world markets, and
ii) indicate the relative competitiveness of the two commodities within the framework of the Malaysian export sector.

An understanding of the competitive positions of rubber and palm oil will be useful in a later evaluation of policies regarding the most suitable crop to promote within the Malaysian plantation sector.

5.2 Export Performance and Competitiveness

Economists have often noted the net gains from international trade where, through specialization, individual countries should maximise the production and trade on commodities which they could produce from a position of comparative advantage. Comparative rather than absolute advantage is being emphasized. The former refers to comparison for production efficiencies of commodities produced within the country while the latter compares production efficiencies between countries. Lipsey

(1963, p. 424) for example has summarised the proposition as "...The gains from specialization and trade depend on the pattern of comparative advantage and not absolute advantage."

In practice, however, absolute advantage is also of interest as it indicates the production efficiency or competitiveness obtaining in the producing country. A producer which has a greater level of relative absolute advantage or competitiveness in producing a commodity can expect to capture a growing share of the world market for the commodity concerned.

This latter proposition has been employed as the basis for comparative studies of regional production efficiencies in the Shift-Shares type analysis by Brown (1969), Dunn (1960) and others. According to this approach, regional growth can be decomposed into its components which are i) that attributed to national growth, ii) shift from the national growth rate which may be due to structural competitiveness and iii) a residual attributed to the compositional mix of production from the region.

A similar decomposition approach has often been employed to test the relative competitiveness of exports from various countries. Although export performance is expected to be linked to the level of competitiveness of the country producing the particular commodity, it is not easy in practice to obtain measures such as unit cost of production which can be a proxy for competitiveness. Instead, export growth performance is itself used to indicate the relative competitiveness of the exporter through the decomposition technique. This assumes that the export growth trend contains the relevant information reflecting the competitiveness of the product exported by the country in question.

The first study of export performance using the decomposition approach was reported by Tyszinski (1951). The approach was later referred to in the literature as the Constant Market Share (CMS) analysis, and was employed in numerous studies on export competitiveness (Baldwin, 1958; Spiegelglas, 1959; and Richardson, 1971).

In its simplest form, the CMS model assumes that the growth in the export of a commodity can be disaggregated into three components: that due to world growth, a competitive effect and an interaction effect. Thus, if q is the export quantity of a commodity i, s its export share of the market, and Q the world export quantity of the commodity in question, then

$$q = sQ \qquad (5.1)$$

$$dq = s_1Q_1 - s_0Q_0$$

$$= (s_0 + ds)(Q_0 + dQ) - s_0Q_0 \qquad (5.2)$$

Thus, $$dq = s_0dQ + Q_0ds + ds.dQ \qquad (5.3)$$

where dq represents the change in export of commodity i from one period to the next. The term s_0dQ represents the world growth effect, Q_0ds represents the competitive effect, and ds.dQ represents the interactive effect.

Equation (5.3) represents the simplest form of the CMS model. More detailed decomposition is possible depending on the objective of the analysis (see for example, Richardson, 1971, pp. 111-123). The term Q_0ds in Equation (5.3) is normally interpreted as the competitive effect, while the residual term ds.dq only represents the increase or decrease in the share of the export of commodity i resulting from its capturing a larger or smaller share of the growing or shrinking world market. In some applications the interaction term is referred to as the diversification or compositional effect (Kravis, 1970).

The decomposition technique can be adapted for comparing competitiveness between countries, or between commodities. Richardson (1971), for example, adapted the method to study the export growth of manufactured goods for the U.S.A. relative to other major countries of the world. He also showed in a further investigation, (Richardson, 1971a), that the CMS method is sensitive to the basis used in the classification of commodities, and the selection of the base period. Different results and conclusions may be obtained if different base periods are used in the computation of s_0 and Q_0 in equation (5.3) above.

The technique was also criticised by Houston (1967) as being non-causal in that equations such as (5.3) were merely identities and the reasons for increased competitiveness were not evaluated. Despite such criticisms, the technique has survived its testing period in the sixties and seventies, due perhaps to its simplicity in illustrating competitiveness in export trade. Feeney (1982), for example, used the CMS method in studying trade performances for Thailand while more recently, Bowen and Pelzman (1984) used the method for another analysis of US export competitiveness.

It is also noted that the CMS method compares the terminal market shares pertaining to a time period and does not in general make full use of the information usually available in a time series. To overcome these drawbacks, Love (1984) introduced a regression approach, claiming that a time series analysis is more persuasive than the decomposition technique. According to the regression approach, a country's trade performance is determined by three factors:-

i) external market conditions for traditional exports,

ii) the country's ability to compete in world market, and

iii) the extent by which the country succeeds in diversifying the commodity compositions of its exports.

These three components are equivalent to those described for the CMS approach, but to facilitate a regression approach, indices for the three components are constructed for use as explanatory variables in a regression analysis. The indices are constructed as follows:-

i) <u>Market conditions</u>

The value of world trade in a particular commodity is employed as an indicator of external market conditions for that product. For a set of commodities a country usually exports, an index of market condition for year t, M_t, may be constructed as

$$M_t = \sum_{i=1}^{j} w_{it} V_{it}, \qquad (5.4)$$

where, for $i = 1,\ldots,j$, w_t represents the share of the commodity i in the country's earnings from traditional exports. V_i is an index number for the value of world trade in commodity i, with $V_i = 100$ for $t = 1$, and j is the number of the country's traditional exports.

ii) Competitiveness

The effect of competitiveness can be captured in the difference between the actual market shares and the normative market shares. The definition of normative market share is arbitrary. Kravis (1970) used the initial period market share as the normal share while Love (1984) adopted the average country's market shares during the preceding four years. A measure of the country's overall competitiveness can then be defined as

$$C_t = \sum_{i=1}^{j} w_{it}(m_{it}/s_{it}) \qquad (5.5)$$

where m_{it} represents the ith commodity's actual market share, s_{it} represents its market share norm and m_i/s_i is set equal to 100 for $t = 1$.

iii) Diversification

The diversification index may be constructed by using the Gini-Hirshman coefficient (see MacBean and Nguyen (1980) for detailed discussion on this coefficient) which is defined as

$$G_t = \sqrt{\sum_{i=1}^{k} (w_{it})^2} \qquad (5.6)$$

where k is the number of products the country exports, x_i is the share of the commodity i in the total export earnings, and

G_t is set equal to 100 for t = 1.

A regression model can then be specified as

$$X_t = a_0 + a_1 M_t + a_2 C_t + a_3 G_t + e_t, \quad (5.7)$$

where X_t is an index of total export earnings with X_t set to 100 for t = 1, and where e_t is the error term.[1]

The above methods can be adapted to the evaluation of export competitiveness for rubber and palm oil as follows:-

i) The export competitiveness for palm oil within the oil and fat market is evaluated through the use of equation (5.3). By confining the definition of world trade to those of oils and fats only, the total exports of oils and fats become the basis for determining world trade growth, and so the performances of the individual oils and fats, irrespective of their sources, can then be compared. The comparison can be extended to the export performance of individual oils and fats exported from a particular country by regarding the oil from that country as another oil competing in the world market.

ii) A similar analysis can be duplicated for rubber even though the number of different types of rubber is restricted to two, i.e. natural and synthetic rubbers.

iii) Equation (5.7) can be evaluated to examine the competitiveness of palm oil for Malaysia using the regression approach. The evaluations again assume that world trade is confined to that of oils and fats only, and by evaluating equation (5.7) for the U.S.A., Malaysia and Brazil- the world's three major exporters - the competitive position of Malaysia as a producer of palm oil can be compared.

5.3 Results of the Market Share Analysis

Equation (5.3) has been evaluated by comparing the export performance of various oils and fats between 1958 and 1982, and the results are shown in Table 5.1. Two sets of terminal periods are selected. The long term change in relative competitiveness can be evaluated by using the period 1958 and 1982 as the basis. The recent pattern of competitiveness can be examined using the period 1978 to 1982 as the base. In estimating the total exports of the seed oils, the oil equivalent of the exported oilseed has been taken into account using the relevant conversion factor (see Table 5.4).

While the use of the CMS model does not indicate the causal relationship which determines the competitiveness of an oil, it nevertheless provides a statistical representation to show the main components contributing to past growth of an oil.

It is seen in Table 5.1 that palm oil has been very competitive in recent years (1978-1982), and the achievement is attributed to the rapid growth of palm oil production in Malaysia. Similarly, the rapid increase in soyabean production and exports from Brazil is reflected in the moderately high coefficient of the corresponding competitive term as shown in Table 5.1.

Table 5.1 also shows that U.S. soyabean oil and Canadian rapeseed oil were highly competitive for the 1958-82 period but they appeared to have suffered some setback for the more recent period 1978-82 with indications of some loss of market shares. In contrast tallow, which is exported mostly by the U.S.A., shows negative competitive effect which implies that exports of tallow were not expanding in line with world expansion in the oils and fats market. In practice, this means that tallow is being replaced by other more competitive oils in the world market.

Table 5.1: Export Competitiveness of Selected Oils and Fats

	Percentage increase in export due to:					
	World Market effect		Competitive effect		Interactive effect	
Commodity	58-82	78-82	58-82	78-82	58-82	78-82
Palm oil	45.9	37.1	14.7	50.2	39.4	12.7
Soyabean oil	42.4	96.9	15.7	2.5	41.9	0.6
Rapeseed oil	23.9	48.1	20.7	41.5	55.4	10.5
Tallow	127.0	270.9	-7.4	-136.4	-19.7	-34.4
Malaysian palm oil	7.6	26.7	25.2	58.5	67.3	14.8
U.S soyabean oil	45.8	134.4	23.4	-27.5	39.4	-6.9
Brazilian soya bean oil	1.6	43.9	26.8	44.8	71.6	11.3
Canadian rape-seed oil	21.8	159.4	21.3	-47.4	56.9	-12.0

Source: Mielke (1983)," The Past 25 Years and the Prospects for the Next 25", Oil World, ISTA, Hamburg, for export data on oil and fat exports.

The corresponding results for rubber are shown in Table 5.2. It is well known that natural rubber has suffered significant loss of market shares in the last three decades and thus negative competitive effects are to be expected for natural rubber as shown in Table 5.2. Erosion of the natural rubber market has been attributed to the increasing production and exports of synthetic rubber which is offered at competitive prices to the world market (see Allen et al, 1973 for a detailed evaluation). It is important to note that the comparison of export performance for synthetic rubber against that of natural rubber conceals the fact that the former is mostly consumed in the country where it is produced. In recent years, the synthetic rubber producing industry has been facing overcapacity problems as most major consumers would normally strive to have their own synthetic rubber plants to reduce their dependence on imported supplies.

Table 5.2 Competitiveness of Natural Rubber from Malaysia Relative to World Rubber Exports

	Percentage increase in export due to:					
	World Market effect		Competitive effect		Interactive effect	
Commodity	58-82	78-82	58-82	78-82	58-82	78-82
World Natural rubber(NR)	415.8	72.0	-194.4	29.7	-122.4	-1.7
Malaysian NR	153.0	60.0	-27.6	46.3	-25.5	-6.2
World Synthetic Rubber(SR)	36.0	0.0	11.2	100.0	52.8	0.0

Source: IRSG, Rubber Statistical Bulletin, various issues

The slight improvement in the competitiveness of exports of natural rubber, especially those from Malaysia, is noticeable for the more recent years as illustrated in Table 5.2. Again, the interpretation of the above results are subject to the provision of variations due to a different choice of the base period. In analysing the export statistics, it is noted that the export trend for synthetic rubber has reached a plateau (not shown) indicating that the rubber market appears to have reached saturation, and in the process natural rubber has enhanced slightly its competitiveness in recent years.

The results of the CMS method can be compared with those of the regression approach. The latter is obtained from evaluation of equation (5.7) on the basis that world trade is restricted to the world's oils and fats market only. Hence, the position of Malaysia as a competitor can be evaluated and compared with that of other major exporters of oils and fats such as the U.S.A. and Brazil.

The regression results based on equation (5.7) are shown in Table 5.3, where two sets of estimates corresponding to the two base periods are presented. The possible effect of multicollinearity on the estimated coefficients may be corrected by using the 'Ridge' estimator.

A 'Ridge' estimator of the coefficient in a linear model $y = Xb + e$ has the form $b = (X'X + gI)^{-1} X'y$ where g is a scalar computed in various ways (see Hall, 1983) and I is an identity matrix with dimensions equalling the number of independent regressors. The effect of adding a positive constant to all the diagonal elements of X'X will be to reduce the tendency for X'X to be singular or nearly singular. The results (not reported) of the estimation to correct for multicollinearity on Equation 5.7 also indicate a negative coefficient for the competitive term for palm oil thus suggesting that the negative coefficient for palm oil in the previous regression was not due to multicollinearity.

In the computation of the respective indices, the initial year of the period concerned has been used as the base year against which market shares are compared.

Table 5.3: Determinants of Export Performance for Oils and Fats for Major Exporting Countries

Country	a_0	M	C	G	R^2	DW
Estimation period 1958-1982						
U.S.A.	-339.6898	0.0898	2.3000	1.4478	0.9803	1.7464
	(-5.957)	(4.211)	(7.678)	(2.703)		
Malaysia	2418.8330	7.5871	-7.6638	-23.633	0.9917	1.9648
	(1.971)	(18.783)	(-3.404)	(-2.117)		
Estimation period 1970-1982						
U.S.A.	-31.8941	0.6937	0.8442	-0.2288	0.9812	1.8147
	(0.341)	(6.611)	(1.190)	(-0.200)		
Malaysia	920.8759	2.5302	-2.0051	-8.7915	0.9817	1.8147
	(1.514)	(9.769)	(-1.979)	(-1.580)		
Brazil	-1298.212	7.4604	-17.8002	22.3900	0.7671	1.7701
	(-1.246)	(2.931)	(1.208)	(3.004)		

Source: As in Table 5.1

Note: Figures in brackets are t statistics

The results in Table 5.3 show that the growth of world market size has been the most important cause of growth in exports of oils and fats from Malaysia and Brazil. The coefficient of the competitive component is negative and appears to contradict the results from the decomposition technique. However, the basis of the comparison is slightly different. The regression approach compares export of oils and fats between the major exporting countries, while the CMS method compares the export performances between various oils and fats irrespective of the countries.

The negative coefficient for the competitive term (Table 5.3) reflects the slow growth in the share of palm oil in the world markets, despite its rapid growth in Malaysia. In particular, the coefficient of greater than 1 for the market share component suggests that Malaysian palm oil production has expanded at a higher rate when there exists an expansion of the world market share of oils and fats. It also implies that the world share of palm oil has not grown as rapidly as that of Malaysian palm oil suggesting that exports from other traditional producers have declined. This is consistent with the export trend in practice where for example, Nigeria which was once the world's largest exporter of palm oil has become a net importer of that commodity in recent years.

A similar interpretation can be made for soyabean exports from Brazil where despite the rapid growth in its production and exports, the overall impact on world market share from the Brazilian production is still small.

In contrast, the positive coefficients for the competitive and diversification components of equation (5.7) for the U.S.A. as shown in Table 5.3 indicate the advantageous effects of the steady expansion in the production of soyabean and sunflowerseed oils in the U.S.A. in the last two decades. In the process, the U.S.A. has become the world's largest exporter of sunflowerseed oil in addition to the substantial increase in its production of soyabean oil for which the country remains the world's leading exporter.

Unlike the decomposition method, the regression approach would not be suitable for use in evaluating very short term changes in competitive position for the year 1978-1982. The short length of the series may restrict the degree of freedom in the regression estimate, resulting in less reliable estimates of the coefficients of the model.

The negative sign for the competitive term for Malaysian palm oil in Table 5.3 contradicts both a priori expectation as well as the positive sign of the competitiveness effect from the decomposition approach reported in Table 5.1 though comparing the coefficients from the regression approach with the decomposition approach(CMS) is not strictly valid because of the different conditions and basis used. However, the results in Table 5.3 show that the coefficients for the competitive term for Malaysian palm oil becomes less negative as the estimation period is shortened towards the 1982 terminal period. Thus, the apparent contradiction tends to diminish for analysis carried out for the sample period of more recent years (1970-1982). This suggests that the competitiveness of palm oil has improved in the latter part of the period under review. One explanation is that the increasing contributions of palm oil exports from Malaysia relative to world palm oil exports in recent years had begun to have an impact on the world total exports of oils and fats.

Finally, the decomposition approach could be applied to analyse the competitiveness of commodities exported from Malaysia. This is not carried out in the present analysis as it is clear that given the rapid expansion of palm oil and the lower rate of growth in rubber exports over the last twenty years, computation of the CMS model will no doubt show a positive competitive term for palm oil and negative for rubber.

5.4 Production Costs and Technical Advantages

There are many attributes which make a product more competitive. In practice relative price is usually the first indicator of competitiveness but factors such as quality improvement, improved financing arrangements and changes in discriminatory non-price trade policy will also influence the competitiveness of a product (Richardson, 1971). Other things being equal, a product may have the edge over its competitors if its price appears attractive to the consumer but the price must not be too low to affect production viability in the long run.

In the world of oils and fats, prices are highly correlated due to the high degree of substitutability among these commodities in their end uses (see Agusto and Pollak, 1978, p. vi-78). Consequently, relative prices appear to have only a minor role in reflecting competitiveness of an oil. The prices of oils and fats reflect not the production costs in the various countries but the movements of world prices of oils and fats in general resulting from the aggregated balance or imbalance of world supply and demand. Producers of oils and fats, unlike those of manufactured goods, appear to have very little influence on the market price for their commodities.

The importance of supply viability of an oil cannot be over emphasised. Producers must be rewarded with adequate margins of profit for continued output to prevail in the long run. The highly correlated prices imply that the different oils and fats are marketed at approximately similar price levels. Since the gross production margin is price less production and transportation costs, lowering the levels of the latter two is critical in enhancing the gross margins and in improving the overall competitiveness of an oil exported from the individual countries. An oil with a lower cost of production, transportation and processing is likely to be more viable to produce in the long run and is expected to gain a growing share of the world market.

The cost components will be examined in more details under the following headings:-

i) the relative cost of production

ii) the locational pattern of supply and logistics relating to the consuming country

iii) technical properties which lead to desirable attributes and savings in the application, processing and manufacturing of the oil or fat.

5.4.1 Cost of Production Comparison

The cost of production of a vegetable oil is influenced directly by the yield of the crop. In this respect, palm oil is in an advantageous position because of its high yield of about 5 tonnes of oil per hectare compared to 0.5 to 1.0 tonne per hectare for soyabean and rapeseed oils. The cost of production of palm oil is about US$ 240 per tonne (Table 5.4) while its prices in the past have been above US$ 400 per tonne showing the presence of adequate margins to make it viable to produce palm oil. Since the price of palm oil is determined in relation to prices of other oils and fats, the industry will become more competitive if the production cost for palm oil can be reduced in relation to production costs of competing oils and fats.

Comparing the costs of production of different oils and fats is often subjective because of the variety of ways that costs of production are estimated in practice. The validity of such comparisons is often questionable not only due to the different assumptions used in the computation of the production cost but also in the way that certain endowments existing in the different countries are quantified and compared. Nevertheless, as shown in Table 5.4, some scanty data on costs of production of oilseeds and oils and fats are available, and these can give us a rough pattern of production costs for the different oils.

It is noted however that the cost of production of soyabean oil cannot be computed directly. Soyabean oil is a joint-product of the soyabean meal industry. For a given production cost of the oilseed, it is only possible to arbitrarily apportion the cost of the oil and meal components separately by applying the relevant range of cost apportionment based, for example, on the value of the component products. In this way the range for the cost of production can be indicated.

Given that the production cost per bushel of U.S. soyabean for 1980 was US$ 5.02 or equivalently (5.02 x 36.74 =) US$ 184.45 per tonne (Table 5.4) and that the oil content of soyabean was 17.5 % (see Table 5.5), the cost to produce a tonne of oil, i.e. about 5.7 tonnes of soyabean is given by the simple formula:

$$\text{Production cost of oil} = 5.02 \times 36.74 \times 5.7 \times cc \times vf$$

where vf is the value of oil component in the total value of the soyabean, and cc is the crushing cost factor, assumed to be 1.1. If the soyameal has no market value, vf equals 1.0 and the total cost of the soyabean needed to produce a tonne of oil (vf x 5.7 x US$ 184.45) will have to be borne fully by the oil component.

In the past, the value of the oil component varies between 25 % to 45 % of the total value of the two products. Thus the cost of the oil for 1980 can be estimated as falling within the range of 0.25 to 0.45 of 5.7* US$ 184.45 ie from US$ 263 to US$ 473 per tonne oil basis. Finally these figures must be multiplied by a factor of at least 1.1 to include the cost of crushing of the bean and refining of the oil.

Table 5.4 shows similarly that the production cost of a bushel of Canadian rapeseed in 1980 is US$ 3.04 and given that the oil content of rapeseed oil is 38.5 %, the amount of rapeseed needed to produce a tonne of oil is 2.59 tonnes. The rapeseed meal is priced much lower than soyabean meal owing to the lower protein content (34 % cf 46 % for soyabean meal, see Table 5.5). The proportion of oil value of the rapeseed is thus much higher and in the past the range has been from 55 to 75 % of the total value of the component products. Thus, the cost of production of rapeseed oil can be estimated to lie between US$ 196 to US$ 268 per tonne oil basis, excluding the allowance for crushing and refining costs which would at least increase the cost by a further 10 %.

A comparison of the cost of production figures mentioned in the preceding paragraphs shows that palm oil is fairly competitive. In addition, the production of palm oil also yields a co-product - the palm kernel - which in turn can be crushed to produce palm kernel oil and palm kernel meal. The palm kernel is usually regarded as a by-product in plantation accounting and would normally be omitted from the estimation of the cost

Table 5.4 Cost of Production of Palm oil and Selected Oilseeds and Market Prices of the Component Oils and Meals

	1978	1979	1980	1981	1982
A. Cost of production					
Soyabean, US$/bushel	3.39	3.60	5.02	4.79	n.a.
Soyabean oil, US$/tonne[a]	294	302	380	329	n.a.
Rapeseed, US$/bushel	2.46	3.04	3.76	4.63	5.42
Rapeseed oil US$/tonne[a]	172	211	243	282	232
Palm oil, US$/tonne	n.a.	n.a.	239	265	266
B. World Prices of components Products					
Soyabean oil, US$/tonne Dutch, fob ex-mill	607	662	598	507	447
Soyabean meal, US$/tonne US cif Rott	213	243	259	253	218
Rapeseed oil, US$/tonne, Dutch fob ex-mill	597	636	571	483	417
Rapeseed meal, US$/tonne,fob ex-mill Hmb	169	187	204	200	179
Palm oil, US$/tonne, cif NW Eur	600	654	583	571	444
Palm kernel oil, cif, NW Eur US$/tonne	703	968	669	588	458
Palm kernel meal, US$/tonne, cif HMb	n.a.	194	197	175	165

Sources:- For soyabean: USDA Report (1981)," Cost of producing selected crops in the U.S.A., 1978, 1979, 1980, and projections for 1981" ; For rapeseed: COMCON (1982) Vol. 4(1), p. 4; and Anon (1973) "Prairie rapeseed production cost", Agriculture Canada, Rapeseed management no. 149.10; For palm oil: Malaysian Oil Palm Growers Council (MOPGC), Cost of production surveys, 1981, 1982; For prices: Mielke (1983), Oil World, op cit. pp.83-84. Note: [a] The cost of production of the oil is computed by apportioning values and the extraction rates of the oil and meal components.

of production for palm oil. Nevertheless, the yield of palm kernel is about 10 to 13 % the weight of palm oil or about 7-10 % by value basis. This no doubt will add to the profitability and competitiveness of palm oil production, provided it can always be sold.

More importantly, the long term advantage in palm oil production lies in the saving in land utilization due to the high relative yield of exportable products per hectare. Comparative yield figures are shown in Table 5.5. It can be seen that the output of palm kernel oil and meal alone, each at the rate of 0.5 tonne per hectare may already equal the yield of oil and meal from some of the oilseeds, and these are in addition to the 5 tonnes of palm oil per hectare produced as the main product.

The high yield per hectare has two major implications. When amortization cost for land is included in the cost of production estimation, the larger land area needed to produce a tonne of the seed oils will tend to raise the unit cost of production of these oils. Secondly when land is scarce, production of the high yielding palm oil may reduce the shortages on land which could alternatively be used for grain production.

The significance of the first implication is that in a country such as Brazil where many million hectares of land are available for growing either oil palm or soyabean, less investment may be incurred if oil palm is grown instead of

Table 5.5 Comparison of Extraction Rates for Oils, Cakes and Protein, and Yields of Oils for Selected Oilseeds

	Crude oil %	Oil cake %	Raw Protein %	Oil Yield (Tonnes/Ha)
Soyabeans	17.5	80.5	46.0	0.5- 0.8
Cottonseed	17.5	46.0	41.0	na
Groundnut	44.5	55.0	52.0	0.6- 1.0
Sunflowerseed	44.0	55.0	40.0	n.a.
Rapeseed	38.5	59.0	34.0	0.8- 1.1
Copra(coconut)	63.5	36.0	22.0	1.1- 1.6
Palm Kernels	46.5	52.5	23.0	0.3- 0.5
Palm oil	na	na	na	3.0- 5.0

Note: Palm oil is not a seed oil but a fruit oil obtained from the flesh (mesocarp) of the oil palm fruit and the mesocarp contains 65 % palm oil cf 46.5 % palm kernel oil in the kernel.
Sources: World Bank, Economic Analysis and Projection Department, for extraction rates; Ng Swee Kee (1972) for oil yields.

soyabean. The significance of the second implication is that countries which are short of arable areas for grain production may have to rely on cheaper imported palm oil for their oil supply and utilise instead their available land for growing other more essential food crops.

5.4.2 Pattern of Distribution of Supply and Consumption

Oil is a universal consumer item for which world consumption varies from 5 kg per capita for the populous and less wealthy nations such as China and India, to 30kg per capita for the U.S.A. and Europe. Most countries are engaged in the production of some type of oil or fat. However, for many countries, not all of their fats requirements can be fully met by local production and for them, shortages are met by imports. As mentioned earlier in Chapter 4, about 33 % of world production of oils and fats enters world trade. This implies the existence of oils' and fats' exporting countries where excess oils and fats are being produced.

The most striking feature of the oils and fats industry is that only a few countries are major net exporters. They are the U.S.A., Canada and Brazil in the West and the Philippines and Malaysia in the East. The Philippines is the world's largest exporter of coconut oil and since this oil is technically different from the more general purpose oils, the Philippines is regarded as a source of a special purpose oil. In this respect, Malaysia can be regarded as the sole major supplier of general purpose oils and fats in the east. Indonesia has become an exporter of palm oil only in recent years, as a result of increased output from that country, but its export share of palm oil is still small.

In terms of proximity pattern between the supplier and the consumers, Malaysia is the only major source of oil which is close to the consuming regions in Asia and the Middle East. Malaysian palm oil for example, can be shipped to India in 6 days compared to 6 weeks for soyabean oil shipment from Brazil or the U.S.A. Shorter transportation distance and time may imply lower transportation costs and lower level of stocks needed to be kept in the importing country, and these will make

Malaysian palm oil somewhat more competitive.

There are technical aspects of transportation and handling which are important in reducing the transportation and handling cost of Malaysian palm oil. The handling and shipping costs can be prohibitive to the viability of oils and fats exports. Shipment by drums and lorry tankers can be particularly costly. However, with the development and upgrading of the major Malaysian ports and shipping facilities, it has become cheaper to transport palm oil in bulk to the western coast of the U.S.A. from Malaysia at US$ 45 per tonne compared to shipment of soyabean oil by lorry tankers from the producing areas in the mid west of the U.S.A. to the west coast of the country at US$ 80 per tonne. Thus, in terms of close proximity to the major importing countries and efficiency in transportation in bulk, palm oil from Malaysia appears to have a competitive edge over its competitors.

5.4.3 Technical Advantages

An oil with the right technical properties for certain applications may contribute to savings in processing and manufacturing costs of the end-products. For example, certain oils such as palm oil have better heat and oxidative stability so that the frying life of the oil and the shelf-life of the resultant food products are longer when compared with the situation for less stable oils. These attributes can contribute to an overall saving from minimal usage of oil and in upgrading of end-product quality. In this way, superior quality can lead to an increase in the competitiveness of an oil.

The establishment of the palm oil refining industry in Malaysia was aimed at achieving such improvements in quality and competitiveness of palm oil products. As argued by Bek-Nielson (1984), the establishment of the refining industry in Malaysia had enabled palm oil products to be marketed all over the world to an extent that more than 95% of all crude oil produced had been further processed in Malaysia before being exported.

One could compare the savings from advantageous technical attributes for the different oils and fats, but such comparisons are usually clouded by possibilities of local differences in estimating the levels of saving between the oils to be compared. As an alternative the overall economic suitability of an oil may be compared if an empirical index reflecting the technical and economic advantages ('TES index') can be computed. Usually, in any country, the consumer will use more quantities of an oil if its relative price is low and its technical properties are more desirable. In the 'TES' index defined below, these properties are reflected through the use of the relevant market shares, consumption shares and relative prices.

$$\text{TES Index} = \frac{\begin{array}{c}\text{market share of oil j} \\ \text{used in product i}\end{array} \times \begin{array}{c}\text{\% of j out of total} \\ \text{available used in product i}\end{array}}{\begin{array}{c}\text{ratio of local price of oil j} \\ \text{to average price of local oils}\end{array}}$$

The first term of the numerator indicates the importance of the particular oil in a certain product, e.g. margarine or shortenings, in the country. The second term indicates the suitability of the particular oil for use in the product concerned as opposed to its use in other fats products for the given country. If a higher percentage of the particular oil available in the country is used in product i, then the oil is assumed to be more suited for use in that particular product.

The values of the TES index are shown in Table 5.6 for Japan which is selected as an illustration because of readily available data and the country's position as a major oils and fats importing country. Table 5.6 shows that fish oil has the highest level of suitability index. This is explained by the fact that fish oil is a locally produced oil which is cheap and easily available in Japan. It is also seen that, palm oil has the next highest TES index eventhough it is an imported oil. The relatively high TES indices for palm oil in shortenings and margarine products shown in Table 5.6 illustrate the suitability of the palm oil in such products.

The suitability of palm oil in certain applications as indicated in the case of Japan may explain for the continual imports of palm oil into the U.S.A. despite the excess production of oils and fats in that country.

It is generally possible to enhance the cost competitiveness of an oil in various ways. A common approach is through the role of promotion and backup services in export promotion. A second approach is to present the product as close as possible to the form desired by the importers. Promotional strategies are very important in marketing industrial products but a detailed investigation in that area is beyond the scope of the present study.

Table 5.6 Technical and Economic Suitability Index for Selected Oils and Fats in Japan, 1979.

	Margarine	Shortenings
Fish oil	12.03	6.21
Soyabean oil	1.47	0.02
Palm oil	2.79	4.88
Rapeseed oil	0.03	0.58
Tallow	0.32	0.36
Coconut oil	0.02	1.07
Cottonseed oil	0.64	0.19
Palm kernel oil	Neg	1.79
Sunflowerseed oil	0.14	Neg
Rice bran oil	0.02	0.25
Whale oil	0.01	Neg
Lard	0.17	0.41

Sources of Data: The Japanese Oils and Fats Importers and Exporters Association, Oilseeds, Oils and Fats Statistics (1982)

The role of technical presentation of the product can be well illustrated by the experience of the recent development in the Malaysian palm oil industry. This refers to the scheme where processing of the oil is carried out locally to produce a range of products which are tailored to meet the requirements of the importer. The offer of both crude and processed palm oil to the world market has led to the growth in the exports of processed palm oil products as described previously in Chapter 4.

The success in the export trade for processed palm oil can be traced to two main advantages. Firstly, countries without adequate processing capacity can import the processed oil and even if reprocessing to refine the processed oil is necessary, the processing will be minimal, and importers will benefit from increased throughput rate and thus production capacity at their processing factories can be expanded. This aspect is useful in countries such as those in the Indian Sub-continent where oil processing capacities are limited.

Secondly, there are substantial savings to be gained from using preprocessed oils. These savings are based on lower losses from refining and processing, and from savings in lower chemical and energy costs during refining. Calculations from trade figures show that savings up to US$ 50 can be obtained when palm oil is used instead of soyabean oil in solid fat products (Table 5.7). In an industrial setting, oils and fats processors would have calculated in advance the various benefits and savings which can be derived from using the particular oil or fat in certain applications. These savings are relatively fixed in the short term and they are usually specific to the factory location, processing facilities and the type of product being manufactured. The relative margins for different oils are then considered together with the prevailing pattern of oils and fats prices in making purchasing decisions for the procurement of oils and fats. This makes it appear that the prices of oils and fats are an important determinant especially in the short run in the decision to select an oil or fat eventhough, as emphasised at the start of this discussion, the comparison of prices alone would be insufficient justification for preferring one oil over another in the long run.

Table 5.7 Comparative Cost Savings from Processing Losses of Selected Oils and Fats in 1980 (US$)

Items	Sunflowerseed oil	Soyabean oil	Palm oil
Process losses	16.63	17.88	4.86
Cost of chemicals	20.87	20.87	3.79
Cost of hydrogenation	44.72	43.88	Neg
Sub-total	82.22	82.63	8.65
Price differential relative to palm oil	+ 17	-47.00	-
Total costs	99.22	35.63	8.65
Net Premiums to palm oil	90.57	26.98	-

Sources: Prices are from Oil World and Porla publications, Costs of process losses and chemical are from trade sources (Basiron and Iftikhar, 1981) and costs of hydrogenation are calculated from estimated amount of hydrogen needed to raise the 'Iodine Value' index of the oil to 42 to effect a higher level of solid content appropriate for fats products (see Moolayil, 1977).

5.5 Competitive Aspects of Natural Rubber

One can now turn to examine similarly the competitive position of natural rubber against its synthetic counterpart. The erosion of market shares for natural rubber is well known and its relatively poor competitive position has been clearly demonstrated in the CMS analysis in Table 5.2. The declining market shares for NR has been the subject of major concern to producing countries ever since synthetic rubber became widely used after the Second World War.

The TES index for natural rubber could be computed but this was not carried out for two reasons:- i) when only two commodities are involved, the TES index formula reduces to an expression of relative share divided by relative prices. The relative share trend is already shown in Chapter 4 to favour synthetic rubber. ii) The relative price for synthetic rubber is practically unknown as consumers usually obtain discounts from the nominally quoted prices especially when purchasing from their sister companies. Assuming, the relative price for synthetic rubber is highly correlated to the relative price of NR, the TES index is thus reduced to comparison of market shares, which have been indicated earlier in Chapter 4.

In many applications, natural rubber can now be completely replaced by the synthetic equivalent. This suggests that the demand for natural rubber has become less dependent on its technical merits but more on its prices relative to the synthetic rubbers. One would also expect that the process of substitution which had been occurring for the past three decades would have resulted in a long term equilibrium market share to be approached. Over the last few decades, producers of synthetic rubber would have increased their capacity until the need to use imported natural rubber has been minimised. The question is for how long will the transition process continue to take place before an equilibrium position is reached. The share for NR will no doubt continue to depend on the relative prices of the two rubbers as well as on the demand due to the remaining non-replaceable uses for natural rubber in certain products.

It may be noted that during the transition process, the consumption of natural rubber need not decline provided world demand continues to expand. Duckworth (1982) for example, has shown that the demand for traditional commodities may continue to expand even though newer competing synthetic materials are introduced to replace the natural products. He argued that such expansion is possible because of the increase size of the 'cake' as world consumption grows. The market share of the natural product could also be improved through the contributions of research and development efforts.

Allen et al (1973) have attempted to study in detail the potential demand of natural rubber by taking into account the end-use performance and processability of NR relative to SR. Based on these two criteria, they determined that the potential share of natural rubber in 1973 was 60 %. By allowing further for the effect of price factors and end-use pattern in various regions of the world, it was shown that natural rubber could have a normative share of 43 %. Actual share for NR was then 36 %. The authors further noted that rubber products manufacturers will try to use maximum amount of synthetic rubber for the following reasons:-

i) they have a captive supply of SR which they will always use in preference to NR if they possibly can.

ii) they are able to buy SR at extremely attractive prices

iii) they dislike NR's unstable prices and marketing arrangements

iv) a combination of i) to iii).

In the derivation of the norm, Allen et al assumed that the tendencies for reducing imports of NR based on i) to iii) above would be minimised or removed altogether. In practice, it is unlikely for these manufacturers, which have investments in SR production to relax their tendency to pursue items i) to iii) above, and so the normative shares as elaborately studied by Allen et al, can be regarded as nothing more than an idealised target for the NR producers.

More recently, Smit (1982) studied the future potential of NR up to the year 2000 and found that there would be a shortage of NR if its current market shares were to be maintained. This conclusion was obtained from the matching of supply and demand projections for natural rubber. Such an approach has the inherent weakness that the projections may not fully account for the fact that producers of NR may choose to plant other alternative crops if NR prices continue to remain less remunerative.

What is possibly a more interesting development is the fact that a few decades have passed during which the substitution of NR by SR has taken place. The longer the time the closer is the possibility of the equilibrium balance in market shares for the two types of rubbers being achieved, assuming stable end-products and that the technical changes and innovations which allow for the substitution of the rubbers have been exhaustively exploited . One could think of the process of substitution as the transition phase which usually accompanies the invention of a new material or technology. Assuming that the SR has reached the maturity phase of its life cycle, the process of substitution should be nearing its completion.

Thus the present share of NR could be regarded as being close to the minimum share level based more on technical requirements rather that relative price consideration.

5.6 Conclusions

The results of the investigation on the competitiveness of palm oil and rubber can now be summarised.

i) the constant market share analysis shows that Malaysian palm oil has a moderately high competitive coefficient, indicating that competitiveness has been a significant factor in contributing to past growth of palm oil in Malaysia, especially in recent years.

ii) A similar analysis for rubber revealed that the coefficient of the competitive term is negative suggesting that natural rubber has in general been much less competitive than the synthetic counterpart.

iii) The regression models of export performances of the various major oil have been evaluated. It was shown that the competitiveness of palm oil has been enhanced through the rapid development of palm oil industry in Malaysia. Without the Malaysian contribution, the export performance of palm oil would be adversely affected due to the declining production from the traditional producers such as Nigeria.

iv) It is interesting to note that palm oil competes with products which are also produced through the agriculture system. Under these circumstances, the higher competitive strength of palm oil will likely continue to prevail since any major changes in costs of production of vegetable oils due to an increase in the cost of inputs such as fertilizers, will likely affect all oils in a similar way. Natural rubber on the other hand is competing with a product which is produced from petroleum feedstock. Production cost structures are thus different. If petroleum feedstock becomes cheaper, the cost of production of synthetic rubber may decline while that of NR may be affected differently.

v) It is also noted that the share of NR must be close to its minimum as the process of substitution could be close to being complete after several decades of SR existence.

vi) Finally, the analysis has shown that palm oil has a greater competitive strength and this position is likely to be maintained in the future. Rubber has a moderately optimistic outlook on account of the fact that the process of substitution by SR may have been close to being completed, but NR's future competitive position is more uncertain due to i) the different cost of production structures between NR and SR and ii) the lower profitability of NR as a crop relative to other plantation crops such as the oil palm.

Notes to the Chapter

[1] The regression approach as represented by Equation 5.7 was first suggested by Love (1980). It is used in this study to provide an alternative approach for comparison with the more established CMS analysis represented by Equation 5.3. The regression approach has a major weakness in that the estimated coefficients of Equation 5.7 will be affected by multicollinearity problems if the value of w_{it} in that equation is close to 1.0. The relatively poor results of the regression approach when applied to the export performance for oils and fats (see results in Table 5.3) is due to the low number of different oils and fats exported by Malaysia as well as by Brazil so that for these countries w_{it} is close to 1.0. The difficulty in interpreting the estimated coefficients especially when the signs are different to the a priori expectations is discussed in Section 5.3.

CHAPTER 6 THE MACROECONOMETRIC MODEL

6.1 Introduction

The aim of this chapter is to formulate a multisectoral macro-model of the Malaysian economy and examine the structural relationships and estimation procedures for the equations constituting the model. After the stochastic equations have been estimated and definitional identities added to form a closed model, the equations are simulated to test a) their ability to track past trends of the key economic variables and b) their ability to emulate the dynamic relationships of the multisectoral economy. The final form of the model is then employed for the evaluation of alternative policies in relation to the sectoral contributions of the rubber and oil palm sectors to the Malaysian economy.

Two methods of policy evaluation are investigated. In the first method the proposed policy options are evaluated by directly simulating the macroeconometric model over a historical period. In this way the impact of hypothetical historical policies for rubber and palm oil on the Malaysian economy can be examined. The second method utilises the macroeconometric model indirectly through the technique of optimal control. The objective is to determine the future optimal growth paths of the key economic variables which can be employed to steer the economy towards a target growth scenario as dictated by the selected policies.

The evaluation of policies in practice involves an iterative process in which the decision maker learns from the preliminary results of model simulation and uses the information to generate a better set of policies. Combining the methods of macroeconometric model simulation and optimal control analysis can provide the decision maker with the means of carrying out the evaluation iteratively. With more informative results, better policies can be formulated even though the iterative process itself may be more complex. The complementary use of the two methods may overcome some of the weaknesses associated with the individual techniques when used singly for policy analysis. The concept of combining macroeconometric model simulation and optimal control analysis was pioneered by Pindyck (1973), and others have projected the potential of the approach as one of the most promising methods for policy analysis available to mathematical economists (see Chow, 1975, p. 149 and Intriligator, 1978, pp. 553-556). The scheme of the iterative and interactive processes of policy evaluation is depicted in Figure 6.1.

As shown in Figure 6.1 policy evaluation may begin with the identification of the problem area and the construction of the econometric model. This chapter discusses the estimation and specification procedures of the equations of the model while the validation and application of the model for policy evaluations are presented in the next few chapters.

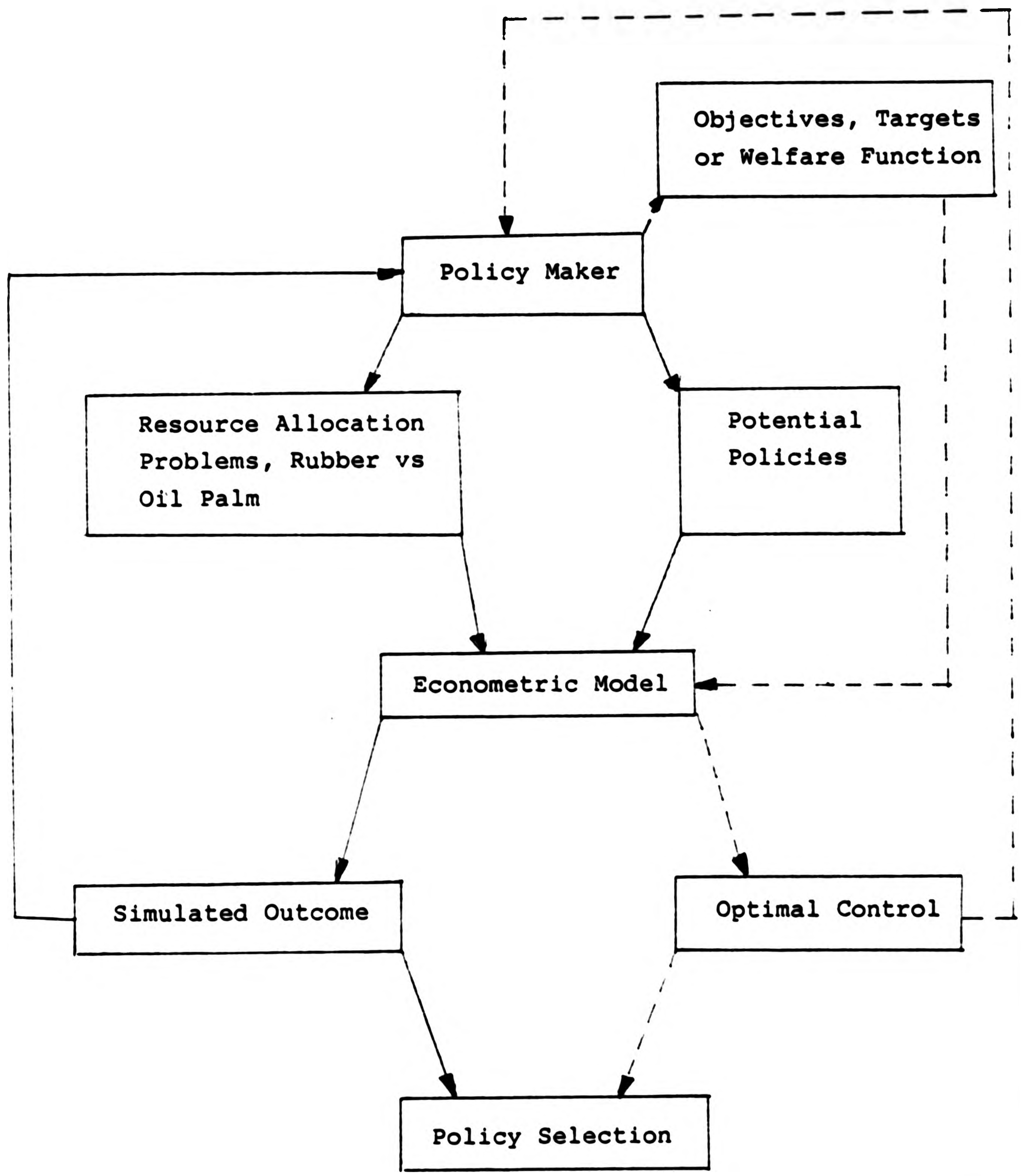

Figure 6.1: The Structure of An Iterative Planning Approach

6.2 Purpose and Background of the Model

The purpose of the macroeconometric model is to provide a consistent framework for carrying out policy simulation experiments in quantitative terms. The problem of crop allocation and other policy alternatives concerning the Malaysian plantation industry could be examined within the consistent framework of the macromodel thereby enabling various proposed policies to be evaluated before the most desirable policy is selected for possible implementation. Without the consistency of an integrated model a policy analysis may be partial and important interactions between sectors of the economy may be overlooked.

The construction of any macroeconometric model is inevitably influenced by its intended applications. Thus, to capture the impact of policy changes for rubber and oil palm, the sectoral models for these industries have to be integrated into the macromodel of the Malaysian economy. A model that is used primarily for policy analysis may be constructed with different emphasis to cater for the different requirements as opposed to a model meant for forecasting.

Typically, the macromodel contains a number of instrument or control variables which are then subjected to shocked changes to emulate changes in policies. The impact of these changes on the other endogenous variables of the model provides the planner with a simulated response of the policies on the economy.

Econometric models can be constructed at various levels of complexity. Adams and Behrman (1982, p. 56) have compared critically the various types of econometric models which have been constructed for studying the commodity markets. Their conclusion was that an integrated econometric model that includes a combination of sectoral, macroeconomic and market models of the commodity being studied can be a superior tool in the analysis of commodity problems when compared with other forms of econometric models. The model must also be sufficiently comprehensive for it to indicate not only the direct and immediate consequences of alternative policies, but also their indirect effects in other areas and the long term consequences.

Since this study emphasises the planning aspect for the plantation sector within the Malaysian economy, the impact of policies designed for this sector must therefore be related to the macro economic variables of the country as a whole. Planning also emphasises the distribution and allocation of physical factors of production namely capital, labour and land and an input-output type of physical planning model is commonly employed in such analysis. However, in the context of the developing country, capital inflows are closely related to monetary sectors such as the country's balance of payments position, money supply and financial flows from abroad. For these reasons, the use of the macroeconomic framework which includes both fiscal and monetary mechanisms of policy planning seems to offer the most suitable vehicle for conducting the policy analysis experiments.

As discussed in Chapter 2, there are certain limitations to the use of macroeconometric models for policy evaluations. The structural relationships as estimated through the model construction procedure may change with time so that the usefulness of the model for long term planning is a matter for further investigation. Secondly, the estimated equations are restricted to contain just a few explanatory variables because of specific estimation problems of multicollinearity, serial correlation etc. This limits the level of inter-relationships and impact multipliers between variables of the model. Thirdly, for the developing countries, lack of consistent data series is a major barrier to macromodel building effort. In addition, adequate computer programmes for macromodel simulation are often not easily accessible, and software, including the one used in this study, is still being improved to cater for the demanding requirements of macromodel simulation. For many countries, including Malaysia, the construction and application of macroeconometric models for policy evaluation is still an ongoing effort and the use of the technique for policy analysis in national planning is still being perfected (ESCAP, 1982).

The application of optimal control technique also requires the model to be linear, in order to utilise a computable solution procedure. However, most comprehensive macromodels are likely to contain several nonlinear equations. Despite these difficulties, it is desirable to explore the applicability of the simulation and optimal control techniques and to build upon the efforts of other researchers who have attempted to use similar tools in the policy analysis for the Malaysian economy in the past (Gulbrandson, 1984; Ho, 1983; Abe, 1982; Cheong, 1974, etc). With progress in data collection and improvement in estimation and simulation techniques over the years, it is now considered feasible, more than ever before, to explore the use of macroeconometric model simulation in conjunction with optimal control technique to evaluate policies in the context of the Malaysian plantation sector.

6.3 An Overview of the Model Structure and Specification

The structural relationship of the macromodel is derived from theoretical considerations and as far as possible the dynamic structure conforms to the Keynesian or post-Keynesian theory. Where data availability allows further exploration in the specification of the model, the equations are appropriately estimated as supply determined rather than a fully demand-determined "Keynesian" model. The emphasis on supply-determined equations for the model is to conform to the requirement that the model is to be used for planning the allocation of physical resources. Furthermore, supply-determined models may fit the notion that supply constraints such as capital scarcity rather than demand factors are dominant in the determination of economic equilibrium or disequilibrium prevailing in a developing country (Basu, 1981).

The requirement of linear models for the optimal control technique is to be achieved by selecting, where possible, the linear forms of the estimated equations. As argued by Pindyck

(1973), estimation fit may have to be sacrificed for the sake of conforming to the special need of the computational simplicity desired in the optimal control technique. Where non-linearity is unavoidable, as in most of the identities for converting "real" to "current" values, the equations are linearised before they are used in the optimal control analysis.

The macromodel consists of seven sectors which are linked into a disaggregated multi-sectoral dynamic model. The level of disaggregation is dependent on the availability of data and the need to capture the dynamics of the sector to be emphasised in this study. The seven blocks of the model are: the output, demand, import and export, government, finance, employment and factor income, and prices. Each block contains the necessary equations which when considered together will represent the contribution of the block to the rest of the economy.

Because of data limitations it is not possible to have a fully supply-determined model. The estimation of GDP through the production block is largely supply determined. The gross domestic product (GDP) is derived from the sum of the outputs of the various supply sub-sectors. Some sectoral equations are formulated on the basis of demand considerations. Therefore, the model cannot be classified as strictly Keynesian in the sense of demand-based model, or strictly classical in the sense of being supply dominated.

The key relationships which affect the model are the equations for gross domestic products (GDP) and the relationship for the balance of payments. The GDP can be determined in three ways: a) through the aggregation of the production block, b) through the aggregation of the demand block, and c) through the factor income block. These equalities are utilised to improve the consistencies of the model during simulation. For example, the GDP deflator is computed by utilising real and current GDP's estimated from two separate methods. The additional information from the identities also enables the estimation of agricultural income which is computed as the residual in the equality between national income and GDP derived from the output sector.

The equation for balance of payments is computed by summing up the current account or net trade, the capital account and the financial flows. This involves contributions from the trade block, government block and the financial flow block. The balance of payments is in turn related to the net foreign assets of the central bank which is one of the determinants of money supply in the model. Money supply in turn will affect inflation rates and price levels and the production sectors will in turn be affected by prices. Other direct linkages are also established among the sectors. The export and import blocks are important in the determination of the balance of payments, the gross domestic product as well as the generation of revenues for the government through taxation. The linkages are further superimposed by additional relationships from the price block through the role of prices in the supply and demand equations, as well as through the deflators used to convert real to current quantities for certain variables of the model.

These interlinkages are depicted in Figure 6.2. Altogether the model has 133 equations of which 63 are behavioural and 70 are identities. The selection and estimation procedures for the behavioural equations and the selection of identities are discussed in the following sections.

6.4 Model Specification

As explained earlier, the model contains seven blocks which are production, demand, trade, government, financial flows, factor income and employment, and prices. The specifications of the 63 behavioural equations are discussed below, while the formulation of the 70 identities may either be mentioned directly in the text or they may be found together with the definitions of variable names in Appendix A.

6.4.1 Production Block

The production block is disaggregated into six sectors which are agriculture, mining, manufacturing, construction, transportation and services. The contributions of these sectors to the gross domestic product of the country are shown in Tables 6.1 and 6.2. It is seen that agriculture has been the dominant sector of the economy while manufacturing has emerged as the growth sector in recent years. The services sector, though accounting for a high proportion of the country's economic activity, has remained relatively stable at a share of 38 %.

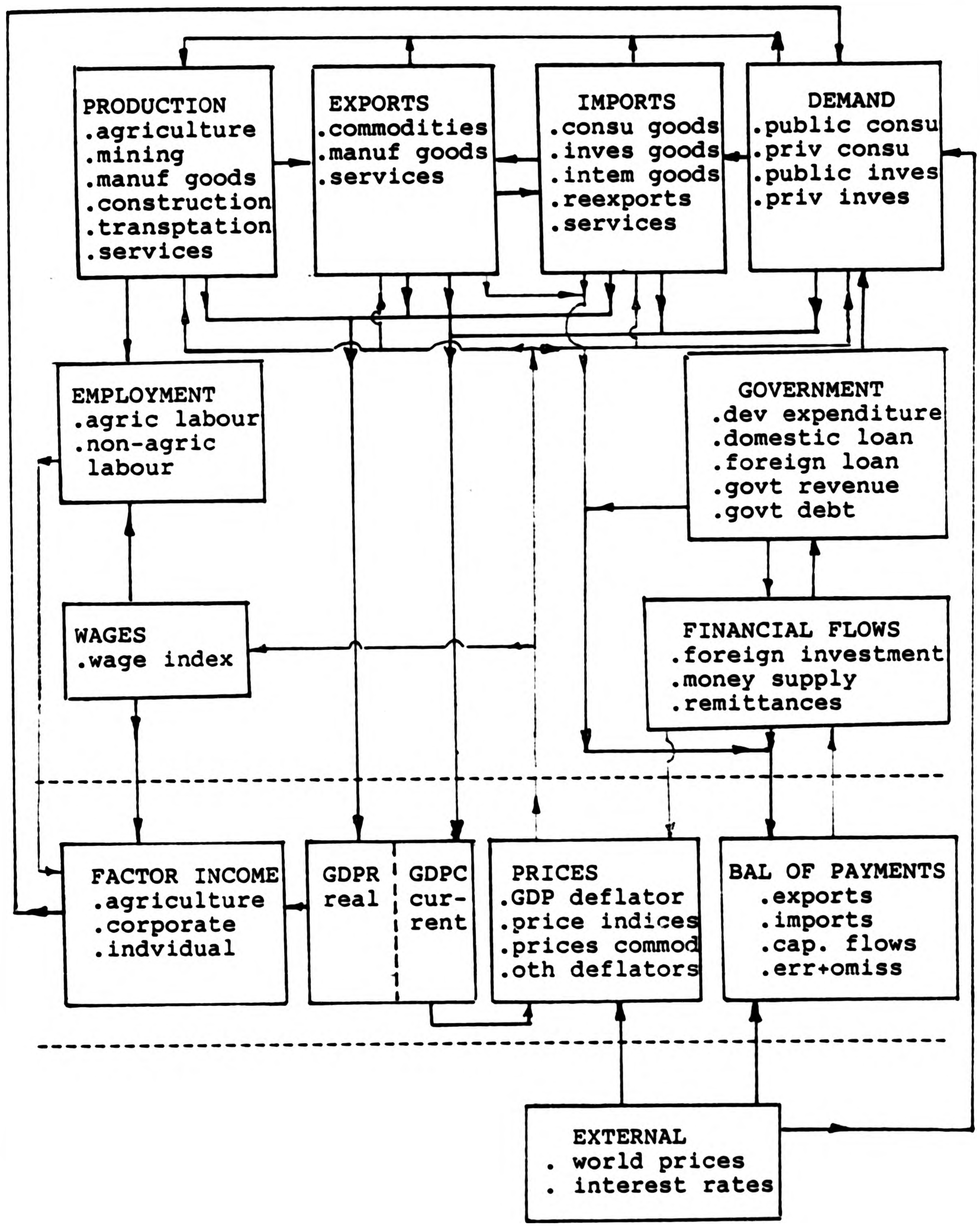

Figure 6.2 Flow Chart of the Macroeconometric Model

Table 6.1 Value added contributions of the major sectors to Malaysian GDP, (Million M$, 1970 values)

Year	GDPR	VAAGRIR	VAMINR	VAMFGR	VACONSR	VATRANR	VASER
1960	6840	2738	415	587	207	292	2375
1961	6719	2510	497	547	233	292	2421
1962	7004	2514	508	603	284	300	2567
1963	7362	2531	540	679	310	307	2754
1964	7789	2516	678	770	323	319	2927
1965	8405	2617	751	876	345	360	3179
1966	8702	2691	684	959	348	361	3374
1967	10145	3298	642	1139	415	459	3881
1968	10612	3495	582	1214	422	497	4088
1969	11615	3780	663	1456	433	494	4421
1970	12560	3766	786	1755	518	550	4803
1971	13016	3852	834	1858	541	632	4901
1972	14241	4146	889	2047	571	720	5437
1973	15904	4634	852	2508	651	827	5886
1974	17227	4954	796	2768	729	947	6451
1975	17365	4804	792	2850	654	1071	6740
1976	19288	5392	955	3377	713	1153	7294
1977	20753	5519	967	3735	800	1290	7960
1978	22264	5610	1054	4081	919	1415	8572
1979	24324	6068	1197	4470	1027	1549	9380
1980	26228	6255	1171	4874	1209	1803	10098
1981	28092	6516	1148	5115	1391	2024	11136
1982	29677	6995	1180	5309	1523	2248	11800
1983	31251	6922	1398	5659	1685	2447	12602

Source: Model Data Base

Table 6.2 Percentage contributions of major economic sectors to Malaysian GDP, 1960-1983

Year	GDPR actual (Mill.M$)	VAAGRIR (%)	VAMINR (%)	VAMFGR (%)	VACONSR (%)	VATRANR (%)	VASER (%)
1960	6840	40.03	6.07	8.58	3.03	4.27	34.72
1961	6719	37.36	7.40	8.14	3.47	4.35	36.03
1962	7004	35.89	7.25	8.61	4.05	4.28	36.65
1963	7362	34.38	7.33	9.22	4.21	4.17	37.41
1964	7789	32.30	8.70	9.89	4.15	4.10	37.58
1965	8405	31.14	8.94	10.42	4.10	4.28	37.82
1966	8702	30.92	7.86	11.02	4.00	4.15	38.77
1967	10145	32.51	6.33	11.23	4.09	4.52	38.26
1968	10612	32.93	5.48	11.44	3.98	4.68	38.52
1969	11615	32.54	5.71	12.54	3.73	4.25	38.06
1970	12560	29.98	6.26	13.97	4.12	4.38	38.24
1971	13016	29.59	6.41	14.27	4.16	4.86	37.65
1972	14241	29.11	6.24	14.37	4.01	5.06	38.18
1973	15904	29.14	5.36	15.77	4.09	5.20	37.01
1974	17227	28.76	4.62	16.07	4.23	5.50	37.45
1975	17365	27.66	4.56	16.41	3.77	6.17	38.81
1976	19288	27.96	4.95	17.51	3.70	5.98	37.82
1977	20753	26.59	4.66	18.00	3.85	6.22	38.36
1978	22264	25.20	4.73	18.33	4.13	6.36	38.50
1979	24324	24.95	4.92	18.38	4.22	6.37	38.56
1980	26228	23.85	4.46	18.58	4.61	6.87	38.50
1981	28092	23.20	4.09	18.21	4.95	7.20	39.64
1982	29677	23.57	3.98	17.89	5.13	7.57	39.76
1983	31251	22.15	4.47	18.11	5.39	7.83	40.33

Source: Derived from Table 6.1

Modelling the production sector involves formulating the equations for estimating the value added of the six productive sectors. Aggregation of the value added from these sectors gives the estimate of the GDP.

6.4.2 The Agricultural Sector

Agriculture continues to be an important sector in the Malaysian economy despite the decline in its share of GDP from 40 % in 1960 to 22 % in 1983. In absolute terms, the agriculture sector has expanded at 3.94 % per annum during the same period. Thus, despite the growth of other sectors, agriculture is still the dominant sector in the economy in which it provides employment for about 36.3 % of the labour force. A significant proportion of the private sector income and government revenue originate from the agriculture sector and the overall economic performance of the economy continues to depend on the performance of both the production and exports of the main agriculture products.

As mentioned in Chapter 3, much of the country is covered with forest and logging and timber extraction have been a major industry. However, the arable land is suitable for cultivation of many tropical crops, given the tropical climate enjoyed by the country. Historically, much of the arable lands have been allocated to the planting of commercial crops of which rubber and palm oil are the most important. Other commercial crops which are grown on a much smaller scale include cocoa, coconut, pepper and pineapple. In the past, major plantation companies, which were mostly established before the county became independent, have developed vast areas for rubber and oil palm cultivation. Ownership of most of these estates has passed into local hands through a series of equity purchases during the seventies and early eighties. With these changes, the planning for crop allocation becomes increasingly the responsibility of the Malaysian owners.

Crops such as rubber can also be grown on a small scale to provide subsistence income to the small farmers. They have thus participated in the cultivation of these crops and collectively they account for 75 % of rubber planting in the country. Thus, planting of rubber has been an integral part of subsistence farming in Malaysia in addition to rice cultivation and small scale animal rearing husbandry.

An interesting feature of Malaysian agriculture is the large scale involvement of specialised government agencies such as the Federal Land Development Authority (FELDA) in the cultivation of the major crops. Although the aim of the development projects was to combat rural poverty by resettling the landless, the success of the schemes has transformed the agricultural sector in a significant way. Through the land development scheme, it has been possible to organise the smallholders to operate their plantations more efficiently in a manner comparable to that found in the estate sector. More importantly, the land development schemes have made it possible for the smallholders to participate more successfully in the cultivation of oil palm where the need for heavy investment in setting up mills and investing in farm machinery had effectively precluded smallholders' participation in the past.

Agriculture is also the area where the highest incidence of poverty occurs. In addition to the land development projects, the government has directed large amounts of public funds at this sector in an effort to raise the living standard of the farmers. Various development programmes such as the fringe land development schemes, the replanting schemes, irrigation schemes and other rural development projects have been undertaken by the government on a large scale to reduce rural poverty. Various specialised institutions have been set up to implement these agricultural development programmes.

As the available land is often suitable for planting any of the four main crops - rubber, oil palm, cocoa and coconut - allocation of the most appropriate crop is an important problem which faces both the individual farmers as well as the institutions and major corporations in their investment decisions. In this respect, the role of government policies in providing guidance on planting priorities and targets would be helpful to assist the development of the plantation industry.

As in most countries in this region rice is the traditional crop upon which agriculture has been based. In Malaysia, however, production of rice is aimed at supplying the local demand. Malaysia is still not self-sufficient in rice production although self-sufficiency has been regarded as an important target by the government. A major obstacle is the low return to investment in rice production under the present traditional form of cultivation. Rice cultivation remains confined to the level of subsistence farming and the survival of the industry depends partly on the subsidy scheme offered by the government. Modernization of this sector through the use of mechanised farming practices is being pursued.

Malaysian agriculture can be considered in a broad sense to include the exploitation of forestry and fishery products. Most of the areas in Peninsular Malaysia and the Eastern States of Sabah and Sarawak are covered with forest. Only 24 % of Peninsular Malaysia, 10 % of Sarawak and 7 % of Sabah are under cultivation. Forestry has therefore been a major resource to the Malaysian economy. Exports are in the form of sawlogs mainly to Japan, while sawn timber has become an increasingly important form of export with the appeal that there is more local processing, and that the market outlet is more diversified.

The fishing industry remains small with production geared towards supplying local demand. Small quantities of prawns are exported. There appears some potential for development in this area but the industry has largely remained underdeveloped.

In view of the diversity of investment potential in the agriculture sector, and the need to optimise the allocation of resources at the national level, the government had introduced the National Agricultural Policy. However, despite much research that was undertaken to prepare the NAP, most of the policies could only be stated in qualitative terms. With regard to rubber and oil palm, the NAP recommended that rubber plantation owners continue to improve the productivity of their plantations and where the land is suitable the cultivation of oil palm through well-managed estates is encouraged.

6.4.3 Value Added of the Agricultural Sector

Value added for the agriculture sector (VAAGRIR) is the sum of the value added of the various sub-sectors within agriculture. Data on the value added for the production of the individual crops are not available. The approach adopted is to compute an agricultural production index (AGPI2), and real value added for agriculture is then related to the agricultural production index as in the following function:-

$$VAAGRIR = f(AGPI2)$$

The agricultural production index is computed from past data series as value weighted index of output of the various crops and products as follows:-

$$\begin{aligned} AGPI2 = {} & 0.1782*OPALM + 0.3221*ORUBSH + 0.3221*ORUBSS \\ & + 0.3381*ORUBES + 0.0423*OSTIM + 0.0178*OSLOG \\ & + 0.1015*ORICE \end{aligned}$$

ORUBSS is exogenously determined in the model.
The equation for value added for agriculture is given by:-

$$VAAGRIR = 957.5407 + 2.8101*AGPI2 \qquad (6.1)$$

$$(8.3043) \quad (33.0151) \; [1]$$

$$R^2 = 0.9766 \quad DW = 1.5851 \quad RHO = 0.427322 \quad PF = 1961\text{-}83$$

where the figures in brackets are the t statistics of the regression estimate, and the usual values for R^2 , Durbin Watson (DW) statistic, autocorrelation (rho) values, and the period of fit (PF) for the regression are as indicated.

In accepting the estimated form of the equation of the model, the criteria used are the correct signs of the coefficients, the high value of R^2 and that the equation is unbiased and efficiently estimated as judged through the value of the Durbin Watson statistic [2]. When there exists a significant serial correlation in the error term, the equation is re-estimated through the first order serial correlation method [3]. Various versions of this method due to Beach and McKinnon (1978), Corchran and Orcutt (1949) and Hildreth and Lu (1960) can be used. The final test of the equation is its ability to produce good dynamic forecasts over a historical period. Details of this type of acceptance test are discussed more fully in the next chapter on model validation.

a) <u>Rubber Production</u>

Rubber is a perennial plantation crop whose output schedule is a function of the yield and the stock of mature trees. Both of these factors are in turn influenced by other forces of the production process including the past, present and future prices, the effect of the weather, and the kind of inputs and agricultural practices applied. The production function for rubber and similar crops can usually be formulated as follows:-

Output = f (planted area, yield, prices, weather, technology)

Some of the early efforts at the derivation of an appropriate supply function for perennial crops had been attempted by French and Mathews (1971) and Bateman (1965). Later Labys (1973) extended the application of the supply response analysis to coconut cultivation. Labys's approach was to derive the reduced form of the supply function, particularly to utilise fully price data in the absence of essential data on planting and crop removal. More recently, Smit (1982) formulated a detailed model for the rubber industry of Malaysia with a mathematical approach to the estimation of the vintages for the planted area.

In all these studies the main objective is to estimate the true size as well as the yield profile of the mature area. As both these quantities are changing with respect to previously made planting decisions, formulating the supply response function for perennial crops requires the lag aspect of production to be taken into account.

For the rubber smallholding sector, output (ORUBSH) is postulated as a function of mature area (MARUBSH), real producer prices (PRUB3R), time (TIME) as a proxy for technological change, and a dummy variable to account for the major replanting of rubber smallholdings under the government replanting scheme since the early seventies. The producer price is computed as the f.o.b. export price less the corresponding export duty. The estimated equation for smallholding rubber output is given by

$$
\begin{aligned}
ORUBSH = & - 224.0217 + 0.6931*MARUBSH + 0.0139*PRUB3R \\
& \quad (-1.3069) \qquad (2.5949) \qquad\qquad (0.2882) \\
& + 5.1509*TIME + 108.0237*DUM7383 + 0.3087*(ORUBSH(-1)) \qquad (6.2) \\
& \quad (0.9597) \qquad (2.6460) \qquad\qquad (1.7534)
\end{aligned}
$$

$R^2 = 0.9750$ DW = 1.1071 PF = 1961-83

The implied short-run elasticity of supply, calculated at the mean for output and price, is 0.024 and the implied long-run elasticity is 0.035. The low price elasticity of smallholders' rubber production can be ascribed to the long gestation period of six years for rubber plantation. Smit (1982) had tested the supply response for rubber smallholdings using more detailed models. He showed that in addition to low price elasticity of production, rubber output was also influenced by 'taget income' behaviour where the smallholders tended to produce less when prices were high as they could reach their target income with less output. It is further noted that Equation 6.2 is formulated with a lagged dependent variable, ORUBSH(-1), as one of the explanatory variables. This introduces a dynamic relationship into the equation which also implies the presence of a partial adjustment process. A coefficient of 0.3087 for ORUBSH(-1) indicates an adjustment coefficient of 0.6913.

The low level of statistical significance for the price coefficient would normally lead to the rejection of the price variable as an explanatory variable of the equation. However, in the context of the present evaluation, prices are important, not only from a priori belief on their effects on rubber production but also their role in determining the country's export revenue etc. in the simulation of the macroeconometric model. The retention of variables with low t statistics in a simulation exercise is thus justified when considered within the overall framework of the model.

The use of mature area in the production function is to facilitate the simulation of the model at a later stage. Mature area could be endogenised but a method can be introduced to augment this aspect of the model in the simulation procedure to be discussed in the next chapter.

The output of rubber from the estate sector (ORUBES) is estimated as follows:-

$$
\begin{aligned}
\text{ORUBES} = & - \underset{(-2.0055)}{493.2142} + \underset{(2.4307)}{1.0264}*\text{MARUBES} + \underset{(0.0961)}{0.0031}*\text{PRUB1R} \\
& + \underset{(2.0803)}{9.4293}*\text{TIME} + \underset{(5.7301)}{0.7436}*\text{ORUBES}(-1) \qquad (6.3)
\end{aligned}
$$

$R^2 = 0.8862$ DW = 2.6997 PF = 1961-83

The low production elasticity with respect to price displayed for smallholding rubber is emulated in the estate sector where a short-run price elasticity of production of 0.0067 is implied from Equation (6.3). The lower price elasticity of supply for the estate sector in comparison to the smallholding sector is attributed to the regimented production schedule usually associated with estate management. Workers in the rubber plantations are employed on a kind of wage arrangement that encourages the continual production of rubber irrespective of the price level on the short run in an attempt by management to at least cover overhead charges. The adjustment coefficient of 0.2564 for the estate sector is also much lower than that for the smallholdings.

b) Palm Oil Output

The high degree of similarity in the method of cultivation and management of oil palm and rubber plantations suggests that the same form of supply function can be used to estimate the output for the oil palm sector. The supply of palm oil (OPALM) is made a function of mature area (MAPALM), real producers price of palm oil (PPALMR), time, dummy variables to represent years of drought which affect output in various years. Another dummy variable is introduced to account for the production boom in 1983 resulting from the biological innovation of the introduction of the pollinating weevil to the Malaysian plantation. The equation, when estimated, showed negative price coefficient which could cause difficulty in later simulation.

An alternative polynomial lags (PDL) method of estimation (see Hall, 1983) has been used to obtain the most acceptable form of the production equation for palm oil. This method employs second order lags which can be postulated to exist between output and prices. For perennial crops such lagged relationships between outputs and prices are plausible and the use of the lagged output variable tends to overemphasize the relationship to include longer price lags. Outputs are expected to be dependent on past prices since the decisions to plant are usually based on prices prevailing at the time that the planting decisions were made several years earlier.

The palm oil output equation is given by:-

$$
\begin{aligned}
OPALM = & - \underset{(-1.9150)}{285.8565} + \underset{(7.9942)}{0.0025*MAPALM} + \underset{(1.5243)}{0.1767*PPALMR} \\
& \underset{(1.5243)}{0.1178*PPALMR(-1)} + \underset{(1.5243)}{0.0589*PPALMR(-2)} \\
& + \underset{(7.1372)}{530.1406*DUM82} - \underset{4.6699)}{264.6703*DUM7883} \\
& + \underset{(2.3112)}{0.2421*OPALM(-1)} \qquad (6.4) \\
& R^2 = 0.9968 \quad DW = 1.7089 \quad PF = 1963\text{-}83
\end{aligned}
$$

It is noted that the t- statistics, shown in brackets in the above equation, are the same for the current and lagged forms of the price variable PPALMR. This is part of the output from the TSP estimation procedure which does not report the t-statistics individually for the lagged price variables. The polynomial estimation method used in TSP regards the standard error to be estimated as though the three polynomial price variables are together as just one variable. The same explanation will apply for the special way that t-statistics values are reported subsequently for other equations estimated through the polynomial distributed lags method.

No distinction is made to disaggregate production by the independent smallholding sector which, unlike the situation in the rubber industry, is relatively small (6 %) in comparison to the estate counterpart.

c) Sawn Timber and Sawlogs

The supplies of sawn timber and sawlogs are postulated to be of the following form:-

$$Q_t = f\ (P_t, P_{t-1}, L_t, F_t, T_t, Z, u_t)$$

where Q_t is supply of sawn timber or sawlogs,

P_t is price of the commodity in question,

P_{t-1} is lagged price variable.

L_{tp} is the supply of stumpage or logs in the case of timber

F_t is the cost index of factors of production

T_t is technological change induced by changes in real capital investment,

Z is a dummy variable to indicate the years when export control was applied,

u is the error term

A priori, the signs of the coefficients of P_t, P_{t-1}, L_t and T_t

are expected to be positive while those for F_t and Z are negative.

Time series data for F_t are not available, and a proxy trend variable TIME is used. The variable TIME therefore indicates the effects of changes in technology in combination with the change in input cost. Both lagged variables for Q_t and P_t may be introduced under the dynamic partial adjustment process associated with the timber and the log production industry. It is usual to assume a log-linear relationship for the production function. However, linear forms are preferred for a later application of the model in optimal control analysis, and estimation of the linear form of the equation gives a reasonably good fit as follows:-

$$\begin{aligned}\text{OSTIM} = & -88.7957 + 0.8957{*}\text{PSTIMR} + 120.6845{*}\text{TIME} \\ & \quad (-0.2088) \quad (0.1741) \qquad\qquad (2.4123) \\ & + 1433.562{*}\text{DUM83} + 0.5833{*}\text{OSTIM}(-1) \\ & \quad (3.3551) \qquad\qquad (3.3893) \\ & R^2 = 0.9710 \quad DW = 2.1093 \quad PF = 1961\text{-}83\end{aligned} \tag{6.5}$$

The implied short-run price elasticity of supply, calculated at the mean, is 0.0325 indicating that timber supply is rather inelastic. This is because of the significant outlay of capital investment and overheads associated with timber production. To cover these overhead charges, production has to continue irrespective of the price levels prevailing in the short term. The positive coefficient of the time variable indicates that the positive contribution of technological improvement and capital investment outweighs the opposing negative forces of increasing factor costs and shortage in timber sources as referred to earlier in the formulation of the equation.

Malaysia is also a major exporter of sawlogs to the world market. However, in recent years the supply of sawlogs has been affected by over-logging where the felling rate far exceeds the rate of forest regeneration especially in Peninsular Malaysia. Fear of over-logging has prompted the government to intervene by protecting certain endangered species from being over-exploited for the export market. The estimated supply equation for sawlog is as follows:-

$$
\begin{aligned}
OSLOG = {} & \underset{(0.4716)}{1786.041} + \underset{(0.9086)}{55.8837}*PSLOGR - \underset{(-1.2579)}{2465.586}*DUM7475 \\
& - \underset{(-1.4361)}{3024.593}*DUM7780 + \underset{(11.8153)}{4.3876}*OSTIM(-1) \qquad (6.6) \\
& R^2 = 0.9138 \quad DW = 0.9682 \quad PF = 1961\text{-}83
\end{aligned}
$$

The negative sign of the coefficient for the dummy variable represents the decline in production when export bans were imposed on the export of certain species of timber as part of the government's conservation policy. It is noted that the lagged production of sawn timber, OSTIM(-1), has been used as a proxy for the demand of sawlogs. The long time involved in the extraction process for sawlogs suggests that decisions for future production may be based on current demand for timber. The longish production process also implies that timber and sawlog production is inelastic to price changes.

d) <u>Rice Production</u>

Rice is a strategic commodity for which Malaysia tries to be self-sufficient. Production, however, is still largely carried out through subsistence farming in which farmers are assisted by the government through a subsidy scheme. As in many developing countries, attractions of better jobs in the cities led to migration of the young villagers to the cities. Consequently, some 350,000 hectares of paddy fields have remained idle or partly abandoned.

There have been no shortage of models for the production functions of annual crops in the literature, and for rice in particular, a detailed analysis of its supply function in the case of Thailand was reported by Behrman (1968). He investigated the postulation that rice production is a function of cultivated area and yield. Cultivated area in turn depends on the price of rice and on the competing use of the land, while yield depends on price levels, technological improvement and weather conditions.

By selecting suitable proxies to represent the above factors, the following function for rice production in Malaysia has been formulated:-

$$\underset{}{ORICE} = \underset{(-2.8705)}{-1519.240} + \underset{(2.5978)}{3.2534*PRICER} + \underset{(3.3736)}{0.0881*POMPSIA}$$

$$-149.3592*DUMDR78 + 104.0899*DUMSD81 + 0.2671*ORICE(-1) \quad (6.7)$$

$$(-2.1423) \qquad (0.9273) \qquad (1.4766)$$

$$R^2 = 0.8622 \quad DW = 1.9160 \quad PF = 1962\text{-}83$$

The drought years indicate a significant impact on production while the introduction of a subsidy seems to increase production though the coefficient is not of sufficiently high level of significance.

6.4.4 Mining Sector

The mining sector consists of two major industries. These are tin and petroleum. There are small quantities of other minerals such as copper and gold being mined and recently, with the completion of the Bintulu Petroleum project in Sarawak in 1983, exports of petroleum gas have become increasingly important. In this model, the value added for the mining sector has to be estimated indirectly because of non availability of individual value added data for tin and petroleum production. The value added for mining (VAMINR) is made a direct function of the individual values of tin and petroleum production.

$$VAMINR = 442.6355 + 0.3509*TINVR + 0.2028*PETVR \quad (6.8)$$

$$(5.1310) \qquad (2.8975) \qquad (6.5881)$$

$$R^2 = 0.8049 \quad DW = 0.9838 \quad PF = 1960\text{-}83.$$

where

TINVR is the value of tin output

PETVR is the value of petroleum output

TINVR is derived from the estimate of tin output (OTINQ) and real tin price (PTINR). The value of petroleum output is similarly estimated by multiplying output by price.

a) Tin Output

Tin production models have been studied extensively and some interesting forms of the supply function for tin have been suggested by Desai (1966), Lim (1975), Bird (1978) and Ho (1983). Comparable models for the supply functions of other minerals products such as copper have been suggested by Obidegwu and Nziramansanga (1981) and Lasaga (1981). There appears to be two basic approaches to the construction of the supply model for non-renewable resources such as tin. The first approach emphasises the inclusion of a variable to explain the depletion of reserve which will affect production in the long run. Ho (1983) explored this method by utilising a quadratic time variable in the equation for tin supply and found that the use of quadratic variables in a forecasting equation tended to cause divergence and instability in model simulation.

The second method belongs to the profit maximising stock adjustment model as earlier described for the supply function of the timber industry. Bird (1978) criticised such an approach for tin supply estimation, arguing that the export control schemes which regulate the supply of tin could distort the market, and even the use of dummy variables in the supply function to account for such export control periods might still be inadequate. He thus suggested the use of polynomial lag prices as the most appropriate explanatory variables for such production functions. Despite his a priori reasonings, Bird had to resort to using supply data including those for the periods when export controls were active mainly for the sake of having sufficient length of time series data with which to evaluate the long lag involved in the polynomial production function.

In this study, the selected form of the supply function for tin following the above discussions is the profit maximising stock adjustment type as follows:-

$$\begin{aligned} OTINQ &= -\ 2.5668 + 0.0006{*}PTINR - 0.5184{*}\ TIME \\ &\quad\ (-0.3835)\quad (1.2809) \qquad\quad (-2.2042) \\ &\quad -2.6462{*}DUM7388 + 5.7237{*}DUM7879 + 1.0550{*}OTINQ(-1) \qquad (6.9) \\ &\quad\ (-1.1960) \qquad\qquad (2.6247) \qquad\qquad (12.8631) \end{aligned}$$

$R^2 = 0.9138$ DW $= 1.8537$ PF $= 1961\text{-}83.$

where

TIME is a time trend to capture the effect of any improvement in technology and to account for the depletion of mining areas,

DUM7388 is dummy to capture the effect of increased competition as a result of commodity price inflation after the oil price hike in 1973.

The coefficient of OTINQ(-1) represents (1-r) where r is the adjustment coefficient. Usually a value for r of less than one indicates that the adjustment process is incomplete within the period of a year. When r is greater than 1.0, the situation is interpreted as over-adjustment; if r is less than 0 non-rational behaviour is a possible cause. In the case of tin, this could be due to the frequent applications of the export control and buffer stock schemes where supplies are artificially adjusted within a short period of time.

b) Petroleum Output

The production of petroleum is under the control of the government and output (OPETQ) is treated as an exogenous variable in the model. Petroleum production in Malaysia was greatly increased with the opening of off-shore oilfields in the early 1970s. Income from petroleum exports has been a major source of government revenue, and in recent years the reserve of fund from petroleum has played a major role in meeting additional expenditures of the government. An equation for estimating petroleum output was constructed but the simulation performance of the equation was poor and there seemed little structural information to be gained from the equation. Furthermore data on petroleum production are affected by the sudden increase of production with the operation of the off-shore fields in the early 1970s. It is thus easier to treat petroleum output as an exogenous variable.

6.4.5 Manufacturing Sector

The manufacturing sector has been the fastest growing sector in the Malaysian economy. Its share of total GDP grew from only 8.6 % in 1961 to 18.1 % in 1980. In comparison, the share of the agricultural sector declined from 40 % to 24 % over the same period. Increasingly, the manufacturing sector is regarded as the growth sector for the future as there appears to be a greater scope for diversification including venturing into heavy industries. Thus various inducements and incentives are made available to both local and foreign investors to participate in the manufacturing activities of the country.

The real output of the manufacturing sector (VAMFGR) is demand determined. The explanatory variables are hypothesised to be consumer expenditure (CONEXPR) and the import price index of intermediate goods (PMINTGI) as follows:-

$$\begin{aligned} VAMFGR = & -791.6903 + 0.2846*CONEXPR - 1.1055*PMINTGI \\ & (-4.3210) \quad (14.4549) \qquad\qquad (-1.9156) \\ & + 333.1950*DUM7683 \\ & (3.5160) \end{aligned} \tag{6.11}$$

$R^2 = 0.9394$ DW = 1.4249 PF = 1961-83 rho = 0.839437

The use of PMINTGI is to represent the input cost of the manufacturing process; the higher the input cost the lower is the value added as value added is output value less input value. Higher input cost also tends to retard manufacturing activities to result in lower level of total value added. Another determinant which could be used is the world demand for manufactured goods. Alternatively, the output of the manufacturing sector can be determined through a supply function using capital stocks, labour, and the imports of intermediate goods as explanatory variables (see Obidegwu, 1981). The lack of data on capital stock at the sectoral level prevents the estimate of the manufacturing output through a supply determined function.

6.4.6 Construction Sector

Value added for the construction sector (VACONSR) is linked to the gross investment expenditure (INVTR). A dummy variable is included to reflect the temporary reduction in construction in the 1975-76 period. The estimated equation is as follows:-

$$VACONSR = \underset{(7.3023)}{137.9466} + \underset{(39.8021)}{0.1453*INVTR} - \underset{(-1.1036)}{23.5344*DUM7576} \quad (6.11)$$

$R^2 = 0.9832$ DW = 1.4659 PF = 1960-83 rho = 0.586616

6.4.7 Transportation Sector

The value added of the transportation and communication sector (VATRANR) is postulated to depend on the demand for services resulting from the development of other industries particularly the agriculture sector and the level of foreign trade. Hence the value added for the agriculture sector and the total level of export and import (TXMERR) have been used as the explanatory variables.

$$VATRANR = \underset{(-3.1299)}{-388.4596} + \underset{(0.9117)}{0.0606*VAAGRIR} + \underset{(5.7477)}{0.0992*TXMERR} \quad (6.12)$$

$R^2 = 0.9594$ DW = 1.8425 PF = 1960-83 rho = 0.434114

6.4.8 Services Sector

The output of the services sector comprises services provided by the government sector, finance sector, wholesale sector, electricity and water services and other residual services. The share of the services sector as a percentage of the GDP has been relatively stable rising only marginally from 34.7 % in 1960 and 38.7 % in 1983.

Value added in the services sector is related directly to the real aggregate expenditure which is defined to include consumption and investment expenditure of both the public and private sectors as well as net level of real exports. This specification can be regarded as an input-output transformation of the input-output type of production process (see Behrman and Klein, 1970). Thus the services equation is given by:-

$$VASER = \underset{(2.2445)}{491.0196} + \underset{(31.8700)}{0.3555}*EXPCNI \qquad (6.13)$$

$R^2 = 0.9691$ DW = 1.5650 PF = 1960 -83 rho = 0.730616

6.4.9 Gross Domestic Product

The Gross Domestic Product (GDP) in real terms can be obtained through the following identity:-

$$GDPR = VAAGRIR + VAMINR + VAMFGR + VACONSR + VATRANR + VASER - VAIBSR + TXIMR$$

where

VAIBSR is the value of imputed bank charges, to be treated as an exogeneous variable in the model,

TXIMR is the import tax in real terms.

6.5 Aggregate Demand

The aggregate demand of the economy can be decomposed into six main components: private and public consumption expenditure, public and private sector gross investment and import and export of goods.

The contribution of public consumption in the aggregate demand for the Malaysian economy has increased steadily during the 1961-1983 period. Public investment grew at 16.4 % per annum, with most of the growth taking place after the introduction of the New Economic Policy in 1971. The shares of exports and imports as a percentage of total GDP are relatively more stable over the sample period. The estimates for export and import sectors are presented in a later section dealing with the balance of payments block.

6.5.1 Private Consumption

Private consumption is postulated to be a function of aggregate income. The quantitative association between consumption and disposible (after tax) income was emphasised by Keynes (1936). Other postulations have been advanced by Modigliani- Ando-Brumberg and Milton Friedman. These are variants of the relationship which attempts to link consumption with some measure of income, and different formulations can be introduced depending on the economy and the availability of data for the country being investigated. For the developing country, consumption may be affected by the lack of financial devices which promote consumption in the developed economies. In the rural economy, for example, consumption may be preceded by a period of saving up, thus suggesting a pattern of differred consumption.

Studies on the consumption pattern of the developing countries suggested that the consumption pattern is largely influenced by current income. Other considerations include the influence of permanent income concept, interest rates and loan availability.

Based on the above discussions, private sector consumption expenditure is expressed as a function of disposible income (INCDSPR), and real interest rate (RCBLR) which is defined as the commercial bank lending rate minus the expected rate of inflation. The interest rate is introduced to capture the effect of the gradual liberation of the financial system in the 1970s on aggregate savings.

$$\begin{aligned} \text{CONPRIR} = {} & \underset{(-0.6630)}{112.0163} + \underset{(1.3804)}{0.1481}*\text{INCDSPR} - \underset{(2.0311)}{42.4579}*\text{RCBLR} \\ & + \underset{(4.1092)}{0.8132}*\text{CONPRIR}(-1) \end{aligned} \tag{6.14}$$

$R^2 = 0.9952$ DW = 1.3659 PF = 1961-83

The term CONPRIR(-1) has been included to reflect the permanent income effect, where the permanent income consumption function, using a geometric lag scheme can be expressed as

$$C_t = a + b Y_t + g C_{t-1}$$

where

C is consumption

Y is disposible income

The short-run marginal propensity to consume (mpc) is b and the long-run mpc is given by b/(1-g). In equation (6.15) the short-run mpc is 0.1481 while the long-run mpc is 0.793. The low value for the short-run propensity to consume, ie less than M$0.15 for every additional dollar earned, may be due to the presence of a large agricultural and rural sector where a period of saving up normally precedes spending.

6.5.2 Public Consumption

The government consumption sector plays an active role in the overall economic activities in Malaysia. In 1983 public sector expenditure in current prices accounted for 27.0 % of nominal GDP. The payment of salaries and transfer of funds to state and statutory authorities are the most important components of government spending.

Real government consumption expenditure is a function of real government revenue adjusted for public transfer to households, and the level of previous year's real government consumption expenditure. The level of current operating expenditure has normally been kept below current revenue as part of the conservative bugeting policy of the government.

$$CONPUBR = 28.4751 + 0.2413*GFREVR + 0.8106*CONPUBR(-1) \quad (6.15)$$
$$(0.4069) \quad (1.6807) \quad (4.8686)$$
$$R^2 = 0.9908 \quad DW = 1.3793 \quad PF = 1961\text{-}83$$

The long-run marginal propensity to consume out of total government revenue is 1.27. This high propensity to consume probably reflects the rapid growth of the economy and this suggests that to sustain such a growth rate, it is necessary to use loans, reserves and other non-revenue sources of fund for financing public consumption.

6.5.3 Private Sector Investment

Investment functions include private sector investment (INVPRIR), public sector investment (INVPUBR), and inventory investment. The latter was not employed in the model.

Investment functions have been suggested by Keynes through the marginal efficiency of capital approach. Other approaches include the marginal efficiency of investment concept suggested by Lerner (1946) and Allen (1967), and the capital stock adjustment postulation of Jorgenson (1965).

The marginal efficiency model as proposed by Allen can be stated as follows:-

$$I = I(\, i,\, K,\, a\,)$$

where I = is investment expenditure,

i = interest rate,

K = capital stock,

a = shift parameter

In this formulation, investment is negatively related to interest rate and the initial stock of capital, and positively related to other determinants, which raise the marginal efficiency of investment. The latter is represented by the shift parameter which is assumed to include such variables as the level of national income, the rate of unemployment or other factors which may influence expected future profits.

The Jorgenson model assumes that firms adjust their stock of capital so as to maximise their present value. By further assuming a Cobb-Douglas type of production function, and lagged adjustment process for achieving the desired level of capital stock, an investment function of the following form was proposed by Jorgenson:-

$$I_t = \sum_{t=1}^{T} (a_i \Delta K^{*}_{t-1} + d\, K_{t-1})$$

where $K^{*} = a\, P\, X\, /UCC$

UCC = user cost of capital; P is the price of the firms output; and X is the level of output.

Many other models for determining investment have been suggested. These models have mainly been devised to estimate the investment function in a developed economy. The situation is often different in a developing country. The investment pattern is often dictated by the other non-profit maximising motives of the investor or the host government. Foreign investors are often concerned with short payback period instead of maximum discounted value to their investment or they may place emphasis on securing the sale of equipment in joint venture projects. The host government on the other hand may encourage projects which could provide employment or these investment projects may be restricted to the conditions stipulated by the loans which are usually obtained from abroad.

These arguments suggest that the investment function in a developing country may be jointly determined by the availability of capital, its cost and the expected return on investment. The variables that could be used in the evaluation include the availability of investment credits (INVCRER), real interest rates (RCBLR), gross output, price index of primary commodities, and export of goods and non factor services. As multicollinearity becomes a problem in the estimation, the explanatory variables were first analysed by means of principal components, and variables which were highly correlated were represented by only one of them.

$$\underset{}{INVPRIR} = \underset{(-2.7036)}{-693.2373} + \underset{(2.4447)}{0.2008 \cdot INVCRER} - \underset{(-0.1156)}{1.7606 \cdot RCBLR} \qquad (6.16)$$

$$+ \ 0.0815*GNPR \quad + 0.0543*GNPR(-1) + 0.0272*GNPR(-2)$$
$$(5.2147) \qquad (0.0543) \qquad (5.2147)$$
$$R^2 = 0.9685 \quad DW = 1.1905 \quad PF = 1962\text{-}83$$

The polynomial lag in GDP was included as it was considered there would be a considerable lag involved on implementing investment projects which would have been decided under conditions of previous GDP levels.

6.5.4 Public Sector Investment

The determinants of government investment are the rate of growth of current period output (CHGDP) previous period's government investment and current lagged values of real direct development expenditure (DDE). The change in GDP is to reflect the tendency for the government to take corrective measures to ensure that investment grows steadily and not be affected by the instability of the economy from year to year. The lagged investment is to account for the fraction of current investment to service, replace or maintain capital stock invested the previous year. Current and lagged values of real direct development expenditure measures the financial resources made available for spending through the government budgetary process. The estimated equation is given by

$$INVPUBR = 126.7235 + 0.4566*INVPUBR(-1) - 155.2599*CHGDP$$
$$(1.8004) \qquad (4.5042) \qquad (-0.2096)$$
$$+ \ 0.2406*DDE + 0.1604*DDE(-1) + 0.0802*DDE(-2) \quad (6.17)$$
$$(7.0070) \qquad (7.0070) \qquad (7.0070)$$
$$R^2 = 0.9910 \quad DW = 2.2180 \quad PF = 1962\text{-}83$$

The negative sign for the coefficient of CHGDP is attributed to the anti-clyclical approach to public investment as mentioned in the preceding paragraph. The same values for the t-statistics for development expenditure (DDE) and its lagged variables are typical results of the PDL method which has been used to estimate the equation (see also equation 6.4).

6.6 Balance of Payments Block

The balance of payments comprises the trade balance and the capital balance. The components can be combined to form the identity of the overall balance (BPCBRC):-

BPCBRC = EXPGNFS + EXPFS - (IMPGNFC + IMPFS) + GFFRLC + BPCOINC + BSPEROM + BPSDR + BPIMF

where EXPGNFC is export of goods and non-factor services

EXPFS is export of factor services

IMPGNFC is import of goods and factor services

IMPFS is import of factor services

GFFRLC is foreign loan of the government

BPCOINC is corporate investment flow of capital

BSPEROM is residual errors and other items not directly included.

BPSDR is special drawing rights

BPIMF is operation of IMF financing facilities.

The relationship between the surplus or deficit in the balance of payments (BPCBRC) and the Central Bank's external reserves (MASEBNC) is represented by the identity

MASEBNC = MASEBNC(-1) + BPCBRC

The overall balance of payments pattern for Malaysia has been in surplus for most of the years except for 1961, 1967, 1981, 1982 and 1983. The trade balance has generally been positive to reflect the strong export sector of the economy. The services sector has been less developed and it has continued to be in deficit throughout the entire period under consideration.

Evaluation of the balance of payments equation involves the estimation of the component variables of the balance of payment identity. This will be presented in the following sections.

6.6.1 Merchandised Exports

Merchandised exports can be disaggregated into exports of primary commodities and exports of manufactured goods. The major primary exports are rubber, tin, palm oil, sawlogs, sawn timber, and petroleum. The exports of manufactured goods are mainly of the light manufacturing type - food, textile, clothing and footwear.

The volume of export for the main commodities can be explained by the level of output, after accounting for transient imports, the changes in stock and disappearance due to local consumption. As these are relatively stable and small in comparison to the volume of exports, they are omitted from the export equations. Thus, the export equations for the primary commodities are modelled as supply functions.

a) <u>Equation for Exports of Rubber (EXPRUBQ)</u>

EXPRUBQ is a function of the output of rubber (ORUBQ). The estimated equation is:-

$$EXPRUBQ = 83.0340 + 0.9598*ORUBQ \qquad (6.18)$$

(1.0156) (15.2386)

$R^2 = 0.8825$ DW = 1.9440 PF = 1960-83 RHO = 0.655291

b) <u>Equation for Exports of Palm Oil (EXPOPQ)</u>

$$EXPOPQ = 26.5962 + 0.8789*OPALM \qquad (6.19)$$

(0.7985) (39.3225)

R^2 =0.9853 DW = 2.1640 PF = 1960-83

c) <u>Equation for Exports of Sawn Timber (EXPSTQ)</u>

$$EXPSTQ = 23.0830 + 0.5387*OSTIM \qquad (6.20)$$

(0.1727) (13.2634)

$$- 214.2887*DUM7475 - 443.3271*DUM8083$$

(-0.9051) (-1.9317)

$R^2 = 0.9180$ DW = 1.2100 PF = 1960-83

d) <u>Equation for Exports of Sawlogs (EXPSLQ)</u>

$$EXPSLQ = -1007.7433 + 0.5734*OSLOG \qquad (6.21)$$

(-1.1731) (14.4380)

$R^2 = 0.8775$ DW = 1.7500 PF = 1960-83 RHO = 0.538525

e) Equation for Exports of Tin (EXTINQ)

$$EXTINQ = -4.5839 + 1.0783*OTINQ + 0.9633*IMPTINQ \qquad (6.22)$$
$$(-0.4765) \quad (8.1433) \qquad (4.6095)$$
$$R^2 = 0.7554 \quad DW = 1.8976 \quad PF = 1960\text{-}83$$

f) Equation for Petroleum Exports (EXPPETQ)

$$EXPPETQ = -2231.6182 + 0.1153*OPETQ + 1469.2533*DUM6070$$
$$(-3.0100) \quad (16.2531) \qquad (2.6323)$$
$$- 75.1700*DUM7175 + 0.3657*IMPPETQ \qquad (6.23)$$
$$(-0.1994) \qquad (2.2048)$$
$$R^2 = 0.9574 \quad DW = 1.0157 \quad PF = 1960\text{-}83 \quad RHO = 0.835080$$

The pattern for petroleum exports shows three major stages of development. Between 1971 and 1975, exports began to increase rapidly as a result of production from the off-shore fields off the east coast of the State of Trengganu. The facilities developed enabled trade to flourish so that Malaysia was able to export the high quality petroleum and import instead cheaper crude from the Middle East. In the process, imported crude may be re-exported for refining in Singapore and this is reflected in the national statistics where petroleum export quantities has consistently exceeded production since 1976. The complex pattern of exports for petroleum is difficult to model in a single regression equation. Dummy variables were used to delineate the various phases of development, and petroleum imports were included as an explanatory variable.

g) Equation for the Exports of Manufactured Goods

As in many developing countries, the export of manufactured goods is regarded as a way of introducing industrialization into the traditionally agricultural based economy. Usually, local demand for the manufactured goods is limited, and for manufacturing industries to be viable, the goods produced must find an export market. The government also looks towards the manufacturing industries for the creation of employment opportunities. Hence in Malaysia, special free trade zones are established to attract investors to establish their factories. To promote these facilities which include a package of other incentives, the government had established special agencies to facilitate the identification of projects, source of capital, and arrangements for joint ventures.

The strong influence of external market outlets and sources of capital in the manufacturing activities in Malaysia suggests that the export of manufactured product should be estimated through a demand determined function. The export equation is thus made a function of growth in world demand for manufactured goods and the relative price of Malaysian goods. The former is represented by the GDP of the U.S.A. The relative price for Malaysian export is computed as the ratio of the export price index for manufactured goods and the overall import price index (see identity for PXMFGR in Appendix A). The estimated equation for manufactured exports is given by:-

$$\begin{aligned} EXPMFGC = & -2406.0642 + 1.8014{*}GDPUSC + 13.5772{*}PXMFGR \\ & \quad (-4.0368) \qquad (8.4270) \qquad\qquad (1.7455) \\ & - 424.8661{*}DUM7388 \\ & \quad (-1.4140) \end{aligned} \tag{6.24}$$

$$R^2 = 0.9560 \quad DW = 0.7624 \quad PF = 1960\text{-}83$$

h) Equation for Exports of Non-factor Services

Exports of services are mainly tourism, freight and insurance. The export equation for services is treated as a demand function, and it depends on the volume of trade (TXMERR) and the real prices of services (PXSERR). The estimated equation is:-

$$XSVXIR = -686.9057 + 3.8755{*}PXSERR + 0.0948{*}TXMERR \qquad (6.25)$$

$$(-1.5419) \qquad (1.0215) \qquad (9.2869)$$

$$R^2 = 0.7510 \quad DW = 1.2629 \quad PF = 1960\text{-}83 \quad RHO = 0.784554$$

i) Equation for Exports of Factor Services

These are mainly income received from abroad from dividends and earnings from foreign securities held by the central bank. The main explanatory variables are the level of the bank's external reserves at the beginning of the year and the level of foreign interest rates, proxied by a weighted average of the interest rates in the U.S.A. and the UK. The equation for factor services is given by:-

$$EXPFS = -255.6785 + 0.1558{*}MASEBNC(-1) + 32.2170{*}INRBOND(-1)$$

$$(-1.6118) \qquad (6.0672) \qquad (1.1837)$$

$$-\ 76.4178{*}DUM7483 - 165.3351{*}DUM8283 \qquad (6.26)$$

$$(-0.6398) \qquad (-1.4796)$$

$$R^2 = 0.8210 \quad DW = 1.9148 \quad PF = 1961\text{-}83 \quad RHO = 0.629661$$

Having estimated the various components of the export sector, the aggregated export variables can be computed as identities in the model as follows:-

j) <u>Identity for Exports of Goods and Non-factor Services</u>

EXPGNFC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC +EXPTINC + EXPPETC + EXPMFGC + EXPSVXIC + EXPLNGC + EXPOTC

k) <u>Identity for Exports of Merchandised Goods</u>

EXPMERC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC + EXPTINC + EXPPETC + EXPMGFC + EXPOTC + EXPLNGC

l) <u>Identity for Export Value of Primary Commodities</u>

EXPRIMC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC + EXPTINC + EXPPETC + EXPOTC

6.6.2 Import Sector

The import sector is modelled according to disaggregation of imports by economic function. Imports are disaggregated into consumption goods, investment goods and intermediate goods. In addition, imports for non-factor services and imports of factor services are estimated accordingly.

a) <u>Imports of Consumption Goods (IMPCONC)</u>

The imports of consumption goods are mostly luxury items both non-durables and durable of which the major items are motor cars, television, radio sets, refrigerators and fans. The imports of these items are expected to be influenced by the growth of the economy.

The imports of consumption goods are made a function of real consumption expenditure, import tariffs, relative prices of imports to domestic price levels (PIMIR), which equals (PIMI/PGDPI) and dummy variables are included to account for economic downturn in 1975 and racial disturbance in 1969. The resulting estimates are as follows:

<u>Equation for Consumption Goods</u>

$$\begin{aligned} IMPCONC = {} & \underset{(1.4863)}{2010.7789} + \underset{(13.3045)}{0.0798*GDPC(-1)} - \underset{(-0.8395)}{5455.5762*MTRFF} \\ & - \underset{(-0.9694)}{6.8718*PMCNGIR} - \underset{(-1.3599)}{458.9575*DUM75} - \underset{(-1.6408)}{303.0962*DUM6972} \end{aligned} \quad (6.28)$$

$R^2 = 0.9700$ DW $= 0.8198$ PF $= 1961\text{-}83$

Correction for serial correlation, as indicated by the low DW value, did not improve the result. An alternative formulation was tried with consumption expenditure (CONEXPR) replacing GDPC(-1), and the resulting equation, with equally low DW statistics as shown below, was finally used in the simulation because it seemed to give better dynamic simulation results.

$$\begin{aligned} IMPCONC = {} & \underset{(2.3073)}{4809.2261} + \underset{(7.3593)}{0.2070*CONEXPR} - \underset{(-1.9205)}{19051.4551*\ MTRFF} \\ & - \underset{(-2.2520)}{25.7025*\ PMCNGIR} - \underset{(-0.2187)}{123.0680*\ DUM75} - \\ & - \underset{(-1.1319)}{352.6989*DUM6972} \end{aligned} \quad (6.28)$$

$R^2 = 0.9183$ DW $= 0.7240$ PF $= 1961\text{-}1983$

b) <u>Imports of Investment Goods (MIVGC)</u>

The investment goods are mostly machinery and equipment for use in the manufacturing and construction industries. The demand for imports of investment goods depends on the level of real investment activity, relative prices, import tariffs, and in addition dummy variables are used to account for the decline in imports in 1969 and 1975. The dummy variables were later found to be not significant as explanatory variables and they were omitted. The estimated equation is as follows:-

<u>Equation for imports of investment goods</u>

$$\underset{}{MIVGC} = \underset{(4.5137)}{3793.7305} + \underset{(30.7337)}{0.9187*INVTR} - \underset{(-4.6438)}{23.0506*PIMCHIR} \quad \underset{(-4.2371)}{-18192.2656*MTRFF} \tag{6.28}$$

$R^2 = 0.9926$ DW = 1.9201 PF = 1961-83

where INVTR is total investment

PIMMCHIR is price index of imported investment goods divided by GDP deflator.

MTRFF is import tariff.

c) <u>Imports of Intermediate Goods (MINTGR).</u>

Intermediate goods imported are mainly for the manufacturing sector, for construction, and crude petroleum. There has been a rapid increase in the value of imports for intermediate goods since 1974 partly due to the high prices of these imports.

The demand for imports of intermediate goods is explained by the manufacturing activities and generally by growth in GDP. Other explanatory variables are relative prices, PMINTGI/PGDPI or PMINTGIR, and import tariff (MTRFF). Dummy variables are included to account for the effects of racial disturbance in 1969 and the substantial imports to implement the Fourth Malaysia Plan in 1980 despite the recessionary trend.

Equation for Imports of Intermediate Goods

$$MINTGC = 7328.884 + 1.6199*VAMFGR - 34768.2695*MTRFF \quad (6.29)$$
$$(3.3103) \quad (13.3182) \quad (-2.9908)$$
$$- 34.9806*PIMINR + -378.8943*DUM6972 + 5688.462*DUM8083$$
$$(-3.3118) \quad (-1.1662) \quad (-16.6122)$$
$$R^2 = 0.9929 \quad DW = 1.9871 \quad rho = -0.339345 \quad PF = 1961\text{-}83$$

Many other specifications for the above function were explored but the results were unsatisfactory. The price variable (PMINTGR) returned a wrong sign and was replaced by PIMINR, the deflated price index for imports.

d) Imports of Non-factor Services (IMPNFS)

The imports of non-factor services consist mainly of freight and insurance and other services associated with trade. The import function is explained by the volume of merchandised trade, and the relative prices of imports (PIMIN/PGDPI). Polynomial lags in the explanatory variables were used to account for adjustment process of imports to variations in past relative prices and total imports.

Equation for Imports of Non-factor Services

$$IMPNFS = \underset{(2.1735)}{1759.1320} + \underset{(19.8050)}{0.0792*XPMC} + \underset{(19.8050)}{0.0528*XPMC(-1)}$$

$$+ \underset{(19.8050)}{0.0264*XPMC(-2)} \underset{(-2.5458)}{-10.0005*PIMINR} - \underset{(-2.5458)}{6.6670*PIMINR(-1)} \quad (6.30)$$

$$\underset{(-2.5458)}{-3.3335*PIMINR(-2)}$$

$R^2 = 0.9796$ DW = 1.3411 PF = 1963-83

e) Imports of Factor Services (FPDTC)

The imports of factor services are made up of payments of profits, dividends and interest earnings to foreign investors. The main sources of earnings of the foreign investors come from the investments in the manufacturing industries and also in tin and petroleum minings and the rubber and oil palm plantations.

The profit level is dependent on the export price and the volume of sales. As the main exports are primary commodities, the commodity price index was used as the relevant price for the import function for factor services. As a result, import of factor services is made a function of (GDPC) nominal GDP, and the export prices of primary commodities (PPRIMIR).

Equation for Imports of Factor Services

$$FPDTC = \underset{(-2.6383)}{-855.9629} \underset{(19.5078)}{+0.0779*GDPC} + \underset{(1.7026)}{4.7890*PPRIMIR} \quad (6.31)$$

$R^2 = 0.9391$ DW = 1.2565 PF = 1961-83 RHO = 0.736868

f) Identity for Imports of Goods

The identities for the imports of merchandised goods and of total goods are as follows:-

IMPMERC = IMPC- IMPRES

IMPC = IMPCONC + MIVGC + MINTGC + IMPFREX

6.7 Government Sector

The public sector in Malaysia consists of the Federal Government, the 13 State Governments, a number of local authorities (City and Municipal Councils) and certain designated public enterprises. The Federal Government, which accounts for three quarters of public sector consolidated revenue and expenditure, operates through an annual budgeting system where funds for current expenditure and development expenditure are allocated.

The bulk of current expenditure goes into payments of salary to public servants, servicing of debt charges, and contribution to statutory funds and the development fund, which forms an emergency pool of resources for development projects.

The allocation of development expenditure is based on the five year plans the first of which was initiated in 1955. The development targets are indicated in the plan documents but for each year the development plan is implemented through the annual bugetary process. Controlling the development expenditure has been used by the government as a means of regulating the level of government spending, in addition to the manipulating of current expenditure as a fiscal instrument (Tan Siok Lee and Chong Lily Teh, 1979).

The government has implemented a conservative policy on the pattern of spending in that current operation expenditure has been financed entirely by the available domestically raised revenue. Only the financing of development expenditure has required the borrowing of fund from abroad. In recent years, however, foreign borrowing has become increasingly important especially to sustain the high growth rate of development initiated during the late seventies. In addition, the good credit rating for Malaysia enabled borrowing to be arranged with relative ease and this allowed the government to attempt to stimulate the economy during the recession in the early 1980s by maintaining government's targeted spending.

The main sources of funds for financing public sector revenue are public sector savings, domestic borrowing, foreign borrowing, special receipts and the use of government assets. Domestic borrowing by the government has consistently been the major source of funds for development expenditure.

External borrowing has been used as a residual source of funds. Historically, before 1980, Malaysia had always had a small external debt. In 1981, the external debt of the Federal Government was M$ 8.28 billion. This increased to M$ 20.68 billion in 1984.

Other sources of funds include the drawing down of government assets, and short term borrowing from the IMF compensatory financing facilities. The Federal Government has been able to accumulate a pool of funds as another source of financing.

6.7.1 Development Expenditure

The level of development expenditure (GFDETOC) is determined by the development plan target (PLANTAR), the growth rate of nominal GDP (PCGDP), and a dummy variable to capture the period after the introduction of the New Economic Policy (DUM7183). The contribution of domestic loan as a major source of development expenditure was also explored and the best results are given by the following equation.

$$\begin{aligned} GFDETOC = & -407.5933 + 0.1511*PLANTAR + 0.1007*PLANTAR(-1) \\ & \ (-1.3529) \quad\ (2.3413) \qquad\qquad (2.3413) \\ & + 0.0504*PLANTAR(-2) + 1.6889*GFDMLC \qquad\qquad (6.32) \\ & \ (2.3413) \qquad\qquad\qquad (6.2764) \end{aligned}$$

$$R^2 = 0.9358 \quad DW = 1.8844 \quad PF = 1963\text{-}83$$

6.7.2 Domestic Borrowing

The sources of public development financing are public savings, domestic borrowing, foreign borrowing, special receipts and the use of assets. The main source has been domestic borrowing, but in recent years, foreign borrowing has increased significantly. Nevertheless, foreign borrowing is the secondary source after the government has exhausted its ability to borrow from domestic sources. The main variation in the amount of development financing is explained by the availability of domestic sources of finance.

Domestic borrowing (GFDMLC) is thus made a function of the change change in employees provident fund contribution, post office savings (TEPFPOS) and lagged GFDMLC to reflect the effect of present loans on the feasibility of future loans. A dummy is included to reflect the introduction of interest rate liberation policy of the government towards the latter half of the 1970s.

$$\begin{aligned} GFDMLC = {} & \underset{(0.9611)}{121.8243} + \underset{(7.2416)}{3.4993}*TEPFPOS \\ & - \underset{(-1.4979)}{599.7924}*DUM78 \underset{(-1.4451)}{-0.2572}*GFDMLC(-1) \end{aligned} \tag{6.33}$$

$R^2 = 0.9416$ DW = 2.7005 PF = 1965-83

6.7.3 <u>Government Revenue (GREVR)</u>

Government revenue is modelled as the summation of direct taxes (DTAX), indirect taxes (IDTAX) and non-tax revenue (NTAX). Direct taxes are imposed on income and profit, while indirect taxes are derived mainly from taxes imposed on foreign trade, and on the production and sales of services. Non-tax revenue consists of public sector's commercial undertakings, services fees, and receipts from the issue of licences.

$$TGREV = DTAX + IDTAX + NTAX$$

a) Direct Taxes

Direct taxes are derived from individual income, corporate income and petroleum company profits. Non-tax revenue is treated as exogenous in the model. The estimated equations for the other direct taxes are given below:-

$$TXDINDC = -197.7585 + 0.0395*INCINDC(-1) \qquad (6.34)$$

$$(-5.4316) \quad (22.3746)$$

$$R^2 = 0.9578 \quad DW = 1.4160 \quad PF = 1961\text{-}83$$

$$TXDCORC = 169.5485 + 0.2142*INCCORC(-1) \qquad (6.35)$$

$$(2.3763) \quad (18.1207)$$

$$R^2 = 0.9370 \quad DW = 1.4947 \quad PF = 1961\text{-}83$$

where TXDINDC is tax from individual income (INCINDC),

TXDCORC is tax from corporate income (INCCORC),

b) Indirect Taxes

Indirect taxes are estimated from the aggregation of export duties (TXEXPC), import duties (TXIMC), excise duties (TXEC), sale taxes (EXSALE) and other taxes (TIDOTH). The estimated equations for these are given below:-

$$TXEXPC = -91.6914 + 0.0923* EXPRIMC \qquad (6.36)$$

$$(-1.5132) \quad (19.0251)$$

$$R^2 = 0.9401 \quad DW = 0.9129 \quad PF = 1960\text{-}83$$

$$TXIMC = 183.9997 + 0.0777*IMPC \quad (6.37)$$
$$(9.5923) \quad (53.0161)$$
$R^2 = 0.9919$ DW = 1.0828 PF = 1960-83

$$TXEC = 18.3296 + 0.0995*VAMFGC + 3.3156*PCGDPC \quad (6.38)$$
$$(0.7085) \quad (25.1941) \quad (1.7881)$$
$R^2 = 0.9707$ DW = 1.2713 PF = 1961-83

$$TXSALE = -136.4810 + 0.0429*VASEC + 1.3004*DUM7183 \quad (6.39)$$
$$(-5.3253) \quad (14.2101) \quad (0.0282)$$
$R^2 = 0.9470$ DW = 1.3877 PF = 1960-83

The identity for indirect taxes is as follows:-

$$IDTAX = TXEXPC + TXIMC + TXEC + TXSALE + TIDOTH$$

6.8 Financial Flows

There are two categories of financial flows: the domestic and international flows. The domestic flows are explained by the change in government debt and the change in the money supply. The international flows include private investment profits from abroad, remittances of investment profits to overseas, flow of investment capital and the net international reserve position.

6.8.1 Net Claim on the Government

The total local debt of the government is computed from the cumulative loans of the country. This is obtained from the identity

$$GFDDEBC = GFDDEBC(-1) + GFDMLC$$

Gross domestic loan (GFDMLC) has been estimated in the section on government sector.

6.8.2 Money Supply

The supply of money changes in response to government borrowing from the Central Bank and from commercial banks. When the government borrows from the Central Banks, and spends the money, the monetary base changes, and the money supply may change. When the government borrows from the commercial banks, money supply may or may not change. Government securities form part of the banks' reserve assets. Hence borrowing by the government to finance its deficits is likely to lead to changes in the money supply, and thus the money supply will be sensitive to government deficit or surplus. Another factor affecting the money supply is the change in foreign assets (BPCBRC). If foreign assets rise, the domestic money supply will be affected when these foreign assets are converted into local currency by the Central Bank. This situation is explained by the supply and demand identity for reserve money (or high powered money) when at equilibrium.

$$RM^d = CUR + RR + ER$$

$$RM^s = BPCBRC + NCG + LCP + OIF$$

where

CUR is currency in circulation

RR is required reserve

ER is excess reserve

NCG is net credit to the government

LCP is lending to the private sector

OIF is other items

Thus BPCBRC directly influences the reserve money supply. Variation of reserve money could be estimated as a function of BPCBRC, NCG and OIF. However, the present interest is to relate the money supply determinant BPCBRC, to the broadly defined money supply M3Q. The estimated equation for the change in money supply is as follows:-

$$CHM3Q = -12.0971 + 1.0873*BPCBRC + 0.9164*GFDMLC \qquad (6.40)$$
$$(-0.0533) \quad (3.7814) \qquad (8.4804)$$
$$R^2 = 0.8372 \quad DW = 1.8340 \quad PF = 1961\text{-}83$$

The identity for the broadly defined money supply is

$$M3Q = M3Q(-1) + CHM3Q$$

6.8.3 International Flow

The flow of capital from abroad is partly realised through the investment by foreign corporations. The level of foreign investment is made a function of the interest rate (INRA) and the level of remittances from investment earnings (FPDTC). Dummy variables are used to account for the perturbations of the oil crisis in 1973 and 1974. The estimated equation is given by

$$\begin{aligned} BPCOINC = & - 203.9345 + 31.5174*INRA + 0.5746*FPDTC \\ & \quad (1.3595) \quad\quad (0.9666) \quad\quad\quad (7.2088) \\ & - 212.5702*DUM73 + 427.6225*DUM74 \qquad (6.41) \\ & \quad (-0.6384) \quad\quad\quad (1.2662) \end{aligned}$$

R^2 = 0.9099 DW = 1.1175 PF = 1961-83

6.9 Factor Income and Employment Block

6.9.1 Factor Income

Four income categories are idêntified in the model. They are wages and salaries (YWSC), agricultural income (YAC) profit of petroleum companies, and operating surpluses of business corporations i.e. corporate income (INCCORC).

a) Wages and Salaries (YWSC)

Data for wage rates are not available for Malaysia. The wage rate index used in this model is a constructed series. Wages data which are available from the national account statistics for certain years were taken into account in the construction of the wage rate index. Using the constructed wage rate index it was possible to generate data on agricultural income (YAC) by subtracting the wages and salaries (YWSC) from the total individual income (INDINDC).

The wage level is made a function of productivity index (NPRODI), the GDP deflator (PGDPI), and Dummy variables to reflect the two periods when the economy experienced major price changes. The estimated equation for wages and salaries is given by:-

$$
\begin{aligned}
WGRI = & -1.1569 + 0.1176*NPRODI + 0.0191*PGDPI \\
& (-13.1623) \quad (2.3089) \qquad (14.9183) \\
& -0.0302*DUM75 + 0.3249*DUM8083 \qquad (6.42) \\
& -0.4113) \qquad (5.0859)
\end{aligned}
$$

$R^2 = 0.9955 \quad DW = 1.5462 \quad PF = 1960\text{-}83$

b) Agricultural Income (YAC)

Agricultural income represents the residual income not obtained through wages and salaries or from company profits. These may be income from subsistence farming which is significantly influenced by the rubber and palm oil sectors. Agricultural income (YAC) is determined by the level of agricultural output (VAAGRIR) and the export price index of primary commodities (PPRIMI) which is deflated by the cost of production. As the cost of production which comprises mostly wages is not available the overall GDP deflator (PGDPI) was used as a proxy, and the ratio of the two variables is represented by PPRIMIR.

$$
\begin{aligned}
YAC = & -11661.955 + 4.3968*VAAGRIR + 30.4555*PPRIMIR \qquad (6.43) \\
& (-3.6964) \quad (10.5562) \qquad (1.3320)
\end{aligned}
$$

$R^2 = 0.7982 \quad DW = 1.5598 \quad PF = 1960\text{-}83 \quad RHO = 0.683695$

c) Corporate Income

The computation of corporate income (INCCORC) is through an identity as both the agricultural income and wages and salaries have been estimated individually. The variable PRFCOPC representing profits from petroleum companies is treated as an exogenous variable in the identity.

INCCORC = GDPC - YWSC - YAC - PRFCOPC

where GDPC is gross domestic expenditure in nominal term.

YWSC is wages and salaries

YAC is agricultural income

Gross domestic expenditure (GDPC) is obtained from the sum of the aggregate demand components which have been estimated in the demand block.

6.9.2 Employment

a) Employment in the Agriculture Sector.

In 1983, about 36 % of the employed labour force in Malaysia were engaged in the agricultural sector. Within the agricultural sector, there exist two distinct subgroups, a modern commercial agriculture sector and a traditional subsistence agriculture.

The modern agriculture sector consists of the large rubber and oil palm plantations. The traditional agricultural sector where farmers are not under formal salary employment as in the estates sector, consists of the rest of agricultural activities including rice growers and smallholders. Fortunately, as many of the smallholders have participated in the land development schemes of the government, they have increased their efficiency and their participation in the oil palm sector.

The employment in the agriculture sector is formulated as a function of agricultural output (VAAGRIR), a dummy variable to explain the enforcement of the Employment (Restriction) Act (1969) which affects employment of non-citizen workers, and the real wage rate (WGRIR) which is the ratio of wage rate index to the price of primary commodities. WGRI/PRRIMIRI is used to measure the real cost of labour to the producers in the modern agriculture sector.

$$\begin{aligned}
LABAGIR = {} & \underset{(52.8964)}{1511.370} + \underset{(17.1444)}{0.8774*VAAGRIR} - \underset{(-2.2801)}{27.0345*DUM6970} \\
& \underset{(-1.1535)}{-1935.7003*WGRIR} - \underset{(-1.1535)}{1290.4669*WGRIR(-1)} \underset{(-1.1535)}{-645.2334*WGRIR(-2)} \\
& - \underset{(-7.8648)}{99.1358*DUM8083} \qquad (6.44)
\end{aligned}$$

$R^2 = 0.9761 \quad DW = 2.3888 \quad PF = 1963\text{-}83$

b) <u>Employment in the Non-agricultural Sector</u>

Employment in the non-agricultural sector (LABNAGR) is also modelled as a labour demand function. Compared to the agricultural sector, there are more opportunities for factor substitutions in the non-agricultural sector.

The explanatory variables for LABNAGIR are real output of non-agricultural sector (VAGDPNA), relative factor prices (WGRR) which is the ratio of wage rate index to commercial bank's landing rate. The estimated equation is given by:-

$$LABNAGR = 671.0067 + 0.1276*VGDPNA - -941.1574*WGRR \quad (6.45)$$
$$(4.2174) \quad (19.3089) \quad (-2.4136)$$
$$R^2 = 0.9227 \quad DW = 1.4542 \quad PF = 1960\text{-}83 \quad RHO = 0.691272$$

6.10 Price Block

This section deals with the determination of consumer prices, export prices, import prices, the overall GDP deflator as well as price deflators for investment and consumption expenditures.

6.10.1 Consumer Price Index

Price levels or inflationary pressures, as measured by the consumer price index, can be explained by analysing their causes and mechanism of propagation. Usually, the analytical approaches can be classified into three categories: i) the monetarist view and ii) the Keynesian view and iii) the cost-push view.

According to the monetarist view, which is normally associated with the work of Milton Friedman, inflation is mainly caused by excess demand for goods and services generated through an excessive expansion of the money supply in the economy. The

Keynesian view is that inflationary pressures are due mainly to failures in some sectors of the economy to adjust quickly to changes in the level of aggregate demand. The cost-push view which has benefited from the work of Kahn (1976), Hicks (1975) and Kaldor (1976), regards the cause of inflation as the increase in the cost of production, partly from the relative wage leap-frogging practices of union groups.

In Malaysia, inflation was maintained at a low level before 1973. Since then prices began to move upwards at a faster pace. Compared with the rest of the world however, inflation in Malaysia was relatively mild. Except for 1973 inflation rates were below 10 %.

The causes of inflation in Malaysia were traced by Chander, Robless and Teh (1981) as due to the following:

1. Import prices- leading to 'imported' inflation
2. Export prices- triggering increased spending
3. Capital Inflows- triggering increased spending
4. Exhaustion of low cost imports- leading to imported inflation
5. Public sector deficit- triggering increased spending.

Inflation in Malaysia is attributed to both domestic and foreign sources. Individually, the monetarist, Keynesian or cost push view may be regarded as not fully appropriate to explain inflation in Malaysia. A combination of all these views may be more useful.

The list of exogenous variables used for explaining inflation includes wage rate index, index of capacity utilization, money supply, import price index, export price index and direct development expenditure of the public sector. Wage rate, import prices and index of capacity utilization are closely associated with cost-push inflation, while export prices, money supply and direct development expenditure of the government are viewed as demand-pull factors. Lagged money supply is used to explain the delayed effect of money supply changes on prices in view of the price control system implemented by the authorities for essential commodities.

The most suitable equation selected for the model is as follows:-

$$\begin{aligned} PCI = {} & 76.0885 + 0.1847{*}PIMI + 0.0019{*}M3Q(-1) \\ & (12.7856) \quad (3.3125) \qquad (9.4935) \\ & + 15.4908{*}DUM7483 \qquad\qquad (6.46) \\ & (3.4918) \end{aligned}$$

$R^2 = 0.9950$ DW= 1.3930 PF = 1961-83

where PCI is consumer price index

PIMI is price index of imported goods

M3Q is money supply broadly defined.

6.10.2 Implicit GDP Deflator (PGDPI)

PGDPI is a summary measure of the overall price performance in the economy. Since both GDP in current prices and GDP at 1970 prices are determined in the model, the implicit GDP deflator can be derived from the following expression:-

PGDPI = GDPC/GDPR *100

6.10.3 Export Prices

The export prices to be estimated concern the major exports of Malaysia namely rubber, oil palm, sawlogs, sawn timber, tin and petroleum. The prices of these commodities are determined in the international markets. Except for petroleum where there has been a cartel system of pricing, most producers of the above primary commodities have little influence of the prices of their exports (Adams, and Behrman, 1976). In the present model, it is assumed that Malaysia is a price taker for all her primary exports. An investigation by Mohammed (1977) showed that there was no significant effect of Malaysian rubber production on the international price of rubber. Assuming that the international prices of the primary commodities are externally determined in the model, the domestic export price of each of the major commodities is then made a function of the world price of that commodity after the neccessary conversion into local currency.

a) Export Price of Rubber

The export price of the RSS3 grade rubber (PXPRUB3) is a function of world price of rubber converted into Ringgit (WPRSS3*ER) where ER is the exchange rate.

$$PXRUB3 = 296.0262 + 0.6632*WRSS3*ER \qquad (6.47)$$
$$(2.2942) \quad (14.8137)$$
$R^2 = 0.9288$ DW = 1.9933 PF = 1960-83 RHO = 0.801479

Similarly, the price of the RSS1 grade rubber is given by

$$PXRUB1 = 354.3944 + 0.6493*WRSS1*ER \qquad (6.48)$$
$$(2.7091) \quad (14.0072)$$
$R^2 = 0.9234$ DW = 2.1551 PF = 1960-83 RHO = 0.766415

b) Export Price of Palm Oil

The world price of palm oil (WPALM) is highly correlated to the world prices of other major oil and fats. The Rotterdam market is the usual source of price quotations for oils and fats. The export price of palm oil in Malaysia (PXPALM) is related to the world price for palm oil by the following equation.

$$PXPALM = 197.7061 + 0.6947*WPALM*ER \qquad (6.49)$$
$$(5.3959) \quad (21.7577)$$
$R^2 = 0.9519$ DW = 1.7074 PF = 1960-83

c) Export Price of Sawlogs

$$PXSLOG = 17.1537 + 0.5810\ WPSLGE * ER \qquad (6.50)$$
$$(1.24245) \quad (10.0274)$$
$R^2 = 0.9008$ DW = 1.9038 PF = 1960-83 RHO = 0.268052

d) <u>Export Price of Sawn Timber</u>

$$PXSTIM = 11.8814 + 0.6405*WPSTM*ER \qquad (6.51)$$
$$(1.1122) \quad (21.7219)$$
$$R^2 = 0.9528 \quad DW = 1.7522 \quad PF = 1960\text{-}82 \quad RHO = 0.093895$$

e) <u>Export Price of Tin</u>

$$PTIN = 3880.0674 + 0.6820*WPTIN*ER \qquad (6.52)$$
$$(2.3802) \quad (12.3785)$$
$$R^2 = 0.8366 \quad DW = 1.5424 \quad PF = 1960\text{-}83 \quad RHO = 0.823838$$

f) <u>Export Price of Manufactured Exports</u>

The export price index for manufactured goods is postulated to depend on the price of intermediate goods and the level of wages as represented by the respective indices.

$$PXMFGI = 34.8374 + 0.3457*PMINTGI + 27.6019*WGRI \qquad (6.53)$$
$$(5.1575) \quad (5.1147) \qquad (2.7586)$$
$$R^2 = 0.9698 \quad DW = 1.7882 \quad PF = 1960\text{-}83 \quad RHO = 0.303018$$

g) <u>Export Price of Non-factor Services</u>

Export price of non-factor services is related to the general price levels as represented by the GDP deflator index.

$$PXSERI = 12.0025 + 0.9335*PGDPI \qquad (6.54)$$

$$(1.4146) \qquad (15.3568)$$

$R^2 = 0.9609$ DW = 0.8459 PF= 1960-83

h) Export Price of Primary Commodities

The prices of primary commodities are represented by a price index of the main commodities exported by Malaysia.

$$PPRIMI = 0.069967*(0.5514*PXRUB3*0.4486*PXRUB1) + 0.05653*PXPALM + 0.098513*PXSTIM + 0.546*PXSLOG + 0.2249*PPET + 0.004057*PTIN$$

where PPRIMI is the price index of primary commodities, weighted by the average volumes of each commodity over the 1960-1983 period.

i) Export Price Index

Export price index (PEXI) is made up of weighted average sum of price index of primary commodities and price index of manufactured goods.

$$EXPI = 0.4180*PXPRIMI + 0.5820*PXMFGI$$

6.10.3 Import Prices

a) Import Price of Consumption Goods

The import price of consumption goods (PMCONGI) is made a function of world export price index for manufactured goods (WEXPIE), and a dummy to differentiate the post 1973 oil-hike period.

$$PMCONGI = 55.7591 + 0.4109*WEXPIE + 48.1860*DUM7483 \quad (6.55)$$
$$(4.4595) \quad (3.7704) \qquad (3.1115)$$
$$R^2 = 0.9279 \quad DW = 0.6658 \quad PF = 1960\text{-}83$$

b) <u>Import Price of Intermediate Goods</u>

The import price index of intermediate goods is related to the world price index of primary commodities, and to the world price of manufactured goods exported by the developed countries from which Malaysia obtains most of the imports.

$$PMINTGI = -27.4286 + -1.3733*WPRIME + 3.2231*WEXPIE \quad (6.56)$$
$$(-0.5660) \quad (-3.7897) \qquad (5.9814)$$
$$R^2 = 0.8864 \quad DW = 1.4121 \quad PF = 1960\text{-}83$$

The negative coefficient for WPRIME is contrary to expectation, where primary commodities which form part of the intermediate goods imported by Malaysia should have a positive influence on the import price index for intermediate goods. The negative relationship is brought about by the rapid rise in the overall price of intermediate goods in Malaysia relative to world price of primary commodities. However, equation (6.73) is retained to reflect the pattern that existed for the period of estimation.

c) Import Price of Investment Goods

The import price index of investment goods is postulated as a function of world price index of manufactured goods.

$$PIMMCHI = \underset{(4.4548)}{46.2119} + \underset{(5.1377)}{0.2818}* WPMFGIE + \underset{(2.9826)}{35.8498}*DUM7483 \quad (6.57)$$

$R^2 = 0.9450$ DW = 0.8901 PF = 1960-83

d) Import Price Index

The import price index is linked to the weighted price index of investment goods, consumption goods and intermediate goods (PIMIN) and the appropriate dummy variables which shift import prices significantly.

$$PIMI = \underset{(12.2419)}{36.5221} + \underset{(27.5945)}{0.7809}*PIMIN + \underset{(4.7742)}{18.2577}*DUM7483$$
$$- \underset{(-1.6300)}{5.5860}*DUM8283 \quad (6.58)$$

$R^2 = 0.9975$ DW = 1.3549 PF = 1960-83

e) Import tax deflator

Import tax in current values has to be converted into real values and an equation has been formulated for this purpose as follows:-

$$IMTXDFI = 48.3055 + 0.5422^{*} PGDPI + 0.05943^{*} PIMI \qquad (6.59)$$

$$(2.7547) \quad (3.4049) \qquad (0.6221)$$

$R^2 = 0.7340$ DW = 1.3927 PF = 1960-83 RHO = 0.89016

6.10.5 <u>Aggregate Demand Deflators</u>

There are four components of deflators to be estimated. These are deflators for private consumption (PCOPRI), public consumption (PCOPBI), private investment (PINPRI), and public investment (PINPBI). The estimated forms of these equations are as follows.

$$PCOPRI = -7.0444 + 1.0064^{*}PCI \qquad (6.60)$$

$$(-1.2626) \quad (26.6194)$$

$R^2 = 0.9647$ DW = 1.6157 PF = 1960-83 RHO = 0.776873

$$PCOPBI = 50.7049 + 0.2165^{*}PCI + 22.8185^{*}WGRI \qquad (6.61)$$

$$(5.0658) \quad (1.4258) \qquad (4.0335)$$

$R^2 = 0.9808$ DW = 1.6073 PF = 1960-83

$$PINPRI = 33.6695 + 0.3256^{*}PIMMCHI + 29.7966^{*}WGRI \qquad (6.62)$$

$$(10.0649) \quad (6.0941) \qquad (11.8734)$$

$R^2 = 0.9925$ DW = 1.5736 PF = 1960-83

$$PINPBI = 33.6518 + 29.7980^{*}WGRI + 0.3257^{*}PIMMCHI \qquad (6.63)$$

$$(10.0306) \quad (11.8397) \qquad (6.0778)$$

$R^2 = 0.9925$ DW = 1.5688 PF = 1960-83

6.11 The Complete Model

The model has 63 estimated stochastic equations and 70 identities. The complete model can be regarded as consisting of 133 equations with 133 unknowns. There are 54 exogenous variables and most of these are externally determined prices, dummy variables and variables which have been regarded as residuals in the identity relationships of the model. Not all the identities are presented in the above sections as the full set of identities for the model and the list of variable names are presented in Appendix A.

The structure of the equations of the model has been kept linear and the size of the model as small as possible to ensure computability, while maintaining a sufficiently high degree of inter-linkages [4] with the various economic blocks to ensure the high degree of responsive behaviour needed in carrying out the proposed policy analysis experiments. In comparison with models that have been constructed for similar purposes for countries of the South East Asian region, (ESCAP, 1982) the present model is categorised as of a moderate size.

The flow mechanism of the model structure can be viewed in general terms from the flow chart presented in Figure 6.2. The structural linkages of the model can also be demonstrated by ordering the equations into recursive and simulataneous blocks with the help of the TSP programme which will be used for simulating the model. Thus, the detailed flow process in the model can be evaluated by following the causal linkages of the model using the three blocks of ordered equations presented in Appendix A. For example, wage rate index (WGRI) is mainly determined by NPRODI and PGDPI. NPRODI depends on GDPR and LABTOT. PGDPI is a function of GDPR and GDPC. LABTOT is a summation of LABAGIR and LABNAGR while the GDPR is dependent on the value added of the sector in the production block. As shown in Appendix A, these variables appear in the highly simultaneous structure of Block 2 of the model.

At some point in the simultaneous relationship, there are linkages between blocks 1 and 2 of the model. For example, GDPC depends in part on agricultural value added VAAGRIR and both of these variables are in block 2. However, VAAGRIR is linked to block 1 through variables in that block such as output of palm oil (OPALM) while OPALM depends on price of palm oil, PPALMR, which is further up the list in block 1, while PPALMR is a function of PXPALM. PXPALM is finally determined by world price of palm oil (WPALME). The recursive nature of the latter four variables is indicated in the description of the flow process above, and once WPALM is known, PXPALM can be evaluated; with PXPALM known PPALMR can be solved and so on. These variables appear in the recursive block 1 of the model and their values are used as inputs for variables in block 2. Block 3 of the model contains mostly identities which can be evaluated once its component variables whose equations are located in block 2 or 1 have been evaluated.

6.11.1 Use of Dummy Variables

A number of dummy variables have been used in the construction of the macromodel. Dummy variables are used to account for the fact that observations within a given category are associated with one set of regression parameters while observations in a second or third category are associated with different regression parameters. The dummy variable procedure can be illustrated by a simple classical example where consumption is affected by war for some years of the period of observation:

$$C_t = b_1 + b_2 Y_t + a_1 D_t + e_t$$

where D = 1 for war time, and zero other wise.
Noticing that the expected value of C is equalled to $b_1 + b_2 E(Y_t)$ in peacetime and $(b_1 + a_1) + b_2 E(Y_t)$ otherwise, the role of the dummy variable corresponds to the assumption that the intercept of the consumption function changes during wartime but the slope stays the same. A test of whether such a change is statistically significant is provided by a test of the null hypothesis that
$a_1 = 0$. (by checking that the t-statistics of the coefficient of the dummy variable is significant).

A test of whether the slope parameter changes during the observation period can be carried out if the equation is formulated as follows:

$$C_t = b_1 + b_2 Y_t + a_2 D_t Y_t + e_t$$

The use of the dummy variables in the present model provides a way of accounting for the numerous exogenous events that have influenced the growth of the Malaysian economy. The level of structural changes introduced by these events is increased firstly by the long observation period, and secondly by the fact that the economy is influenced by exogenously determined events such as the extreme effects of world economic depression and inflation. In the model simulation stage, the dummy variables help to attain a better fit and lower simulation error but there is a danger that the use of too many dummy variables will weaken the structural relationship of the equations, reduce the degree of freedom and introduce further complications in the forecasting stage of the model simulation. These factors have been taken into consideration when constructing the macroeconometric model in this study.

Notes to the Chapter

[1] A coefficient of slightly greater than 1.0 is expected for such a relationship for AGPI2 but a higher figure of 2.8010 is obtained. This could be due partly to the different dimensions of the component variables forming the indices. The output values of the component variables are not normalised and no allowance or discounting factor is provided to account for the shifts in relative contributions between rubber and oil palm in the AGPI2 index construction. Furthermore, the index AGPI2 does not fully represent the whole of the agricultural sector, and output values as repressented by the index only represent a part of the contribution to value added as input values and price changes also influence the level of real value added. Nevertheless, in actual application of the equation, the simulation error (RMSPE) for Equation 6.1 is quite low and the tracking property is quite good (see Table 7.1 and Figure 7.1).

[2] Durbin Watson (DW) statistics have values ranging from 0.0 to 4.0. An estimation without serial correlation in the regression will show a DW value of 2.0. If the equation contains the lagged term of the dependent variable as an explanatory variable, the DW value will be biased toward 2 as noted in Durbin (1970).

[3] The AR1 method of the TSP procedure (see Hall, 1983) was used for estimating equations with autocorrelated error terms. The equations have to be expanded to account for the rho value when the model is simulated, and thus the rho values are indicated for equations estimated by the AR1 method when the equations are listed in Appendix A.

[4] The linkages between the production functions and investment equations should preferably be more fully established to improve model consistency. The production functions in Section 6.4.3 are not completely supply determined in the sense of the Cobb-Douglas production functions in which labour and capital may be regarded as the possible supply constraints for the developing economy. The absence of such direct linkages is due to the lack of data on value added, labour and capital for the individual production sectors. An alternative approach is to construct investment data for the sectors concerned through an apportioning procedure and to subsequently derive the sectoral data for capital from the investment data as was suggested by Obidegwu and Nziramasanga (1981). Such an approach is considered unsuitable for the present study especially because sectoral value added data are still not available for this study.

CHAPTER 7: MODEL VALIDATION, SENSITIVITY ANALYSIS AND POLICY SHOCK TESTS

7.1 Introduction

The macroeconometric model developed in the previous chapter can be regarded as a general purpose tool which could be used for evaluating various policies related to the Malaysian economy. However, the model must first be validated in order to test its simulation performance and acceptability in terms of:

a) its ability to track past trends of the key endogenous variables,

b) its ability to predict the turning points in the trends for the main economic variables , and

c) its ability to show a sufficient level of sensitivity to shocked changes that could be imposed on certain policy variables that are relevant to the objectives of the policy analysis.

This chapter is devoted to testing these aspects of the model emphasising in particular its suitability for conducting policy analysis experiments concerning the rubber and palm oil sectors in Malaysia.

7.2 The Acceptance Criteria

The acceptance of the model is based on its ability to simulate dynamically the behaviour of the macroeconomic processes operating in the Malaysian economy. It must also be sensitive enough to detect the effects of policy changes which could be applied to influence the development of the plantation sector. The validation procedure thus involves simulating the model and subjecting the results to various tests of simulation errors and sensitivity analysis in relation to shocked changes imposed on the model. The TSP programme was used to simulate the model.

These tests are not exhaustive nor fully conclusive. If a model is linear, it is possible to determine the dynamic properties through an analysis of the characteristic roots and the stability and oscillation behaviour of the model. An equivalent approach cannot be extended to the analysis of nonlinear multi-equation models as there are no equivalent mathematical expressions to characterise the model behaviour (Pindyck and Rubinfeld, 1981). The performance of the model is thus evaluated in the "simulation context". The analyses of simulation errors and magnitude of impacts can then be regarded as an approach designed to provide a balanced judgement of the overall simulation performance of the model. In practice, the performance tests can be applied during the final stages of model construction as this could assist in debugging of errors, and in improving the model into its final form. Part of this validation process includes the flow analysis and 'fine-tuning'. The first involves examining the validity of the interlinkages and flows of determinants using a flow chart of the model (refer Figure 6.2). TSP simulation programme also provides an ordering of the equations so that the recursive and simultaneous structure of the model can be examined and the effect of a shift in a policy variable on the other variables of the model can be monitored more easily through the ordered blocks of equations. The ordering of the equations into the recursive and simultaneous blocks is shown in Appendix A. As regards the second approach, Pindyck and Rubinfeld (1981, p. 402) suggested that it should be used as a last resort to improve especially the simulation errors of the model.

The tracking properties of the model can be measured through a number of methods. These include measurements of the mean absolute error, the root mean square error and the root mean square percentage error. They in turn can be complemented by other forms of error statistics such as the Theil inequality coefficient (U) and its breakdown components (Theil, 1966). Additionally, the plotting of the simulation results alongside the historical values of the respective endogenous variables of the model can give a visual presentation of the ability of the model to predict the turning points in the data trend. Such plots can reveal the tracking performances and the discrepancies between the simulated and historical values of the endogenous variables of the model.

The 'base solution' from the simulation of the final form of the model will be retained for comparing with results of the policy analysis experiments to be presented in the next chapter.

7.3 The Simulation Procedure for Multi-Equation Model

The complete model consists of 63 stochastic equations and 70 identities. Each of the stochastic equations is an estimate of the causal relationship that is hypothesised to exist between an endogenous variable and its determinants. The identities are added to establish the linkages which allow a closed model to be formulated and meaningful economic quantities to be defined and simulated as part of the endogenous variables of the model.

The system of equations which constitute the macroeconometric model contains n equations with n unknowns, where n equals 133 in this model. Most macroeconometric models of this size are usually nonlinear in their endogenous variables, and thus they cannot be solved directly by the matrix inversion method normally applied to linear models. Nonlinear equations can however be easily solved by one of the many iterative techniques available in computer programming packages designed for simulating econometric models.

Usually it is helpful to arrange the equations to reflect the recursive linkages and the simultaneous relationships among the economic sectors. It can be shown that the present model has three blocks of equation. The first block contains 44 recursive equations and these, when arranged in their recursive order, could be easily solved as each of the ordered equations could be evaluated once the equations above it had been solved. The second ordered block contains 77 simultaneous equations and these have to be solved by one of the many iterative methods suitable for solving a system of nonlinear equations. When the system of equations is linear, as represented by

$$Ax = b \ ,$$

the usual method of solution is by matrix inversion.

Thus, $$x = A^{-1} b$$

However, for nonlinear equations, the matrix A cannot be formulated as defined above. When the iterative solution technique is used, such as the Newton method used in this study, the procedure is to apply the idea of the matrix inversion to obtain the solutions for the nonlinear model in the following way: At each iteration, the model is linearised in its variables around values from the previous iteration. The linearised model is then solved by matrix inversion. Other iterative procedures which differ in their iterative efficiency, length of computing time and size of computer storage required, include the Gauss-Seidel and the Fletcher-Powell methods and their variants (see Ortega and Rheinboldt, 1970 ; Rabinowitz 1970). Unlike the more efficient Fletcher Powell method, the Newton method used (Hall, 1983) in the solution of this model does not require that the model be first ordered into recursive and simultaneous blocks, as it is a powerful method if there is sufficient computing capacity.

Finally, a third ordered block of the model contains recursive equations which can be solved once the first and the second blocks are solved (see Appendix A).

As the model is only an empirical representation of the economy being studied, the solved values of the variables of the model will invariably deviate from their historical trends. However, if the equations have been well formulated and estimated the errors should be acceptably small. Simulation of the equations of the model is equivalent to selecting the optimal values of the endogenous variables so as to minimise the residual sum of square values of the functions represented by the equations.

7.4 Simulation Error Analysis

The model was solved for the 1970 to 1983 period both under static and dynamic simulations. The static simulation procedure proceeds by substituting the actual historical values for evaluating the lagged endogenous variables appearing in the equations. The dynamic simulation differs from the static simulation in that it substitutes previously computed values for evaluating any lagged endogenous variables in the equation. Given the system of equations, the dynamic simulation procedure depicts a process similar to what would have happened in a forecasting exercise in 1970 if values for the endogenous variables for the future period of 1970-1983 were not known.

The deviation of the simulated solution from the actual values of the endogenous variables is an indication of the simulation error. These errors can be summarised in different ways to give specific information about the nature of the deviations. Details discussions of the error statistics are given in Theil (1966), Pindyck and Rubinfeld (1981) and Maddala (1977). The summary statistics used for measuring simulation errors in this study are:-

a) the Root Mean Square Percentage Error (RMSPE), and

b) comparison of the mean of the solved values against the mean of the actual values.

In addition, the Theil Inequality Coefficients (U) and the bias components of the inequality coefficient (Um) have been computed and reported together with the error statistics. A further idea of the fit of each equation can be assessed from the plot of the actual and solved values of each endogenous variable of the model. The information from these five types of error statistics provides a complementary set of error indicators which would be adequate to determine the acceptability of the tracking properties of the model.

The root mean square percentage error (RMSPE) is given by

$$RMSPE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} \left(\frac{Ys_t - Ya_t}{Ya_t} \right)^2}$$

where Ys is the simulated value of Y, Ya is the actual value, and T is the number of periods in the simulation.

Other summary statistics, such as the absolute error, mean absolute error or the percentage mean absolute error could also be used. They all reflect the overall 'average' level of errors for the period of simulation for each of the endogenous variables in the model.

The decomposition of the MSE as first suggested by Theil (1966) yields useful measures of the nature of the simulation error. The Theil Inequality Coefficient (U), as it is often called, is defined, in its revised version (Maddala, 1977), as follows:

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Ys_t - Ya_t)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Ya_t)^2}}$$

The numerator represents the mean absolute error. For a good fit, the U value should be close to zero, and in a perfect fit where Ya = Ys, the U value is zero. A higher simulation error will cause the U value to be greater than zero and a U value much greater than 1 indicates a poor fit suggesting an error level which may be unacceptable.

The Theil's coefficient can be decomposed into three components: Um, Us, and Uc as shown below:-

First, it can be shown (see Pindyck and Rubinfeld, 1981, p. 365) that

$$\frac{1}{T}\sum_{t=1}^{T}(Ys_t - Ya_t)^2 = (Ys' - Ya')^2 + (cs - ca)^2 + 2(1 - r)*cs*ca$$

where Ya', Ys', cs, ca are the means and standard deviations of the series Ys_t and Ya_t, respectively, and r is their correlation coefficient.

The three components of the Theil inequality coefficient are then defined as follows:-

i) $Um = (Ys' - Ya')^2/D$

ii) $Us = (cs-ca)^2/D$

iii) $Uc = 2(1-r)cs*ca/D$

where

$$D = \frac{1}{T}\sum_{t=1}^{T}(Ys_t - Ya_t)^2.$$

The proportions Um, Us, and Uc are the bias, the variance and the covariance proportion respectively. It has been claimed (Maddala, 1976) that the latter two components Us and Uc of the inequality coefficients are not very useful in indicating simulations errors, and an alternative decomposition yielding correspondingly the regression and disturbance components in place of Us and Uc has also been suggested by Theil and they can have a more relevant interpretation of error characteristics (Maddala, 1976).

The bias proportion is an indication of the systematic error and regardless of the value of the Theil coefficient U, the value of Um should hopefully be close to zero. Pindyck and Rubinfeld (1981) suggested that a value of Um greater than 0.3 may indicate the presence of a systematic error which may require the revision of the model. In this evaluation exercise, only the bias error (Um) is regarded as the most important of the three components, and the values of the Us and Uc are not included in Table 7.1. They are not critical with respect to the simulation property of the final model and omitting them also saves space as five different types of error statistics are already being reported as shown in Table 7.1 and Figure 7.1. Furthermore, a higher degree of importance is attached to achieving a low value of U and the value for Um also indirectly indicates the level of Us and Uc as the three sum up to 1.

Thus, in the preliminary testing of the model, the information provided by the Theil statistics was used as a guide in diagnosing the nature of the errors. Where the preliminary result showed the presence of a significant bias error, the relevant equations have been re-formulated and in this way some improvements were obtained though in some cases it was not possible to find an improved formulation.

The results of the dynamic simulation are presented in Table 7.1, in terms of the mean values for the endogenous variables and these are compared with the corresponding actual mean values of the variables. The plots of the main simulation results relative to actual data are shown in Figure 7.1. Only dynamic simulation of the model was carried out throughout this study since the dynamic simulation results provide a better test of the forecasting ability of the model compared with those of static simulation (refer to beginning of Section 7.4).

When a multi-equation model is simulated, some variables will have fairly small and acceptable simulation errors while others may show large deviations. Depending on the application of the model and the emphasis of the study, the large errors for some of the equations of the model may be acceptable if the whole model simulates well and the key variables to be emphasised in the study are not badly affected. Usually, under dynamic simulation, errors are cumulatively compounded through the feedback effect of the lagged endogenous variables, and there is a tendency for the model to diverge with the lengthening of the period over which the simulation is carried out. In instances where logarithmic functions are widely employed, there would be a greater tendency for instability problems to occur as reported by Gulbrandson (1984) in his simulation of a macromodel of the Malaysian economy.

There are no standard cut-off points to determine when an error is unacceptably large or when it can be tolerated. The rule of thumb is to ensure that the RMSPEs are below 10 % (Priovolos, 1981). Graphical presentation of the simulation errors gives a direct indication of the simulation performance. However the scale used in the plot of the curves often exaggerates the errors when small values are compared while errors may be suppressed when large values are compared and plotted on a page of the same size.

Table 7.1 Error Statistics for Simulation Period 1970-1983

Variables	Theil Coef.(U)	Theil Bias(Um)	RMSPE (%)	Mean Actual	Mean Solution
Agriculture Sector					
1. Agriculture output (VAAGRIR)	.001	.359	2.7	5388	5295
2. Agricultural production index (AGPI2)	.002	.491	4.5	1585	1541
3. Rubber output, smallholdings (ORUBSH)	.002	.007	4.0	813	816
4. Rubber output, estates (ORUBES)	.002	.137	4.5	617	606
5. Palm oil output (OPALM)	.013	.147	8.4	1697	1613
6. Rice output (ORICE)	.009	.011	10.5	1228	1240
7. Sawn timber output (OSTIM)	.006	.051	7.9	4947	4855
8. Saw log output (OSLOG)	.006	.283	9.6	25521	24410
Other Production sectors					
9. Mining value added (VAMINR)	.014	.022	11.0	1001	983
10. Tin output, (OTIN)	.001	.454	4.3	64	65
11. Petroleum output value (PETVR)	.006	.040	7.2	1059	1080
12. Manufacturing output (VAMFGR)	.007	.695	7.9	3600	3338
13. Construction output (VACONSR)	.002	.129	5.0	924	941
14. Transportation output (VATRANR)	.006	.029	10.4	1334	1353

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11. Petroleum output value (PETVR)	.006	.040	7.2	1059	1080
12. Manufacturing output (VAMFGR)	.007	.695	7.9	3600	3338
13. Construction output (VACONSR)	.002	.129	5.0	924	941
14. Transportation output (VATRANR)	.006	.029	10.4	1334	1353

15. Services output (VASER)	.001	.350	3.3	8076	7886
16. Gross domestic product, real (GDPR)	.001	.618	3.3	20884	20268
<u>Aggregate demand</u>					
17. Consumption expenditure private (CONPRIR)	.004	.032	6.5	11668	11524
18. Consumption expenditure public (CONPUBR)	.007	.354	6.6	3879	3678
19. Investment expenditure, private (INVPRIR)	.008	.078	10.0	3347	3253
20. Investment expenditure, public (INVPUBR)	.012	.723	15.4	2050	2268
21. Gross domestic product (GDPC)	.007	.15	8.2	34579	33300
<u>Trade sector</u>					
22. Petroleum export (EXPPETQ)	.005	.09	39.1	6895	6676
23. Rubber export (EXPRUBQ)	.005	.001	7.0	1513	1515
24. Palm oil export (EXPOPQ)	.009	.242	7.5	1525	1444
25. Tin export (EXPTINQ)	.007	.179	11.2	75	78
26. Sawn timber (EXPSTQ)	.026	.035	15.3	2561	2481
27. Saw log export (EXPSLQ)	.014	.042	12.7	13387	13049
28. Manufactured goods export (EXPMFGC)	.018	.111	52.7	1975	2088
29 Non-factor service export (XSVXIC)	.016	.052	33.9	1729	1791
30. Exports of goods + non-factor services(EXPGNFC)	.001	.022	6.2	17810	17913

31. Exports of merchandised goods (EXPMERC)	.001	.005	5.3	16088	16128
32. Imports of consumption goods (IMPCONC)	.026	.014	18.5	2940	3005
33. Imports of investment goods (MIVGC)	.008	.199	15.3	4322	4531
34. Imports of intermediate goods (MIVTGC)	.009	.243	11.9	6579	6209
35. Imports of non-factor (IMPNFS)	.006	.022	17.7	3518	3569
36. Imports of goods + non-factor services(IMPGNFC)	.003	.002	8.9	17611	17562
37. Imports of merchandised goods (IMPMERC)	.004	.009	8.1	14093	13994
<u>Government sector</u>					
38. Government total revenue(GFTOREV)	.003	.499	7.3	8524	8117
39. Export taxes (TXEXPC)	.031	.002	21.3	1208	1197
40. Import taxes (TXIMC)	.003	.125	6.6	1310	1281
41. Direct taxes (DTAX)	.019	.277	20.5	3233	2946
42. Indirect taxes (IDTAX)	.004	.142	6.5	4229	4109
43. Government debt (GFDDEBC)	.001	.421	3.1	13730	13367
<u>Financial flows</u>					
44. Foreign investment (BPCOINC)	.057	.018	26.6	1356	1410
45. Exports of factor (FPDTC)	.010	.026	16.5	2204	2247

46. Overall balance of payments (BPCBRC)	1.027	.000	380.0	679	672
47. Change in money supply (CHM3Q)	.120	.006	45.3	2676	2589
48. Money supply (M3Q)	.012	.478	12.1	17604	15958
49. External assets of Central Bank (MASEBNC)	.085	.496	27.8	6193	4782
<u>Factor income and employment</u>					
50. Agricultural income (YAC)	.008	.004	10.7	14646	14560
51. Corporate income (INCCORC)	.076	.148	45.1	7403	6451
52. Individual income (INCINDC)	.010	.035	11.1	25778	25238
53. Wage rate index (WGRI)	.009	.005	10.7	2.4	2.4
54. Labour in agriculture (LABAGIR)	.000	.443	0.9	1902	1890
55. Labour in non-agricture (LABNAGR)	.006	.642	7.9	2408	2260
<u>Prices and Deflators</u>					
56. GDP deflator (PGDPI)	.005	.001	7.5	154	154
57. Price index, manufactured goods (PXMFGI)	.016	.023	14.4	202	206
58. Export price index (PEXI)	.007	.001	8.8	182	181
59. Consumer price index	.002	.259	4.0	154	151
60. Rubber price,RSS1, (PRUB1R)	.008	.456	9.3	1047	1111
61. Rubber price,RSS3, (PRUB3R)	.007	.383	8.3	1113	1169

62. Palm oil price (PPALMR)	.006	.057	7.5	661	673
63. Price of tin (PTINR)	.005	.04	8.5	11868	12046
64. Sawn timber price (PSTIMR)	.005	.033	7.3	172	170
65. Saw log price (PSLOGR)	.010	.067	10.1	74	72
66. Import price index (PIMI)	.008	.003	8.8	209	208

7.5 Results of the Tracking Performance Tests

The simulation errors can be conveniently discussed according to the economic blocks of the model. For the output block, both Table 7.1 and Figure 7.1 indicate that the agricultural sector simulates well with the final aggregated variable having a RMSPE of 2.7 %. The other productive sectors are relatively easy to model except for the mining sector which returns a simulation error of 11 %, but overall, the resultant aggregated variable for GDP has a low error of 3.3 %.

In the output block, and throughout the rest of Table 7.1, certain variables show Um values which are greater than 0.3 and as discussed earlier, such level of error may require reformulation of the equation. The process of reformulation and 'fine tuning' of the equations has been carried out, and the retention of equations with higher Um values is justified on the basis that the other error terms are acceptably small and the simulation (tracking) behaviour of the particular equation as judged from Figure 7.1 is also acceptable. It is also important to note that the bias component Um of the Theil error statistic is transmitted to the identities. Thus when an identity contains a variable whose equation has a high Um value, while other variables of the identities have equations with low Um values, the Um value of the identity itself is likely to be high. Considering that even the equation with very small U statistic can have Um value close to 1.0, a balanced view, based on all the error statistics, has to be adopted in accepting the particular equation for the final model. In this respect, the slightly higher Um values for VAAGRIR, AGPI2 and other variables in Table 7.1 are considered admissible.

The errors for the variables of the demand block are summarised by the acceptable RMSPE error of 8.2 % for the aggregated demand (GDPC) even though a slightly larger error was noted for the investment expenditure (INVPRIR). Similarly, the key aggregated variables in the trade block, namely EXPGNFC and IMPGNFC have errors of 6.2 % and 8.9 % respectively. These are considered acceptable even though some larger errors were obtained for some of the component variables. The same arguments apply with respect to admitting equations with slightly higher (RMSPE) error in the sense that overall error statistics for the equation are acceptable and that the particular equation, although necessary as a component of the block concerned, is usually not critical with respect to the policy variables of interest to this study. Thus although a simulation (RMSPE) error level of less than 10 % is desirable for the model of a developing country compared with less than 5% perhaps for the developed country, it is usually not possible to have all the equations perfectly formulated to meet these criteria. As will be shown later, a large (RMSPE) error is indicated for the balance of payments variable, but the plot of the simulated results indicates that the main turning points are replicated by the simulation results, and thus the 380% (RMSPE) error is admissible. Abe (1982), for example, noted a RMSPE error of 1103% for one of the variables (stock change) in the simulation of his model of the Malaysian economy.

The important variables in the government and factor income blocks have relatively low RMSPEs. Where errors are relatively larger such as for export taxes and direct taxes, the plots and the overall assessment of the simulation errors are satisfactory and they do not contribute excessively to the overall simulation error for the aggregated variable in the particular block. Similarly, the price block simulates well, with RMSPE of less than 10 %. Less satisfactory, however, are the errors for the balance of payments (BPCBRC) and corporate income (INCCORC). These are identities which compute the differences of two large values through which large errors can be introduced. The balance of payments is usually a familiar problem encountered in many model simulation studies. Apart from the high level of error tendency due to the computation of the difference of two large numbers, the balance of payments is a variable that contains quantities such as 'errors and omissions' in the actual computation of its value in order that national accounting statistics can be balanced by the authorities concerned. Furthermore, identities in general also transmit the errors of the components variables of the equation and thus less importance is attached to errors in these types of variable. Given that the emphasis of the model construction is to evaluate the impact of policy changes and not on forecasting, the level of errors as discussed above may be acceptably small for purposes of policy analysis. In some modelling work, low simulation error may be sacrificed in favour of good response of the model to policy changes. Such sensitivity tests with respect to policy changes are discussed in the following section.

7.6 Sensitivity Analysis

One of the major requirements in using the macroeconometric model for policy analysis, is to ascertain the ability of the model to detect the impact of policy changes which could be imposed on the economy. A series of policy shocked tests are therefore carried out, and the results are compared with the base solution of the model. The response to the policy shocked tests will indicate the sensitivity of the model but it is also important to ascertain intuitively if necessary that the impacts and changes are of the right signs and order of magnitude. An additional requirement to be emphasised in this study is to examine the acceptability of the changes specifically in terms of the variables of interest which affect the growth and development of the rubber and oil palm sectors.

The shocked changes can be imposed in several ways. Exogenous variables can be given values different from their historical values for the selected years that the shocked changes are imposed. A second approach is to test the effect of a slight change in the coefficients of the endogenous variables. Alternatively, the endogenous variable can be exogenised and shocked changes be applied just as for any exogenous variables.

Usually, it is useful to test the results of the shock applied for just 1 period. Alternatively, the shocked changes can be sustained over several years, maintaining the pattern of fluctuations as found in the historical data.

7.6.1 <u>Shocked Changes to be Introduced</u>

The relevant policy variables of interest which are expected to have a significant impact on the economy are the prices of rubber and palm oil, the planted areas, export duties and the effects of changes in the yield of rubber and oil palm. The impacts of the shocked changes in these policy variables are expected to be detectable in terms of most of the key economic variables stipulated in the model. In particular, the gross domestic product, export revenue and labour demand will be directly affected by policy changes which alter the supply of rubber and oil palm. The sensitivity of the model to these changes will indicate the usefulness of the model for such sectoral policy analysis.

The following shocked changes were imposed during the simulation tests performed on the model:-

1. A sustained 20 % increase in rubber price throughout the solution period. This increase preserves the pattern of price fluctuations for the period.

2. A sustained 20 % increase in the price of palm oil throughout the solution period. This increase preserves the pattern of price fluctuations for the period.

3. A one period fall of 40 % in the price of palm oil in 1970

4. A sustained 30 % yield increase in the yield of rubber from the smallholding sector throughout the solution period.

5. A sustained yield increase of 40 % for palm oil throughout the solution period.

6. A sustained increase in mature area for oil palm resulting from direct conversion of rubber areas throughout the solution period.

7. The effect of abolition of export duties on rubber throughout the solution period.

7.6.2 Dynamic Multipliers

To analyse the effect of the shocks, dynamic multipliers are calculated. For sustained shocks, a multiplier value is calculated for each period. It is given by

$$Mt = \frac{(Xs^t - Xc^t)}{dZ^t}$$

where Xs^t and Xc^t are the values of the endogenous variables X in the shocked and base solution respectively, and dZ^t is the shock applied.

For a one period shock, the dynamic multiplier is calculated as

$$M_t = \sum_{t=1}^{T} \frac{(Xs^t - Xc^t)}{dZ}$$

where dZ is the exogenous shock applied at time t = 1, and T is the length of the simulation period.
The distribution effects of the changes can be compared by computing the marginal share of gross domestic output

$$MS_t = 100*(Xs^t - Xc^t)/ (Ys^t - Yc^t)$$

where Ys^t and Yc^t are the gross domestic product for shocked and base solutions respectively so that $Ys^t - Yc^t$ is the induced effect of the exogenous change in Z on the gross domestic product. The terms Xs^t and Xc^t, as described earlier, are the values of the endogenous variable X in the shocked and base solution respectively. Thus the change in export revenue relative to the induced change in GDPC can be obtained from the computation of MS_t for a given change in a policy variable.

The marginal share (MS_t) can be compared with the average share (AS_t) to determine the impact of the change in the exogenous variable on the distribution of income.

Average share (AS_t) is given by

$$AS_t = 100 * Xc^t / Yc^t$$

Thus AS_t, which is the ratio of the base solution of an endogenous variable X such as export revenue, to the base solution value of gross domestic product (GDPC) is compared with MS_t values as shown in Tables 7.4 and 7.5.

7.6.3 Results of the Sensitivity Tests

The model was simulated over the period 1970 to 1983 and for each simulation, a single policy change was imposed. The results are analysed according to the methods discussed above.

a) Effect of a Sustained Increase in Rubber Price.

The prices of rubber are exogeneous in the model. The export and producers' prices for rubber are based on these externally determined prices, and thus changes imposed on them should have an effect on the economic activity in the Malaysian plantation industry and on the major macroeconomic variables.

The response of the model, under dynamic simulation, to shocked price changes for rubber is shown in Table 7.2. A sustained 20 % increase in rubber price beginning in 1970 resulted in a corresponding increase in the current GDP by between 1.6 to 3.5

%. Over the solution period, the price indices appeared to increase initially so that real GDP increased only slightly and later showed a decrease. There was an apparent decrease in palm oil output, which could be interpreted as the induced shift in resources from palm oil to rubber due to the attraction of the relative increase in rubber price.

It is interesting to note that the interactions in the model cause real GDP, agricultural value added, investment and employment to become lower towards the later part of the simulation. The effect of the sustained 20% increase in rubber price appear to shift resources from other agricultural sectors into rubber causing, on balance, a decline in overall real value added. In turn, a greater decline in both agricultural and non-agricultural labour demand causes the total labour demand to decline, and the greater level of reduction in non-agricultural labour demand causes the decline in total labour demand to be greater than that for agricultural labour.

Other variables which are directly affected by the shocked changes in rubber prices are the exports of goods and services, and money supply through the increase in net foreign reserve of the Central Bank. Export earnings will influence the GDP in current terms and hence the GDP deflator. A more than proportionate increase in the price deflator will result in a decrease in real commodity prices and these in turn affect the output of other commodities negatively.

As the model treats mature area as an exogenous variable in the output equation for rubber, the long term impact of price changes which should have an effect on the mature area is not fully reflected in the model. This contributes to a slight underestimate of the possible impact. In subsequent policy simulation experiments, which deal with area changes rather than price changes, the shortcoming is remedied by adjusting the effect of changes on mature area in terms of employment, income, and investment changes.

b) <u>A sustained 20 % increase in palm oil price</u>

A sustained shocked change imposed on the price of palm oil over the solution period has a similar effect on the economy as that for rubber. However the impact is much smaller initially due to the smaller proportion of palm oil output especially in the early seventies (Table 7.3). As explained above, the lack of direct acreage response to the shocked changes in price resulted in a lower rate of response for the later part of the solution period when the impact of price on planted area would be expected to be significant. The negative impact on rubber production is due to the decrease in the real price of rubber, as a result of inflationary trend generated by the price increase in palm oil. This phenomenon can be interpreted as the indirect shift in competitive position of palm oil relative to rubber resulting from the imposed price increase in the former commodity. The inflationary trend is explained by the increase in export earnings which affect current GDP and thus PGDPI, and the impact on money supply which affects the consumer price index.

The relative effects of the price changes for rubber and palm oil on the economy can be compared by evaluating their resultant contributions in terms of MS_t and As_t ratios discussed in Section 7.6.2. The ratios of the induced change in the variable of interest in relation to the induced change in GDPC arising from each simulation of shocked price are shown in Tables 7.4 and 7.5 in terms of MS_t and AS_t values although only one AS_t value can be computed for each variable in each simulation run. The values of the induced changes in the component of GDP such as export revenue relative to the induced change in GDP itself provides an indication of the sensitivity of the individual variables to changes in prices of rubber or palm oil.

A 20 % change in the price of rubber appears to induce a proportionately larger change in marginal share for export revenues, transportation, and manufacturing, and surprisingly a lower than proportionate share in agricultural value added as shown by their respective MS_t values. The lower contribution of the agricultural sector to GDP is explained by the drop in relative real prices of commodities which in turn affected agricultural output and hence real value added for agriculture. The positive response of the export and transportation sectors to changes in commodity prices is in agreement with the notion that the major crops and commodities are produced and transported for the export markets.

A comparison of the distribution of induced effects becomes difficult and perhaps invalid when the denominator approaches zero and becomes negative. This problem was encountered when changes in real GDP become negative for the 1980-1983 period for rubber and 1983 period for palm oil. An alternative is to convert the quantities into current values and compute the respective marginal shares, but this procedure was not computed in this study.

c) <u>A 40 % fall in the price of palm oil in 1970</u>

A one period price fall of a major commodity would normally have a direct impact on the economy as well as secondary effects. For palm oil, the secondary effects appear to last up to four years after the occurrence of the shocked price change (Table 7.6). The computed multiplier effect is 285 tonne decrease in palm oil output per dollar fall in price. This is much larger than the direct effect of 176.7 tonne per dollar which can be calculated from the price coefficient in the output equation for palm oil. The contribution from the multiplier effect highlights the interesting contrast between the information obtained from a dynamic multi-equation model against that from single equation models. In a single equation model only the direct multiplier effect can be computed.

d) <u>A sustained 30 % yield increase in rubber smallholdings</u>

An interesting test is to impose a shocked change in the yield of rubber from the smallholding sector by changing the coefficient for planted area. A large number of smallholders are dependent rubber for their income. Thus various ways have been devised by the authorities to improve the yield of rubber from the less efficient smallholding sector. If a significant change in yield could be introduced, the probable impact as in Table 7.7 is an overall increase in real output. An increase in physical output, unlike increases in commodity prices, has a lower inflationary effect on prices and thus real GDP can expand. However, some negative effects on palm oil output are obtained; the inevitable increase in price deflators will cause real producers' price to decline, albeit small, resulting in the decline in palm oil output.

e) <u>A sustained yield increase of 40 % for palm oil.</u>

If palm oil output could be increased by some means, the result would appear to be highly beneficial to the country. Both real and current gross domestic production appeared to increase (Table 7.8). The pattern of increase is similar to that for rubber though the initial impacts are smaller because of the lower level of palm oil output in the early seventies. A larger shocked change of 40 % was introduced compared with 30 % for rubber above to account for the lower level of planted acreage of oil palm relative to rubber especially in the early 1970s. The changes introduced must be adequately large to ensure that the model can indicate significantly the resulting changes.

f) <u>A sustained increase in mature area for oil palm resulting from direct conversion of rubber areas throughout the solution period.</u>

If for simplicity it could be assumed that mature rubber areas could be instantaneously changed into mature oil palm areas each year without any prior development costs, the changes that could result are shown in Table 7.9. In general such a change appears to cause losses or only marginal gains to the economy. Government revenue is more affected probably because of the loss from the higher levy of export duty for rubber compared with palm oil. These changes however, underestimate the potential impacts because of the lack of additional relationships in the model to represent the effect of area changes on income, labour demand and on the level of investment. These latter changes would have to occur simultaneously in practice in order to bring about a certain change in mature areas for a plantation crop.

g) <u>The effect of abolition of export duties on rubber throughout the solution period.</u>

The government has traditionally depended on the levy of export duties on rubber and other commodities as a means of obtaining revenue. The duty structure has also been employed to control excessive income generated through the exports of commodities during high prices. However, as income from rubber and other commodities undergo a progressive decline because of a secular fall in commodity prices in recent years, the imposition of export duty raises the question of the wisdom of taxing the producers the majority of whom are earning at below the taxable rate of income. The argument for removal of the export duty presupposes that the tax burden is borne by the producers and not the overseas buyers thus implying also the assumption that the commodity market is generally a buyers market.

The impact of removing the duties on the export of rubber in a situation where the tax burden is fully borne by the producer can be easily evaluated by this model where price is already an exogenously determined variable. The results of imposing a zero duty on rubber export showed that the total revenue change received by the government is small and over the long run removing the export duty appears to have a positive beneficial effect on the economy (Table 7.10). This observation augurs well for the plan by the government to reduce or remove export taxes in the near future.

7.7 Conclusions for the Model Validation Tests

In evaluating the simulation error statistics, two considerations are relevant. The first is how well the model performs in comparison to other models of similar type, size and class; the second pertains to the uses for which the model is intended.[1]

Results from simulation studies by Obidegwu and Nziramasanga (1981), Ho (1983) and Gulbrandson (1984) seemed to meet the criterion that the root mean square error for the major macroeconomic variables should be less than 10 percent. Priovolos (1981) had compared six econometric models for developing countries. He found that for these models the RMSPE for the real GDP and CPI were in the region 2.9% - 5.3% and 2.1% - 9.1% respectively. The corresponding values obtained in this study are 4 % and 8.2 respectively while the simulation error for real GDP is 3.3 %. These fall within the range of errors indicated by the studies mentioned above.

As the model is to be used for policy simulation, a greater importance is attached to the response within the consistent framework aspect of the model behaviour. Thus a number of sensitivity tests were conducted to evaluate the response of the model under policy shock simulation. These tests showed that the model was able to respond adequately and appropriately to shock changes introduced to prices, yield, and mature areas for rubber and oil palm.

As mentioned earlier, the model has been constructed for use in policy simulation analysis in the planning of the development of the oil palm and rubber industry. The emphasis in the validation procedure was therefore focussed on the adequacy of the model to fulfil the intended application. This implies that variables with large simulation errors but not important in terms of the plantation sector, may still be accepted as part of the model, provided that they contribute to the model in a consistent manner.

Considering all the error statistics and graphical properties of the simulation and the sensitivity test results, as presented in the previous sections, the model performs reasonably well.

It is noted that the sensitivity tests showed that the model responds adequately to perturbations in the key variables and parameters which are important to the planning and policy analysis of the plantation sector. The response is of the right order of magnitude and in the right direction. The rigidity existing in the output equation for rubber and oil palm tends to underestimate the resultant impact. This inflexibility is due to the lack of feed back relationship linking mature area with price changes. However, as mature area is intended to be a control (exogenous) variable in subsequent policy analysis, the desired additional linkages are added in when the model is used for policy analysis (see Chapter 8).

Changes in the rubber and palm oil sector affect output and real GDP as well as the export sector and hence current GDP. Additional effects are observed in the money supply changes brought about by the changes in the balance of payment and net foreign assets of the Central Bank. The effects are translated predictably into inflationary changes which form a feedback mechanism to induce changes in the productive and other economic blocks of the model.

Typically, the plantation sector appears to affect the economy significantly through the changes in income, employment and prices. This signifies the importance of the sector in terms of national income, the number of people employed, and the other induced effects resulting from changes in the plantation sector.

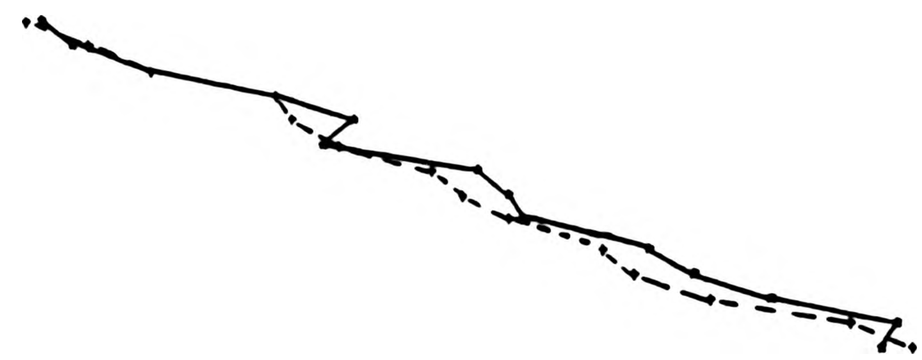
Finally, it is important to highlight that the results of simulating the model under a scenario of zero export duty for rubber showed a positive though marginal gain to the economy in the long-run, and this could form the basis for supporting the view of the industry that export duties on rubber should be abolished.

Notes to the Chapter

[1] A certain amount of model validation tests have been carried out, and these appear to be adequate for purposes of the present study. In practice, however, it is usually necessary to supplement the validation procedure by analysing the structural specifications of the equations using some other formal specification tests and also to perform more exhaustive sensitivity tests against a wider range of relevant key parameters and variables before the model can be used in actual policy formulation exercise.

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: VAAGRIR

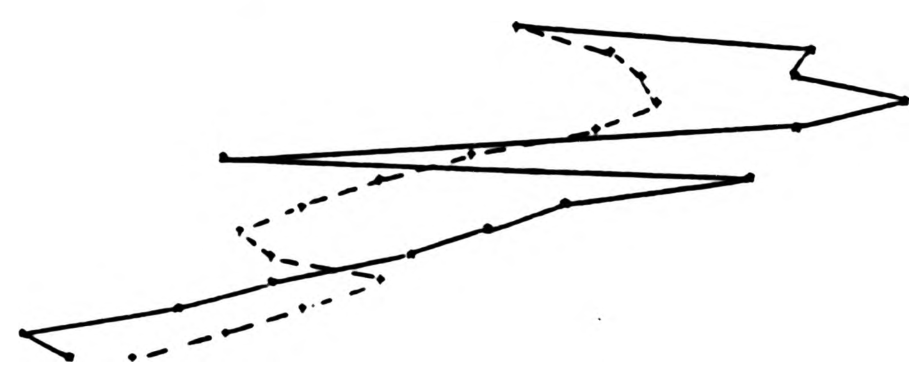
PREDICTED SERIES: VAAGRIRS



ID	ACTUAL	FITTED	RESIDUAL
1970	3766.0000	3689.6577	76.3423
1971	3852.0000	3904.3228	-52.3228
1972	4146.0000	4153.2637	-7.2637
1973	4634.0000	4638.1387	-4.1387
1974	4954.0000	4701.8647	252.1353
1975	4804.0000	4861.5835	-57.5835
1976	5392.0000	5222.7549	169.2451
1977	5519.0000	5325.7944	193.2056
1978	5610.0000	5542.7573	67.2427
1979	6068.0000	5885.7402	182.2598
1980	6255.0000	5999.0239	255.9761
1981	6516.0000	6310.8042	205.1958
1982	6995.0000	6825.2339	169.7661
1983	6922.0000	7070.2373	-148.2373

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: ORUBES

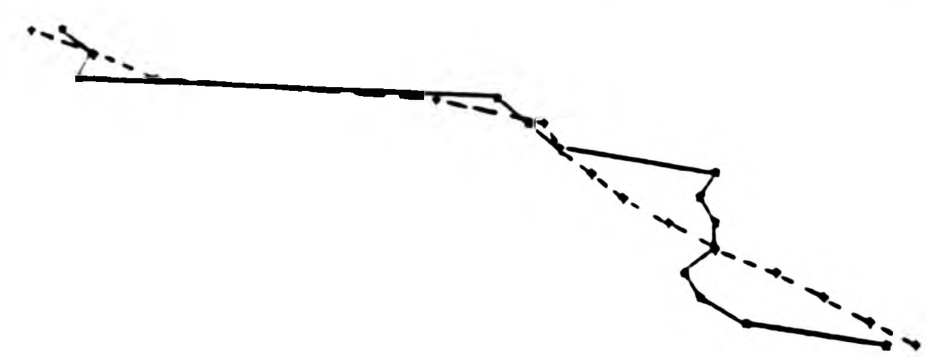
PREDICTED SERIES: ORUBESS



ID	ACTUAL	FITTED	RESIDUAL
1970	621.0000	621.4196	-0.4196
1971	661.6000	633.0915	28.5085
1972	659.3000	639.0536	20.2463
1973	673.0000	639.4694	33.5306
1974	659.5000	630.8942	28.6058
1975	580.8000	614.7239	-33.9239
1976	651.7000	602.1249	49.5751
1977	627.6000	591.5522	36.0477
1978	618.0000	583.7009	34.2991
1979	607.3000	588.6073	18.6927
1980	586.3000	601.1648	-14.8648
1981	574.3000	592.6968	-18.3968
1982	554.3000	581.8075	-27.5075
1983	560.1000	569.2913	-9.1913

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: ORUBSH

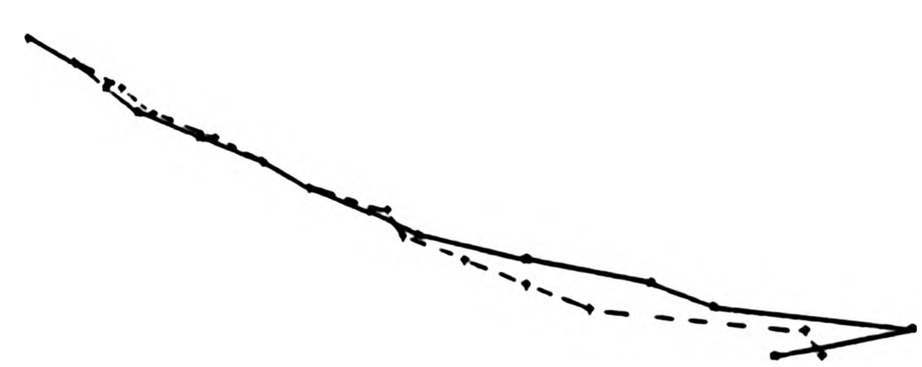
PREDICTED SERIES: ORUBSHS



ID	ACTUAL	FITTED	RESIDUAL
1970	594.7000	580.4474	14.2526
1971	608.8000	605.2983	3.5017
1972	598.8000	633.7838	-34.9838
1973	791.5000	764.5259	26.9760
1974	801.0000	807.7108	-6.7108
1975	817.5000	817.7045	-0.2045
1976	884.0000	828.5607	55.4393
1977	883.9000	843.3762	40.5238
1978	988.0000	963.8016	24.1984
1979	950.0000	946.6312	3.3688
1980	877.1000	916.1618	-39.0615
1981	882.3000	936.8407	-54.54070
1982	902.3000	958.1252	-55.82530
1983	961.5000	978.4577	-16.9577

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: OPALM

PREDICTED SERIES: OPALMS



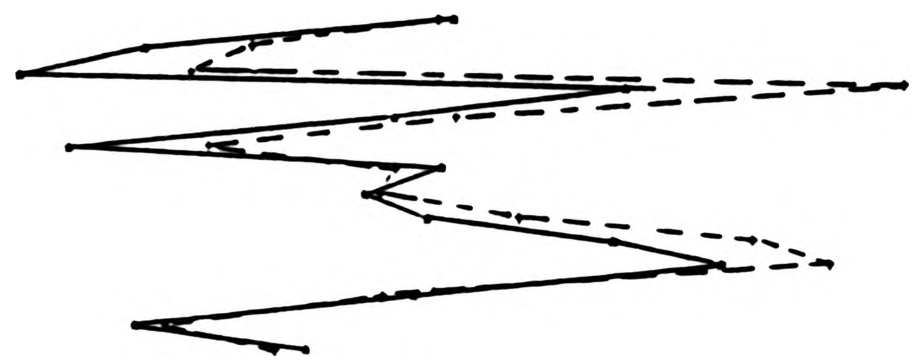
ID	ACTUAL	FITTED	RESIDUAL
1970	431.0000	442.9294	-11.9294
1971	588.9000	592.8233	-3.9233
1972	726.3000	734.0112	-7.7112
1973	810.1000	887.7769	-77.6769
1974	1041.5000	1067.0212	-25.5212
1975	1257.3000	1235.2425	22.0575
1976	1389.7000	1420.2344	-30.5344
1977	1612.7000	1700.3486	-87.6486
1978	1785.5000	1722.2612	63.2388
1979	2188.3999	1933.9720	254.4279
1980	2575.6001	2159.3879	416.2122
1981	2824.5000	2362.8984	461.6016
1982	3514.2000	3112.4741	401.7258
1983	3011.8999	3210.0898	-198.1899

Figure 7.1: Plots of Actual and Fitted Values of Selected Variables of the Model.

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: PRUB1R

PREDICTED SERIES: PRUB1RS

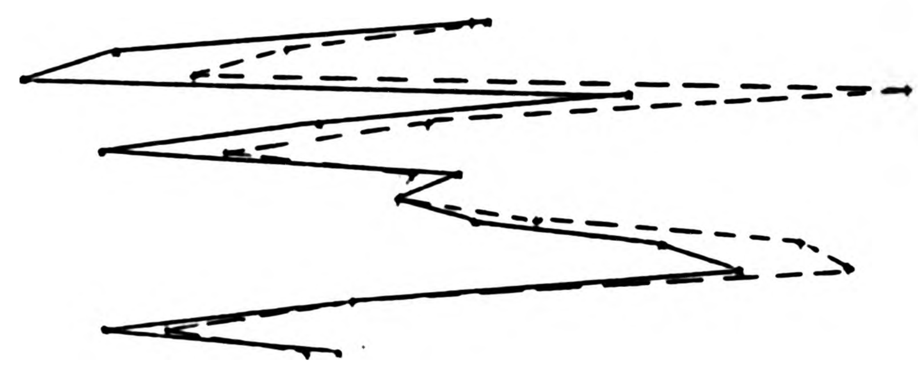
ID	ACTUAL	FITTED	RESIDUAL
1970	1188.8905	1166.9845	21.9060
1971	937.98045	1023.9227	-85.9418
1972	841.89625	979.58327	-137.6870
1973	1314.9879	1536.9523	-221.96440
1974	1131.7318	1185.3730	-53.6412
1975	882.43605	988.71520	-106.2792
1976	1170.7527	1138.7968	31.9559
1977	1108.8853	1118.9680	-10.0828
1978	1164.4171	1226.0573	-61.6401
1979	1307.7589	1418.6073	-110.8484
1980	1390.5944	1478.3000	-87.7057
1981	1146.0732	1120.0789	25.9944
1982	932.36572	946.43309	-14.0673
1983	1057.1815	1037.0212	20.1603



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: PRUB3R

PREDICTED SERIES: PRUB3RS

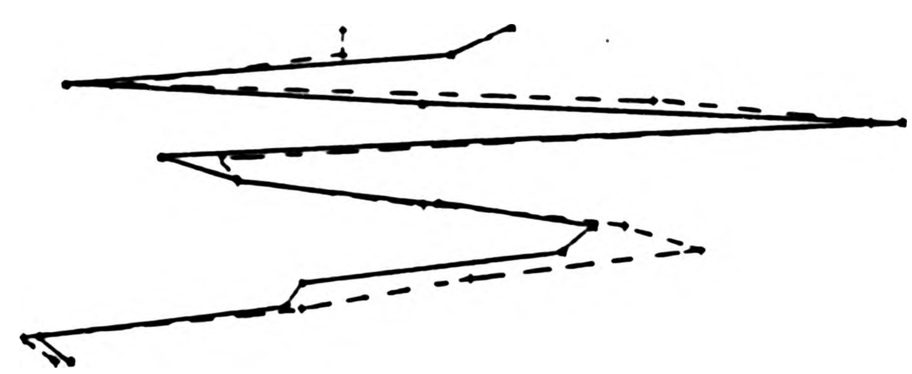
ID	ACTUAL	FITTED	RESIDUAL
1970	1143.0168	1131.5194	11.4974
1971	855.81526	978.89014	-123.0749
1972	778.84368	913.99968	-135.1561
1973	1247.0098	1465.2705	-218.26090
1974	1008.4651	1094.2896	-85.8244
1975	838.99191	935.90006	-96.9080
1976	1115.8313	1082.3156	33.5157
1977	1062.6818	1062.4991	0.1826
1978	1126.6837	1177.5074	-50.8237
1979	1269.0970	1377.4312	-108.3341
1980	1329.3481	1422.6211	-93.2770
1981	1025.9089	1031.7148	-5.8059
1982	840.79829	884.90678	-44.1085
1983	1019.9321	995.93518	23.9970



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: PPALMR

PREDICTED SERIES: PPALMRS

ID	ACTUAL	FITTED	RESIDUAL
1970	730.2282	650.6148	79.6134
1971	711.3415	653.5018	57.8397
1972	517.4846	542.0535	-24.5690
1973	694.6025	808.1982	-113.59570
1974	929.9623	916.9993	12.9630
1975	564.0776	591.0972	-27.0196
1976	602.7150	601.1061	1.6088
1977	702.2122	692.0775	10.1346
1978	773.2750	790.7452	-17.4703
1979	760.9744	832.6354	-71.6611
1980	627.5298	714.4663	-86.9365
1981	620.2981	627.3860	-7.0879
1982	497.5981	492.8116	4.7866
1983	513.6261	504.5003	9.1260



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: GDPR

PREDICTED SERIES: GDPRS

ID	ACTUAL	FITTED	RESIDUAL
1970	12560.0000	12217.8398	342.1602
1971	13016.0000	12916.6719	99.3281
1972	14241.0000	13789.6865	451.3135
1973	15904.0000	15447.7988	456.2012
1974	17227.0000	16920.7012	306.2988
1975	17365.0000	17237.1172	127.8828
1976	19288.0000	18923.3633	364.6367
1977	20753.0000	20287.7734	465.2266
1978	22264.0000	21304.4961	959.5039
1979	24324.0000	23197.9004	1126.0996
1980	26228.0000	24775.4023	1452.5977
1981	28092.0000	26420.5332	1671.4668
1982	29077.0000	28477.6602	699.3398
1983	31442.0000	31339.6113	102.3887

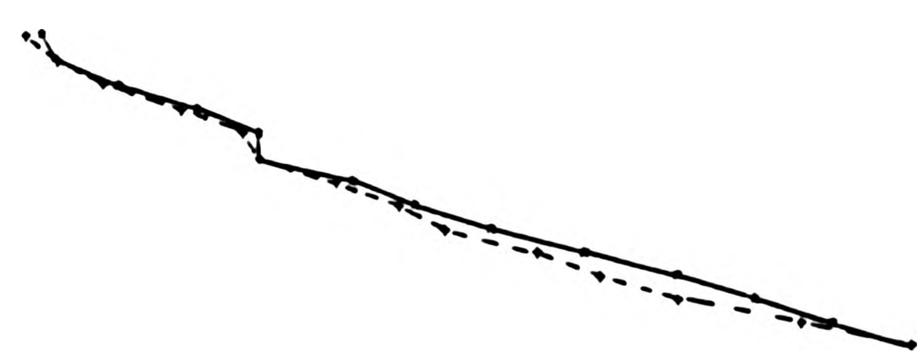
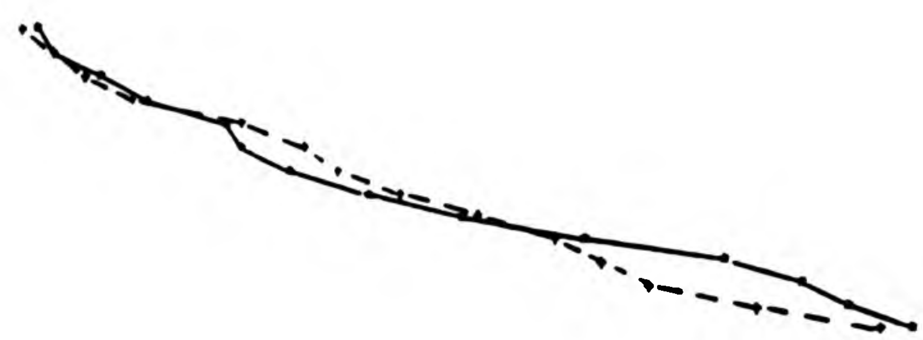


Figure 7.1 (Continued)

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: CONEXPR
PREDICTED SERIES: CONEXPRS

ID	ACTUAL	FITTED	RESIDUAL
1970	9537.0000	9407.8018	129.1982
1971	9809.0000	9925.6650	-116.6650
1972	10561.0000	10384.9268	176.0732
1973	11458.0000	11070.6045	387.3955
1974	12641.0000	12951.8906	-310.8906
1975	12748.0000	13924.2383	-1176.2383
1976	13601.0000	14419.9033	-818.9033
1977	14886.0000	15194.1094	-308.1094
1978	16329.0000	16426.8730	-97.8730
1979	18127.0000	17786.9219	340.0781
1980	20476.0000	18524.8828	1951.1172
1981	21632.0000	19126.3438	2505.6563
1982	22475.0000	20890.0430	1584.9570
1983	23380.0000	22795.6445	584.3555



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: INVTR
PREDICTED SERIES: INVTRS

ID	ACTUAL	FITTED	RESIDUAL
1970	2207.0000	2282.9031	-75.9031
1971	2609.0000	2598.0410	10.9590
1972	2998.0000	3008.2336	-10.2336
1973	3489.0000	3482.0515	6.9485
1974	4252.0000	3848.1182	403.8818
1975	3936.0000	3991.9688	-55.9688
1976	4133.0000	4458.1836	-325.1836
1977	4677.0000	5215.9082	-538.9082
1978	5119.0000	5601.3662	-482.3662
1979	5798.0000	6197.1328	-399.1328
1980	7186.0000	6926.6440	259.3560
1981	8837.0000	8484.3740	352.6260
1982	9800.0000	9983.9307	-183.9307
1983	10517.0000	11215.1973	-698.1973

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: EXPGNFC
PREDICTED SERIES: EXPGNFCS

ID	ACTUAL	FITTED	RESIDUAL
1970	5389.0000	5304.9536	84.0464
1971	5242.0000	5563.7095	-321.7095
1972	5121.0000	5929.7266	-808.7266
1973	7767.0000	8554.4775	-787.4775
1974	11043.0000	11189.4971	-146.4971
1975	10172.0000	11121.5205	-949.5205
1976	14554.0000	14197.3672	356.6328
1977	16216.0000	15963.8838	252.1162
1978	18585.0000	18489.9492	95.0508
1979	26004.0000	26161.6191	-157.6191
1980	30676.0000	31105.4941	-429.4941
1981	30154.0000	28813.3477	1340.6523
1982	31431.0000	30343.0898	1087.9102
1983	36479.0000	37537.9141	-1058.9141

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: IMPGNFC
PREDICTED SERIES: IMPGNFCS

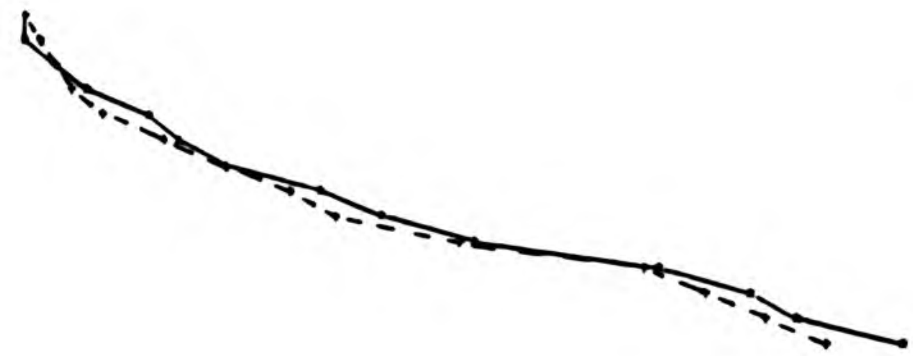
ID	ACTUAL	FITTED	RESIDUAL
1970	4888.0000	5069.5151	-181.5151
1971	5056.0000	5377.6187	-321.6187
1972	5313.0000	5933.9243	-620.9243
1973	6712.0000	8162.0723	-1450.0723
1974	10989.0000	11242.4551	-253.4551
1975	10071.0000	11016.2734	-945.2734
1976	11620.0000	13031.3887	-1411.3887
1977	13788.0000	15007.5049	-1219.5049
1978	16477.0000	16483.3301	-6.3301
1979	21884.0000	20649.6816	1234.3184
1980	29342.0000	27833.5098	1508.4902
1981	33859.0000	31464.0684	2394.9316
1982	36849.0000	35158.1523	1690.8477
1983	39705.0000	39445.0703	259.9297

Figure 7.1 (Continued)

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: GFTOREV

PREDICTED SERIES: GFTOREVS

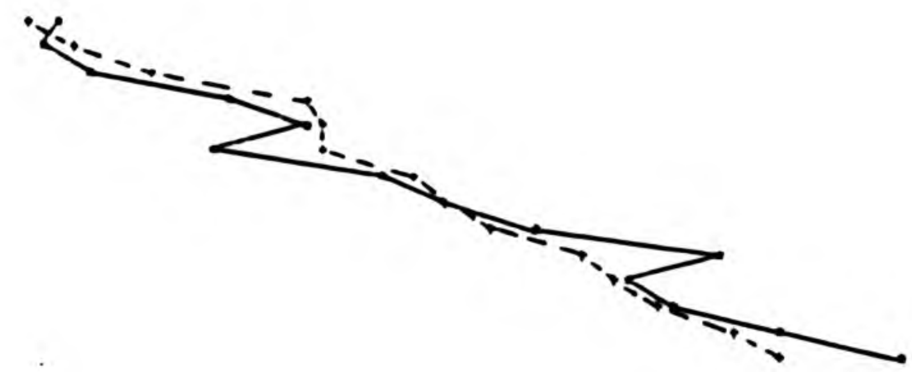
ID	ACTUAL	FITTED	RESIDUAL
1970	2400.0000	2437.0684	-37.0684
1971	2418.0000	2588.3286	-170.3286
1972	2920.0000	2885.3079	34.6921
1973	3398.0000	3153.7271	244.2729
1974	4288.0000	3824.8174	463.1826
1975	5117.0000	4890.8174	226.1826
1976	6157.0000	6064.6763	92.3237
1977	7760.0000	7366.1191	393.8809
1978	8841.0000	8014.4395	826.5605
1979	10505.0000	10224.8154	280.1846
1980	13926.0000	13706.0283	219.9717
1981	15806.0000	14994.1553	811.8447
1982	16690.0000	16176.3447	513.6553
1983	18608.0000	17317.7207	1290.2793



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: YAC

PREDICTED SERIES: YACS

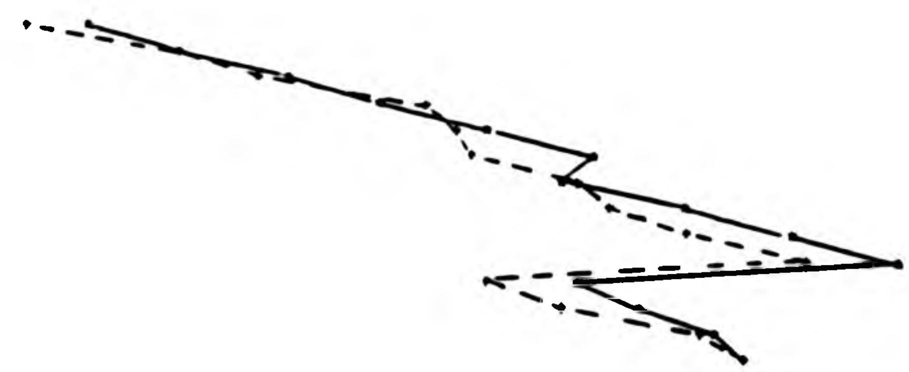
ID	ACTUAL	FITTED	RESIDUAL
1970	6990.4414	6299.2520	691.1895
1971	6596.5474	7204.6499	-608.1025
1972	7475.2925	8716.3438	-1241.0513
1973	10360.6133	12133.8652	-1773.2520
1974	11979.4521	12383.5410	-404.0889
1975	10149.2568	12265.4150	-2116.1582
1976	13564.2119	14197.1113	-632.8994
1977	14869.3701	15018.3740	-149.0039
1978	16814.6641	16048.4023	766.2617
1979	20689.7676	17867.0371	2822.7305
1980	19013.4297	18559.6855	453.7441
1981	19674.1680	19485.7188	188.4492
1982	22213.3203	21265.2988	948.0215
1983	24654.5078	22201.4980	2453.0098



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: LABAGIR

PREDICTED SERIES: LABAGIRS

ID	ACTUAL	FITTED	RESIDUAL
1970	1776.0000	1759.8571	16.1429
1971	1803.0000	1802.6930	0.3070
1972	1830.0000	1821.6549	8.3451
1973	1857.0000	1870.7802	-13.7802
1974	1885.0000	1877.8857	7.1143
1975	1915.0000	1883.4845	31.5155
1976	1908.0000	1910.6334	-2.6334
1977	1941.0000	1921.0186	19.9814
1978	1968.0000	1942.1443	25.8557
1979	1999.0000	1974.0857	24.9143
1980	1911.0000	1884.0803	26.9197
1981	1929.0000	1907.3204	21.6796
1982	1948.0000	1944.1116	3.8884
1983	1955.0000	1958.4639	-3.4639



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: LABTOT

PREDICTED SERIES: LABTOTS

ID	ACTUAL	FITTED	RESIDUAL
1970	3340.3000	3152.5625	187.7375
1971	3467.3000	3320.6157	146.6843
1972	3599.3999	3451.1016	148.2983
1973	3735.3999	3693.6765	41.7234
1974	3876.5000	3852.5439	23.9561
1975	4020.5000	3855.2930	165.2070
1976	4376.5000	4041.5586	334.9414
1977	4476.1001	4194.0444	282.0557
1978	4541.7998	4286.8379	254.9619
1979	4699.7998	4469.4722	230.3276
1980	4817.7998	4528.9873	288.8125
1981	5005.2998	4798.1743	207.1255
1982	5126.2002	5099.0532	27.1470
1983	5255.2998	5348.6211	-93.3213

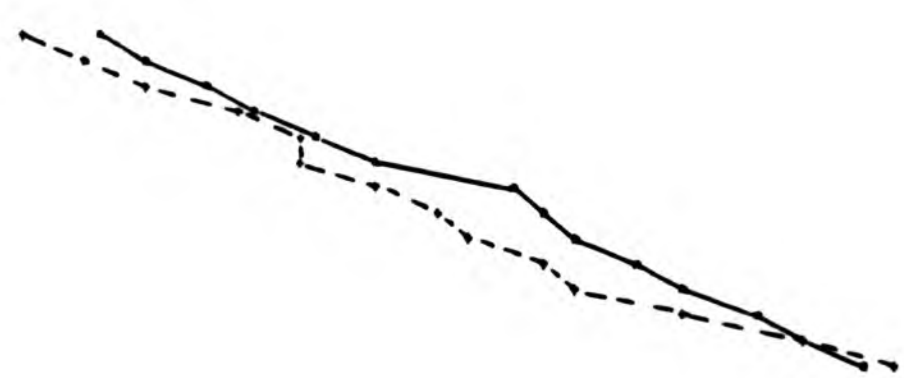


Figure 7.1 (Continued)

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: GDPC

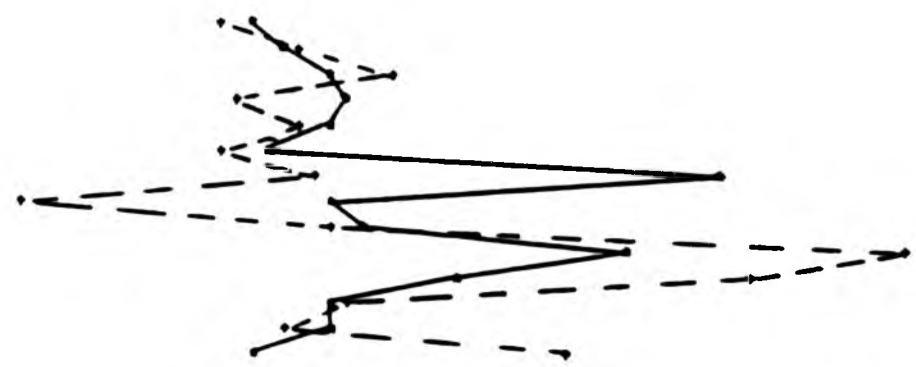
PREDICTED SERIES: GDPCS

ID	ACTUAL	FITTED	RESIDUAL
1970	12560.0000	12247.4717	312.5283
1971	12955.0000	13290.9033	-335.9033
1972	14220.0000	14131.4805	88.5195
1973	18708.0000	16091.3184	2616.6816
1974	22858.0000	22771.1504	86.8496
1975	22332.0000	26425.9785	-4093.9785
1976	28085.0000	28918.2480	-833.2480
1977	32340.0000	31425.3086	914.6914
1978	37886.0000	36996.6797	889.3203
1979	45083.0000	46325.0586	-1242.0586
1980	51838.0000	50099.3945	1738.6055
1981	56064.0000	48010.5039	8053.4961
1982	61196.0000	54060.1250	7135.8750
1983	67979.0000	65404.6680	2574.3320

PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: BPCBRC

PREDICTED SERIES: BPCBRCS

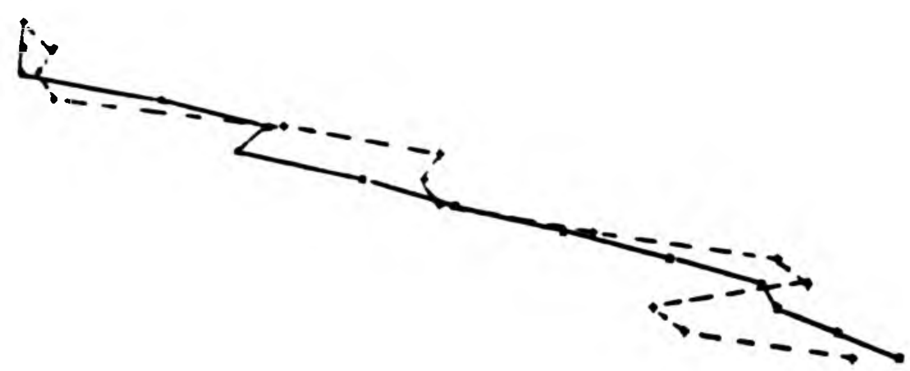
ID	ACTUAL	FITTED	RESIDUAL
1970	132.0000	-51.7783	183.7783
1971	264.0000	345.6679	-81.6679
1972	449.0000	745.5423	-296.5423
1973	576.0000	54.31553	521.6845
1974	452.0000	314.3555	137.6445
1975	171.0000	-23.0394	194.0394
1976	2319.0000	397.6191	1921.3809
1977	490.00000	-989.4613	1479.4613
1978	625.00000	504.37453	120.6255
1979	1863.0000	3194.6497	-1331.6497
1980	1078.0000	2457.7971	-1379.7971
1981	510.00000	582.13351	-72.1335
1982	462.00000	270.52631	191.4737
1983	111.00000	1603.9077	-1492.9077



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: PGDPI

PREDICTED SERIES: PGDPIS

ID	ACTUAL	FITTED	RESIDUAL
1970	100.0000	100.2425	-0.2425
1971	99.53130	102.8973	-3.3660
1972	99.87300	102.4780	-2.6050
1973	117.0900	104.1658	12.9242
1974	132.6871	134.5757	-1.8886
1975	128.6035	153.3086	-24.70510
1976	144.9813	152.8177	-7.8364
1977	155.4619	154.8978	0.5641
1978	170.1671	173.6567	-3.4896
1979	185.3437	199.6951	-14.3513
1980	197.6437	202.2142	-4.5705
1981	199.5728	181.7166	17.8562
1982	206.2068	186.5579	19.6489
1983	214.9181	208.6965	6.2216



PLOT OF ACTUAL(*) AND FITTED(+) VALUES ACTUAL SERIES: M3Q

PREDICTED SERIES: M3QS

ID	ACTUAL	FITTED	RESIDUAL
1970	4130.7002	4120.7266	9.9736
1971	4673.8999	5102.5981	-428.6982
1972	5771.2002	6674.3970	-903.1968
1973	7572.7002	7478.1313	94.5689
1974	8729.4004	8649.3389	80.0615
1975	10051.0000	9544.4355	506.5645
1976	12771.2002	11201.7119	1569.4883
1977	14861.0000	11750.4580	3110.5420
1978	17466.5000	13378.1523	4088.3477
1979	21616.0996	18899.2305	2716.8691
1980	27652.0000	24144.5273	3507.4727
1981	32370.0000	28973.5488	3396.4512
1982	37648.1016	33580.8555	4067.2461
1983	41193.0000	39969.8750	1223.1250

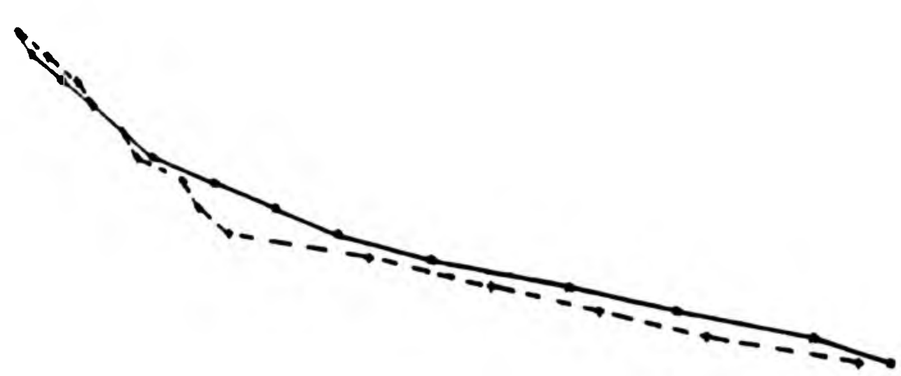


Figure 7.1 (Continued)

Table 7.2 Differences Between Shocked and Base Solution of a Sustained 20% Increase in Rubber Prices, 1970-1983

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables						Percentage Differences								
GDP, Current	1.62	1.26	1.21	2.44	2.01	1.62	2.06	2.17	2.46	2.79	3.20	3.07	3.02	3.50
GDP, Real	0.57	0.45	0.41	0.68	0.46	0.34	0.33	0.25	0.21	0.09	-0.05	-0.24	-0.45	-0.60
Value added, agriculture	0.02	0.02	-0.01	-0.05	-0.07	-0.09	-0.13	-0 17	-0.21	-0.29	-0.36	-0.40	-0.41	-0.44
Agricultural income	2.23	1.67	1.35	1.50	1.11	0.80	0.80	0.61	0.53	0.36	0.23	-0.11	-0.32	-0.36
Exports, goods and services	5.27	4.40	4.07	5.97	4.68	3.86	3.91	3.55	3.72	3.39	3.25	2.46	1.89	1.93
Imports, goods and services	3.46	3.24	3.11	4.20	3.17	2.96	2.97	2.71	2.81	2.53	2.19	1.83	1.39	1.08
Total demand	0.66	0.54	0.54	1.00	0.75	0.58	0.69	0.68	0.68	0.69	0.70	0.51	0.23	0.13
Total investment	0.19	0.12	0.07	0.04	-0.09	-0.16	-0.25	-0.42	-0.52	-0.69	-0.93	-1.25	-1.48	-1.64
Total government revenue	1.88	1.47	1.30	2.64	2.67	2.23	2.25	2.21	2.53	2.69	2.66	2.54	2.20	2.45
Money supply	2.34	3.40	3.71	5.90	7.68	9.02	10.18	12.41	14.09	13.32	13.59	13.38	13.47	13.67
Agricultural employment	0.06	0.10	0.11	0.09	0.07	0.09	0.09	0.07	0.05	0.01	-0.01	-0.03	-0.05	-0.07
Total employment	0.17	0.18	0.19	0.28	0.19	0.14	0.13	0.06	0.00	-0.12	-0.21	-0.28	-0.42	-0.58
							Differences							
Overall balance of payment (mil M$)	88	71	68	178	205	177	261	292	393	582	701	549	593	866
GDP price deflator, 1970=100	1.05	0.83	0.82	1.82	2.07	1.96	2.62	2.97	3.90	5.40	6.57	6.02	6.51	8.62
Consumer price index	0.00	0.18	0.33	0.47	0.84	1.26	1.63	2.17	2.77	3.58	4.78	6.23	7.37	8.59
Palm oil output ('000t)	0.00	-0.2	-0.5	-1.0	-1.7	-2.1	-2.6	-3.3	-4.7	-6.4	-7.7	-8.7	-8.8	-9.1
Rubber output, smallholding ('000t)	2.4	2.7	2.7	4.2	3.8	3.3	3.5	3.5	3.7	4.2	4.4	3.4	2.7	2.7
Rubber output, estates ('000t)	0.5	0.8	1.0	1.6	1.7	1.8	1.9	1.9	2.0	2.2	2.3	2.2	2.0	1.9

Table 7.3 Differences Between Shocked and Base Solution of a Sustained 20% Price Increase for Palm Oil, 1970-1983

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables							Percentage Differences							
GDP, Current	0.32	0.46	0.46	0.86	1.35	0.98	1.02	1.41	1.20	1.63	1.70	1.95	2.03	2.22
GDP, Real	0.15	0.25	0.27	0.38	0.52	0.43	0.38	0.40	0.38	0.33	0.25	0.17	0.03	-0.08
Value added, agriculture	0.23	0.41	0.44	0.46	0.56	0.52	0.40	0.34	0.34	0.32	0.27	0.18	0.08	0.01
Agricultural income	1.79	1.94	1.61	1.55	1.88	1.46	1.07	0.97	0.91	0.73	0.53	0.37	0.13	-0.01
Exports, goods and services	1.01	1.44	1.36	1.97	3.04	2.23	1.78	2.32	2.30	1.96	1.59	1.68	1.56	1.42
Imports, goods and services	0.63	0.89	0.89	1.32	1.80	1.58	1.44	1.64	1.69	1.49	1.19	1.16	1.00	0.81
Total demand	0.12	0.16	0.18	0.34	0.52	0.40	0.43	0.54	0.54	0.55	0.54	0.53	0.41	0.33
Total investment	0.05	0.09	0.11	0.13	0.15	0.11	0.07	-0.02	-0.09	-0.18	-0.29	-0.49	-0.67	-0.80
Total government revenue	0.37	-0.09	-0.16	0.36	1.06	0.88	0.83	1.10	1.42	1.45	1.35	1.40	1.41	1.60
Money supply	0.41	0.93	1.17	1.94	3.44	4.32	4.73	6.20	7.30	6.70	6.94	7.01	7.28	7.52
Agricultural employment	0.08	0.14	0.16	0.16	0.18	0.19	0.16	0.14	0.13	0.12	0.10	0.07	0.03	0.00
Total employment	0.06	0.11	0.13	0.17	0.23	0.20	0.18	0.17	0.15	0.10	0.06	0.02	-0.07	-0.16
							Differences							
Overall balance of payment (mil M$)	15	28	29	61	140	103	111	182	229	318	324	326	381	517
GDP price deflator, 1970=100	0.2	0.2	0.2	0.5	1.1	0.8	1.0	1.6	2.0	2.6	2.9	3.2	3.7	4.8
Consumer price index	0.0	0.03	0.1	0.1	0.3	0.6	0.8	1.0	1.4	1.8	2.5	3.2	3.9	4.6
Palm oil output ('000t)	17.5	32.9	38.4	46.5	58.7	57	50.7	48.5	52.9	58.1	56.8	51.1	41.8	35.7
Rubber output, smallholding ('000t)	0.0	0.0	-0.01	-0.03	-0.04	-0.06	-0.1	-0.13	-0.18	-0.27	-0.36	-0.35	-0.35	-0.42
Rubber output, estates ('000t)	0.0	0.0	0.0	-0.01	-0.01	-0.02	-0.03	-0.05	-0.07	-0.10	-0.14	-0.16	-0.18	-0.20

Table 7.4 **Distribution of Induced Effects of a Sustained 20% Increase in Palm Oil Prices, 1970-1983**

Contribution to GDP	Average ratio (a)	Induced Effect per Induced Effect on GDP													
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Value added agriculture	26.9	1.1	1.36	0.0	-2.1	-4.0	-7.2	-10.4	-18.5	-26.5	-84.6	179.0	40.1	21.2	16.3
Value added mining	5.0	-0.1	-1.09	-2.0	-2.0	-4.6	-6.8	-10.3	-20.0	-31.8	-115.0	283.3	55.6	28.0	19.0
Value added manufacturing	16.1	26.1	25.86	28.1	30.8	35.9	39.0	44.4	58.0	72.7	175.0	-308.3	-44.4	-10.6	-4.2
Value added construction	4.5	0.9	0.76	0.5	0.2	-0.7	-1.6	-2.5	-6.0	-9.1	-30.0	75.0	23.8	15.9	14.3
Value added transportation	6.4	29.0	27.59	26.3	26.0	23.1	23.7	20.6	20.0	25.0	21.5	-5.0	3.3	5.9	11.1
Value added services	38.8	34.8	34.48	36.8	38.5	42.3	44.1	50.8	58.0	65.9	140.0	-191.7	4.8	26.5	29.1
Other Variables															
Consumption expenditure	75.4	89.9	93.1	98.3	106.7	124.4	137.3	158.7	206.0	252.3	610.0	-1075	-154.0	-37.1	-15.3
Total investment	25.8	6.4	5.2	3.7	1.4	-4.5	-11.0	-17.5	-44.0	-65.9	-215.0	541.7	168.3	111.4	97.4
Exports: Goods + services	51.0	141.4	146.7	140.9	130.4	114.7	100.2	93.3	83.1	75.7	68.6	63.1	48.1	35.6	31.6
Imports: Goods + services	49.6	88.4	104.2	107.6	87.5	78.1	76.2	65.0	59.7	51.1	40.3	38.1	39.0	29.8	18.6

(a) Average ratio = 1/14 SUM ((Base-solution value of variable / base-solution GDP) * 100)

Table 7.5 Distribution of Induced Effects of a Sustained 20% Increase in Palm Oil Prices, 1970-1983

Contribution to GDP	Average ratio (a)	Induced Effect per Induced Effect on GDP													
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Value added agriculture	26.9	44.4	50.0	47.4	36.2	29.9	33.8	29.2	22.2	23.2	25.0	26.2	25.0	55.5	-1.9
Value added mining	5.0	-0.1	-0.4	-0.8	-1.1	-1.6	-2.3	-3.9	-6.0	-8.4	-15.1	-27.2	-42.3	-225.6	79.2
Value added manufacturing	16.1	16.7	15.6	13.2	19.0	21.8	21.6	25.0	28.4	30.5	36.8	45.9	65.9	266.7	-88.0
Value added construction	4.5	0.9	1.1	1.3	1.2	1.0	0.9	0.7	-0.2	-0.9	-2.1	-4.9	-13.7	-107.3	51.8
Value added transportation	6.4	0.9	10.1	11.5	13.2	13.9	13.5	12.3	15.1	14.9	13.9	15.2	22.4	104.2	-17.2
Value added services	38.8	25.5	20.6	20.2	26.2	29.8	28.6	32.4	35.5	36.4	40.2	46.3	48.2	74.7	19.4
Other Variables															
Consumption expenditure	75.4	61.1	50.0	47.4	65.5	77.0	74.3	86.1	101.2	108.5	127.6	163.9	229.6	944.4	-304.0
Total investment	25.8	6.1	7.4	9.0	8.1	6.7	6.0	4.6	-1.4	-6.3	-14.5	-33.4	-94.4	-739.0	356.0
Exports: Goods + services	51.0	135.0	131.2	124.6	122.5	110.4	95.4	85.5	83.8	75.8	68.0	58.2	51.8	43.7	36.8
Imports: Goods + services	49.6	80.0	78.7	81.5	78.3	65.9	66.9	63.2	55.5	49.6	40.7	38.8	39.1	32.1	22.1

(a) Average ratio = 1/14 SUM ((Base solution value of variable / base solution of GDP) * 100)

Table 7.6 Differences Between Shocked and Base Solution of a One Period 40% Price Fall for Palm Oil in 1970

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables	Percentage Differences													
GDP, Current	-0.58	-0.13	-0.10	-0.08	-0.06	-0.05	-0.04	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.02
GDP, Real	-0.27	-0.17	-0.12	-0.05	-0.03	-0.02	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00
Value added, agriculture	-0.46	-0.40	-0.22	-0.04	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Agricultural income	-3.60	-0.94	-0.47	-0.05	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Exports, goods and services	-1.82	-0.36	-0.18	-0.05	-0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00
Imports, goods and services	-1.13	-0.22	-0.20	-0.13	-0.09	-0.08	-0.06	-0.05	-0.04	-0.02	-0.02	-0.01	-0.01	-0.01
Total demand	-0.22	-0.03	-0.05	-0.06	-0.05	-0.04	-0.03	-0.03	-0.02	-0.02	-0.02	-0.02	-0.01	-0.01
Total investment	-0.09	-0.08	-0.10	-0.06	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Total government revenue	-0.67	1.12	0.26	0.10	-0.06	-0.07	-0.06	-0.04	-0.04	-0.03	-0.02	-0.02	-0.02	-0.01
Money supply	-0.71	-0.82	-0.70	-0.63	-0.51	-0.44	-0.35	-0.31	-0.26	-0.17	-0.13	-0.10	-0.09	-0.07
Agricultural employment	-0.16	-0.13	-0.07	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total employment	-0.11	-0.09	-0.06	-0.02	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Differences													
Overall balance of payment (mil.M$)	-26	-12	-5	0	2	3	2	2	2	2	2	1	1	0
GDP price deflator, 1970=100	-0.31	0.03	0.01	-0.02	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.04
Consumer price index	0.00	-0.06	-0.08	-0.09	-0.08	-0.08	-0.07	-0.07	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05
Palm oil putput ('000t)	-35	-32	-19	-4	-1	0	0	0	0	0	0	0	0	0
Rubber output, smallholdings ('000t)	0.00	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Rubber output, estates ('000t)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00

Table 7.7 Differences Between Shocked and Base Solution for a 30% Sustained Yield Increase for Rubber Smallholdings, 1970-83

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables	Percentage Differences													
GDP, Current	2.70	3.40	3.84	5.26	4.78	4.40	4.89	5.00	5.17	5.25	5.85	5.93	5.58	5.61
GDP, Real	2.63	3.56	4.00	4.39	4.09	4.06	4.03	3.93	3.89	3.68	3.59	3.4	3.06	2.86
Value added, agriculture	5.95	7.59	7.82	7.08	7.04	6.75	6.23	6.09	5.89	5.55	5.52	5.32	5.02	4.92
Agricultural income	15.3	17.66	16.43	11.65	11.55	11.7	9.90	9.28	8.69	7.73	7.39	7.16	6.76	6.56
Exports, goods and services	6.23	7.13	7.16	8.48	6.58	5.57	5.43	4.94	5.01	4.47	4.25	3.40	2.68	2.74
Imports, goods and services	1.88	3.02	4.14	5.94	4.91	5.00	5.21	5.04	5.14	4.56	3.96	3.66	3.14	2.73
Total demand	0.65	1.11	1.66	2.63	2.62	2.69	3.15	3.38	3.46	3.51	3.74	3.80	3.50	3.29
Total investment	0.96	1.98	2.57	2.75	2.66	2.66	2.49	2.13	2.01	1.78	1.48	0.91	0.52	0.32
Total government revenue	1.85	-2.33	-3.06	-1.31	0.38	1.00	1.62	2.09	2.65	3.07	3.25	3.29	2.84	3.00
Money supply	5.92	10.19	11.62	15.11	16.98	18.22	18.31	20.02	20.47	17.62	16.52	14.94	13.69	12.85
Agricultural employment	1.08	1.43	1.55	1.51	1.51	1.49	1.45	1.44	1.42	1.40	1.47	1.46	1.45	1.45
Total employment	0.96	1.34	1.58	1.82	1.81	1.85	1.92	1.93	1.95	1.91	1.95	1.88	1.74	1.65
	Differences													
Overall balance of payment (mil.M$)	224	254	235	326	312	240	296	277	356	543	607	312	248	496
GDP price deflator, 1970=100	0.06	-.15	-.17	.87	.89	.49	1.26	1.58	2.14	3.02	4.41	4.43	4.56	5.57
Consumer price index	0.00	.46	.99	1.47	2.15	2.79	3.29	3.90	4.47	5.2	6.32	7.58	8.22	8.74
Palm oil output ('000t)	0.00	-.5	-1.31	-2.91	-4.67	-5.28	-5.63	-6.57	-8.21	-10.05	-11.04	-10.06	-10.6	-10.06
Rubber output, smallholding ('000t)	243	329	363	374	379	378	378	380	385	390	399	407	415	420
Rubber output, estates ('000t)	0.00	-0.014	-0.037	-0.09	-0.122	-0.147	-0.185	-0.224	-0.27	-0.335	-0.407	-0.438	-0.444	-0.464

Table 7.8 Differences Between Shocked and Base Solution of a Sustained Yield Increase of 40% for Oil Palm, 1970-1983

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables	Percentage Differences													
GDP, Current	0.96	1.47	1.73	2.49	3.27	2.92	3.22	4.15	4.64	4.79	5.20	6.17	6.05	6.08
GDP, Real	1.01	1.54	1.90	2.26	2.58	2.76	3.00	3.46	3.80	3.89	4.04	4.24	4.17	4.20
Value added, agriculture	2.39	3.35	3.94	4.01	4.46	5.06	5.51	6.43	7.07	7.41	8.01	8.3	8.45	8.9
Agricultural income	6.16	7.79	8.30	6.67	7.25	8.78	8.86	9.89	10.56	10.55	11.16	11.51	11.68	12.23
Exports, goods and services	2.13	3.09	3.15	3.94	5.27	4.26	3.72	4.86	5.26	4.43	3.67	4.05	3.38	3.21
Imports, goods and services	0.52	1.21	1.60	2.53	3.21	3.07	3.08	3.65	4.09	3.77	3.24	3.45	3.18	2.92
Total demand	0.21	0.46	0.70	1.18	1.56	1.57	1.90	2.36	2.64	2.85	3.20	3.63	3.61	3.62
Total investment	0.37	0.83	1.16	1.37	1.53	1.66	1.77	1.78	1.92	1.94	1.87	1.49	1.21	1.11
Total government revenue	0.61	-0.95	-1.40	-0.99	0.49	0.89	0.62	1.03	1.66	1.98	2.02	2.21	2.18	2.31
Money supply	2.17	4.16	5.05	6.91	9.50	11.27	11.98	14.93	17.14	15.81	15.01	14.41	13.78	13.18
Agricultural employment	0.44	0.63	0.78	0.86	0.96	1.12	1.30	1.54	1.73	1.90	2.20	2.35	2.53	2.73
Total employment	0.37	0.58	0.75	0.94	1.12	1.24	1.42	1.68	1.89	2.02	2.22	2.34	2.38	2.48
	Differences													
Overall balance of payment (mil.M$)	82	113	114	166	280	228	250	379	495	639	586	506	416	589
GDP price deflator, 1970=100	-0.04	-0.07	-0.17	0.24	0.90	0.24	0.34	1.03	1.41	1.73	2.25	3.36	3.37	3.75
Consumer price index	0	0.17	0.40	0.64	0.98	1.56	2.03	2.55	3.33	4.36	5.68	6.89	7.93	8.79
Palm oil putput ('000t)	176	262	329	379	429	503	590	705	808	904	1000	1093	1200	1307
Rubber output, smallholding ('000t)	0.00	-0.02	-0.05	-0.13	-0.15	-0.18	-0.26	-0.32	-0.44	-0.63	-0.80	-0.76	-0.71	-0.80
Rubber output, estates ('000t)	0	-.01	-0.01	-0.04	-0.05	-0.07	-0.10	-0.13	-0.18	-0.24	-0.32	-0.36	-0.38	-0.42

Table 7.9 Differences Between Shocked and Base Solution for 40% Increase in Mature Area of Oil Palm and a Corresponding Decrease for Rubber, Equally Contributed from the Smallholding and Estates Sector, 1970-1983

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables	Percentage Differences													
GDP, Current	0.29	0.35	0.15	-0.12	-0.55	-0.06	-0.50	-0.25	-0.58	-1.26	-2.26	-1.82	-1.95	-2.68
GDP, Real	0.34	0.36	0.23	0.04	0.17	-0.03	-0.23	-0.20	-0.35	-0.54	-0.73	-0.66	-0.64	-0.73
Value added, agriculture	0.86	0.73	0.43	0.08	-0.21	-0.37	-0.48	-0.57	-0.77	-0.96	-1.16	-1.36	-1.47	-1.64
Agricultural income	2.24	1.69	0.93	0.19	-0.47	-0.67	-0.72	-0.88	-1.11	-1.23	-1.31	-1.73	-1.89	-2.05
Exports, goods and services	0.58	0.72	0.09	-0.54	1.13	0.04	-1.18	-0.46	-1.02	-1.93	-3.03	-1.78	-1.63	-2.30
Imports, goods and services	0.07	0.34	0.17	0.14	0.76	0.34	-0.35	-0.19	-0.48	-0.95	-1.43	-1.13	-1.02	-1.10
Total demand	0.05	0.13	0.11	0.05	0.30	0.14	-0.05	-0.02	-0.15	-0.37	-0.68	-0.63	-0.62	-1.10
Total investment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
Total government revenue	0.16	-0.49	-0.44	-0.49	-0.45	-0.64	-0.09	-0.17	-0.20	-0.75	-1.42	-1.50	-1.07	-1.44
Money supply	0.68	1.07	0.85	0.37	0.85	0.52	-0.64	-1.10	-1.96	-3.28	-5.27	-5.56	-5.91	-6.77
Agricultural employment	0.16	0.14	0.09	0.02	-0.05	-0.09	-0.11	-0.14	-0.18	-0.24	-0.29	-0.35	-0.40	-0.45
Total employment	0.13	0.14	0.09	0.02	0.07	-0.01	-0.09	-0.09	-0.15	-0.23	-0.31	-0.31	-0.30	-0.33
	Differences													
Overall balance of payment (mil.M$)	26	24	2	-26	42	-22	-111	-53	-122	-330	-599	-313	-344	-662
GDP price deflator, 1970=100	-0.05	-0.01	-0.07	-0.16	.51	0.14	-0.41	-0.08	-0.41	-1.46	-3.12	-2.12	-2.46	-4.11
Consumer price index	0.00	0.05	0.10	0.11	0.05	0.14	0.09	-0.14	-0.25	-0.50	-1.18	-2.42	-3.06	-3.77
Palm oil output ('000t)	175	262	329	380	431	505	593	709	814	912	1010	1105	1213	1320
Rubber output, smallholding ('000t)	-24	-38	-49	-57	-65	-76	-89	-106	-122	-137	-151	-166	-182	-198
Rubber output, estates ('000t)	-36	-72	-108	-142	-175	-213	-255	-306	-359	-413	-469	-525	-584	-644

Table 7.10 Differences Between Shocked and Base Solution of Zero Export Duties for Rubber, 1970-1983

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Variables	Percentage Differences													
GDP, Current	.01	.01	.01	.02	.03	.03	.04	.05	.06	.08	.10	.09	.08	.07
GDP, Real	.01	.01	.01	.02	.03	.02	.03	.04	.05	.06	.07	.05	.03	.03
Value added, agriculture	.02	.02	.02	.03	.06	.04	.06	.08	.10	.13	.14	.09	.04	.04
Agricultural income	.06	.05	.05	.06	.10	.07	.10	.12	.14	.18	.19	.12	.06	.05
Exports, goods and services	.02	.02	.02	.04	.06	.03	.05	.06	.08	.10	.10	.06	.03	.03
Imports, goods and services	.01	.01	.01	.02	.03	.03	.03	.04	.05	.06	.06	.06	.05	.04
Total demand	.00	.00	.00	.00	.00	.00	.01	.01	.01	.01	.01	.01	.00	.00
Total investment	.00	.01	.01	.01	.01	.02	.02	.02	.02	.03	.03	.02	.00	.00
Total government revenue	.01	-.01	-.01	.00	.01	-.01	.01	.01	.02	.04	.04	.04	.04	.05
Money supply	.02	.03	.04	.06	.10	.11	.13	.17	.22	.25	.28	.26	.23	.20
Agricultural employment	0	0	0	.01	.01	.01	.01	.02	.02	.03	.04	.02	.01	.01
Total employment	0	0	.01	.01	.01	.01	.02	.02	.02	.03	.04	.03	.02	.02
	Differences													
Overall balance of payment (mil.M$)	.83	.74	.62	1.73	3.62	1.71	3.86	5.05	8.25	16.22	19.16	6.55	1.47	4.7
GDP price deflator, 1970=100	0	0	0	0	0	0	.01	.01	.02	.04	.08	.07	.08	.09
Consumer price index	0	0	0	0	.01	.02	.02	.03	.04	.05	.09	.13	.14	.14
Palm oil putput ('000t)	0	0	0	-.01	-.02	-.02	-.03	-.04	-.06	-.09	-.13	-.16	-.17	-.17
Rubber output, smallholding ('000t)	.73	.74	.71	1.3	2.42	1.52	2.5	3.2	4.24	6.08	6.56	4.00	1.74	1.66
Rubber output, estates ('000t)	.17	.24	.3	.47	.84	.81	1.08	1.37	1.77	2.41	2.88	2.62	2.07	1.8

CHAPTER 8: HISTORICAL POLICY SIMULATION ANALYSIS FOR OPTIMAL ALLOCATION OF RUBBER AND OIL PALM

8.1 Introduction

This chapter discusses the setting up and the results of the historical simulation experiments performed on the macroeconometric model. The objective is to examine the contributions that could have been made to the Malaysian economy if certain crop allocation policies involving rubber and oil palm had been adopted. By systematically evaluating the effects of various crop planting schemes on the economy, one could determine the direction of the optimal crop allocation for the period 1970 to 1983. The procedure involves comparing the results from the simulation under each crop allocation option with the actual contribution to the Malaysian economy from the existing pattern of planted areas of rubber and oil palm. The key questions to be answered are:-

1) whether past pattern of crop allocation had been optimal,
2) whether an optimal crop allocation scheme could be identified for the historical period selected, and
3) whether investors could have identified the optimal allocation policy when they made their investment decisions.

8.2 Sectoral Planning and Methods of Policy Evaluation

In examining the effectiveness of past policies for the development of the rubber and oil palm sectors, two approaches could be considered. The first involves evaluating directly the effectiveness of the policies and strategies stipulated in the country's development plans. In view of the crucial role of rubber and oil palm in the Malaysian economy, some form of development planning and targets could be expected to exist at the national level, and the effectiveness of the policies and strategies could be evaluated in relation to the targets set in such a development plan.

The second approach is to evaluate the actual performance of the sector in question, assuming that the realised pattern of crop allocation is the cumulative result of various individual 'policies' and strategies which had influenced investors in their choice of the crop to plant. By using the macroeconomic model to simulate hypothetical policies for a selected period in the past, it is possible to examine whether the realised development pattern for rubber and oil palm has been optimal.

8.2.1 Policy Planning in the Plantation Sector.

When national five year planning was first introduced in the Draft Development Plan (1950-55) and First Malaya Plan (1956-60), the plans were "...no more than aggregations of expansion programmes of separate governmental departments.." (Lim, 1983a). This was in the early days when development economists still claimed that " Development planning is a comparatively new branch of applied science, barely twenty years old in the West and fifty years old in the Soviet Union" (Tinbergen, 1967). The Second Malaya Plan (1961-65) and the

First Malaysia Plan (1966-70) saw the use of a more systematic planning technique based on the Harrod-Domar model (see Todaro, 1985, pp. 64-67. Numerical targets were introduced for the first time for national aggregated variables such as income and employment. More modern planning techniques, with macroeconometric models replacing the Harrod-Domar models, were employed in the the Second, Third and Fourth Malaysia Plans. In all of these, sectoral development targets remained implicitly embodied in various policies and strategies which were designed to promote the achievement of various national goals. It is therefore difficult to extract consistent quantitative targets on sectoral developments, especially for the agricultural sector, from these plans.

Nevertheless, agricultural development in Malaysia has been relatively well organised and planned. The policies and strategies for agricultural development, as stipulated in the Second Malaysia Plan, Third Malaysia Plan and Fourth Malaysia Plan relate to activities which would promote greater investments in the agricultural sector to generate modernization and commercialization of agriculture as well as restructuring of the production base. The strategies employed included productive allocation of resources through intensification, extensification and diversification. Additionally, land development and rehabilitation programmes play a major role in the agricultural development strategies (Zulkifly, 1983). The plans therefore contain multiple socio-economic objectives which ultimately promote the increase in national income and eradication of poverty.

Various policies for the development of rubber and oil palm have been mentioned in the agricultural development plans. Most of them, however, are qualitative policy statements, and targets for the growth in the planting of major national crops such as rubber or oil palm are not explicitly stated. For example, in the Fourth Malaysia Plan (1981-1985) when conversion of rubber to oil palm was expected to be a major policy issue, no specific targets for the growth in palm oil production were stated while for rubber the government policy was that " the country should expand its production at a rate of about 7 % per annum". (Fourth Malaysia Plan, p. 162). Such a production target did not indicate whether the growth in production was to be generated through increased productivity or through increased planting of rubber.

The lack of specific targets on sectoral development was not surprising nor was it clear that the inclusion of such targets was beneficial and desirable. For most developing countries, the technique of sectoral planning was still new. Not many of these countries have sectoral models which could be used to provide reliable data for inclusion in their national plans. (See for example, Adelman, 1969 pp. 109-143 as an exception where an early attempt was made for the first time to incorporate the outputs of sectoral planning models in the Second Five Year Plan for South Korea in 1965)

If it is argued that the Malaysian Five Year Plan documents were not the appropriate place for inclusion of major agricultural development targets, then some form of quantitative targets could be expected in the Malaysian Agricultural Policy released in 1984. However, in the latter document, specific targets were also absent. For rubber, the policy recommended that rubber production be increased through increasing productivity, while establishing of oil palm estates is encouraged. This may be interpreted as a recommendation to halt the expansion of rubber areas, without taking away the rights of the investors to exercise their commercial judgement to invest in the crop they think most profitable.

In the absence of specific quantitative planning targets, one can perhaps assume that the government takes the view that the development of rubber and oil palm is a matter of commercial investment decisions to be determined by the individuals and organizations intending to participate in the business of planting the crops. Within the plantation sector it has been an unofficial strategy for companies to diversify their overall crop allocation so as to achieve an average target ratio of 60:40 in favour of oil palm. In view of the small acreage of oil palm in the sixties and seventies, companies hoping to achieve such an allocation target would have to build up their oil palm acreage rapidly and this implies planting a lot of oil palm on land available to them each year for new planting or replanting.

It is noted however, that the government has a high degree of influence in determining the development of the plantation industry. It controls the financing of the land development schemes and administers, through national agencies such as RISDA, the replanting funds for future development of rubber lands. The government could further provide encouragement by providing the appropriate export tax incentives, or the necessary infrastructural facilities in the processing, transportation and marketing of the output of the crops concerned. But this power of influence has not been fully utilised in a way that enables the government to exert full planning control over the development of crop allocation pattern in the country. In this respect, the government seems to have adopted a minimum intervention stance. It could also be that formulating a development plan as explained below is difficult, especially in quantitative terms.

The preparation of a national strategy for the development of rubber and oil palm is essentially a long term planning exercise. Rubber and oil palm are perennial crops whose productive cycles exceed twenty years and both commodities have a complex supply demand and price structure in their respective world markets. Even if quantitative planning targets could be prepared, their reliability and effectiveness for successful implementation may be questioned. This raises the question of the costs and benefits of having such quantitative targets. More of this will be discussed in a later section which evaluates the potential losses incurred under a situation of non-optimal planning in the development of the plantation sector.

It may be recalled from Chapter 3 that Malaysia was trying to diversify away from natural rubber which was threatened by increasing world production of synthetic rubbers. Although no set targets were proposed in the diversification policy, the Malaysian plantation industry has achieved a growth pattern which is in line with the policy recommendations as seen by the rapid development of the palm oil industry. If these past efforts are considered as the realised strategy adopted by the plantation sector in the absence of any officially stated targets, then the diversification policy can be considered to have achieved a considerable degree of success. One could not however, quantify the success, as the targets were not known. An examination of Table 8.1 shows that the estate sector has responded well by achieving a high degree of diversification into oil palm. The small holders, however, by virtue of the numerous restrictions regarding their small plot size, lack of technical know-how and financial resources, were not able to engage in oil palm planting to the same extent as that achieved by the estate sector.

Thus, of the two approaches suggested at the beginning of this section, only the method of simulation analysis may provide a feasible route to the determination of the optimal policies for the allocation of crops in the plantation sector. Observations on the pattern of crop allocation trends in the past may however provide qualitative answers to the effectiveness of past policies for the plantation sector and the capability of the different sub-sectors to undertake optimal crop allocation in practice.

8.3 Setting-up of the Simulation Experiments

This section will examine the results of simulating the model for different regimes of crop allocation ratios. It is assumed that in practice it would be possible to institute a crop allocation policy so that each year the total acreages for replanting and new planting of rubber and oil palm would average to a predetermined ratio as stipulated in the planting policy. Since several past studies (Lim and Chai, 1978; Ariffin and Chan, 1978) have shown that oil palm has been a more profitable crop to plant compared to rubber, the simulation analysis examines only the situation where oil palm is hypothesised to replace rubber in areas which were planted with rubber starting from 1970.

Three sets of experiments were carried out for investigating the crop allocation problem through dynamic simulation of the model. These are as follows:-

a) The hypothetical switch of rubber areas to oil palm with respect to rubber areas planted between 1970 and 1983 was examined. The policy allocation ratios tested were 33 %, 67 % and 100 % rate of annual conversion to oil palm for the rubber areas that were annually planted since 1970.

b) In the second series of experiments, the impact of accelerated replanting of rubber areas to oil palm was examined. This involved evaluating the hypothetical policy of converting a fraction of the productive rubber areas to oil palm. The policy can be regarded as a way of accelerating the replacement of rubber when all available land for normal annual planting and replanting have been allocated to the planting of oil palm. Accelerated conversion rates of 10,000 ha per year up to 50,000 ha per year are tested in the simulation experiments.

c) The third part of the simulation experiment looks at the effect of price fluctuation on the crop allocation policy. Price fluctuation may contribute to increased riskiness that may arise if too much of one type of crop is planted, resulting in a low level of crop diversification. The risk can be interpreted as the losses incurred to the economy when the prices of the more profitable crop (oil palm) fall, or when the prices of the less profitable crop (rubber) increase or when both events occur simultaneously. The simulation experiment will examine a few scenarios which reveal the level of losses resulting from the hypothetical price changes occurring for rubber and palm oil over the simulation period.

However, before describing the simulation procedures, the mechanism of crop allocation and replacement for rubber and oil palm is explained. This is presented in the following section.

8.3.1 Pattern of Crop Allocation for Rubber and Oil Palm

The role of rubber and oil palm in the Malaysian economy has been reviewed in Chapter 3, and the production structure of these crops has been discussed in Chapter 4. It is noted that for the more organised units of the plantation sector, running a plantation is just a normal commercial undertaking which requires regular appraisals of the level of reinvestment to be made for each crop. Over the years these decisions have led to the present pattern of acreage distribution for rubber and oil palm plantations. As mentioned earlier, the ability of the subsectors to implement optimal allocation of crops may differ significantly. The estates sector is generally more efficient and better organised than the smallholding sector. This disparity is reflected in the low rate of conversion of rubber to oil palm for the smallholding sector.

The decision-making process for allocation of rubber or oil palm involves various considerations relating to the relative profitability, price expectations, cost projections and technological developments which would reflect the underlying prospects for each crop. The most promising crop would be expected to experience a more rapid rate of growth. However, it is difficult to determine whether past pattern of crop allocation has been optimal. What has emerged in practice could have been the result of rational and optimal investment decisions; that is, they were optimal at the time that the decision to plant a particular crop was made but such decision might no longer be optimal restrospectively. This aspect of the problem is explored by using the simulation approach to determine whether or not past patterns of crop allocation had been optimal.

The process of replanting or new planting of rubber or oil palm begins with the clearing of the land, followed by preparation of the holes and the nursery for the seedlings, and the transplanting of the young plants. During the immaturity period, the young plantation has to be maintained through regular weeding and applications of fertilizers. It must be remembered that the planting technology is well established. The industry has made major advancements in the technique of carrying out these processes so that there are recognised procedures to be adopted (see for example, Turner and Gillbanks, 1974; and Hartley, 1967).

Generally, the processes for clearing the land, digging the holes, preparing of the nursery and maintenance of the young crop are similar for rubber and oil palm. For simplicity, one could say that the processes in the establishment of the two crops are very similar except for differences in details pertaining to the crop itself. For example, rubber requires an additional bud grafting step and the immature period for rubber is 5 to 6 years compared to 3 for oil palm. Except for these differences, it can be assumed that the basic establishment costs of the two crops are similar. This simplifying assumption will be incorporated into the model during the simulation experiment.

The realised planted areas for rubber and oil palm are shown in Table 8.1. The mature area for oil palm has increased at 14 % per annum from just 44,000 hectares in 1960 to 1.023 million hectares in 1983. The increase has been brought about mostly by new planting through the rapid expansion of the country's land development schemes. Conversion of rubber lands into oil palm plantations occurred mainly in the rubber estate sector. Whenever this sector carries out the annual replanting of its rubber lands, oil palm rather than rubber has been the preferred crop. Consequently, rubber areas in the estate sector have been steadily reduced. Between 1960 and 1983, the total mature area for the estate sector has decreased from 586,000 hectares to about 390,000 hectares.

In contrast, the smallholding sector has continued to maintain a steady growth in the planted area for rubber. In 1983, independent smallholders' participation in oil palm planting constituted only about 5 % of the total oil palm planted area which is insignificant compared to their share of over 40 % in the rubber sector. This trend was maintained mainly through the efforts of the rubber replanting authority (RISDA) which advises and provides funding for rubber replanting. Other influencing factors include the deliberate policy of various land development agencies to expand the rubber sector, and the conservative nature of the smallholders who may find planting rubber a familiar process in comparison to investing in a new crop such as the oil palm.

8.4 Policy Analysis Experiments by Simulation

The effects of hypothetical crop allocation policies can be examined by comparing the simulation results of the model under each policy option with the results of the base simulation of the macromodel. There are many important variables which could be used for measuring the impact of each policy on the economy. The effects of the policy on the level of employment, prices and income are certainly very important. These and other values of the endogenous variables of the model could be examined from the simulation results. However to enable the policies to be compared under numerous simulation scenarios, it is necessary to summarise the results and use only a few of the most important variables to provide a meaningful indication of the contribution of each policy to the economy. In this study, the most important variables selected for use in the comparison are gross domestic product (GDPC), export revenue (EXPGNFC), agricultural income (YAC), Agricultural labour (LABAGIR), total labour employed (LABTOT) and consumer price index (PCI).

The comparison of the results of the various policies involves monetary values which are generated at different times. To standardise the different timings in the flow of income and export revenue generated under each policy, the net present values of these variables are compared.

8.4.1 Experiment 1: Allocation Ratios in New Planting and Replanting of Rubber and Oil Palm

In these simulation runs, three different ratios of conversion rates were investigated. These were 33 %, 67 % and 100 % of the area planted with rubber between 1970 and 1983 to be hypothetically replaced with oil palm. A fourth situation involving 0 % conversion of rubber planted areas to oil palm was already evaluated as the base run.

The results of such policy options are compared with the base solution which is the status quo policy (0 % conversion to oil palm) for the period under consideration.

There are differences in terms of income, labour and the timing in the generation of revenue which must be taken into consideration when a rubber area is hypothetically replaced with oil palm. Mature oil palm plantation has a lower level of labour requirement per acre - usually, one man per ten acres compared with one per four acres for rubber. The revenue generated per acre is usually higher compared with rubber. Other implications which should be taken into consideration include expected changes in the level of income and investment costs. Oil palm starts yielding after 3 years while rubber takes 6 years to reach maturity. The revenue from oil palm can be received in less time than rubber.

These changes are incorporated in the model by modifying the equations for rubber and oil palm mature areas, agricultural labour demand, and the three types of income ie. individual, agricultural and corporate income. For example, the per hectare conversion of rubber to oil palm will cause a decline in the agricultural labour by 0.3 units, and there would also be direct increases in individual income, agricultural income and corporate income since a unit area of oil palm is known to provide a higher rate of income than rubber. It is necessary to augment the effect on the economy, of switching rubber area to oil palm the for specific variables such as agricultural labour demand and income since the equations for these latter variables do not include mature areas for rubber and oil palm as the explanatory variables, and without adding back to these equations the known direct effects of switching rubber area to oil palm, the model will tend to underestimate the impact of crop reallocation on the economy. The indirect effects of changes in mature planted area for rubber and oil palm detected through the rubber and palm oil output equations would be insufficient to account for the major changes in labour and income pattern that would result from switching rubber area to oil palm.

The values used for modifying the equations of the model to reflect the known effects of the conversion of rubber areas to oil palm are calculated from the average trend for the period 1970-1983 on a per hectare conversion basis. Annual establishment costs for rubber and oil palm are expected to be similar and for simplicity, they are assumed to be equal and they need not be specially included in a comparative study through the simulation. Thus for each hectare of rubber area that is reallocated to oil palm, past trends show that income will rise by M$1155 on average, and this amount of increase is then assumed to be shared equally by agricultural income (YAC), individual income (INCINDC) and corporate income (INCCORC). Thus the equations for YAC, INCINDC, and INCCORC have the coefficient 0.385 (representing a third of 1155) added to terms involving new areas of rubber (ANARUB) and existing area of rubber (CUTAREA) which have been introduced into the equation to represent the policy of switching rubber lands into oil palm. ANARUB represents the newly planted land under rubber between 1970 and 1983 which could have been allocated to oil palm and CUTAREA represents the existing rubber plantation that could be cut down prematurely to be replaced with oil palm.

It is noted that lagged values of ANARUB and CUTAREA are involved to account for the fact that owing to crop immaturity period, the benefit of increased income and the resultant reduction in labour demand will appear at a later period from the time that a replacement policy is implemented. Thus, income will increase after the third year of crop reallocation to reflect that the immaturity period of three years for oil palm, and labour demand will decrease also after the third year, assuming that equal amount of labour would be needed in maintaining young oil palm or rubber plantations and the labour changes during the immaturity period of oil palm need not therefore be included in the equations for the comparative evaluation. As shown in Appendix A the inclusions of the ANARUB and CUTAREA into the income and labour demand equations begin with the third year lag to reflect the delayed effects, and only lags of up to the thirteenth year need be included as the run of the simulation extends only for 14 years from 1970 to 1983.

In the simulation of the model, the mature areas for oil palm, rubber smallholding and rubber estates are modified accordingly using the same set of lagged terms for ANARUB and CUTAREA. A coefficient 0.33, or 0.67 or 1.00 is introduced to effect the policy option being investigated with respect to the ANARUB variables. For example, a factor of 0.67 used as the coefficient for ANARUB implies a hypothetical policy where 67 % of all rubber areas planted between 1970 and 1983 were planted instead with oil palm. The newly planted areas for each year for the rubber estates (ANARES) and rubber smallholdings, which together constitute ANARUB are shown in Table 8.1. The modification to generate values for mature area for oil palm (MAPALM), rubber smallholdings (MARUBSH) and rubber estates (MARUBES) are shown in Appendix A.

It is further noted that the the equations for MAPALM contains ANARUB and CUTAREA which begin with a lag of 3 to reflect the shorter immaturity period of oil palm while the equations for MARUBSH and MARUBES contains ANARUB and ANARES terms with lags beginning with 6 to reflect that it would have required six years for rubber mature areas to change even if the land was replanted with rubber. A lagged period of three years was used for CUTAREA in the equations for MARUBES and MARUBSH. This is to account for the fact that in practice, early replacement of rubber with oil palm occurs not with the old rubber trees but with the immature rubber plantations as it is easier to uproot the small plants and replace them with young oil palms (see Lee, 1986). On average, a lagged period of 3 years for the CUTAREA variable appears a reasonable compromise since the ages of immature young rubber trees vary from 1 to 6 years. Alternatively, a lagged period of 1 year could be used for the variable in question to reflect a policy of up-rooting productive rubber plantations but this was not tested in this study.

The results of the simulation runs are shown in Tables 8.2, 8.3 and 8.4. The impact of the 33 % conversion policy is shown by an increase in GDP, export revenue and agricultural income. Agricultural labour, as expected, declines by up to 25,000 units per year. Total labour does not decline by as much since increased economic activities results in the increase in labour demand in the non-agricultural sector. This kind of trade-off is a characteristic feature of the type of information obtained from policy analysis using a macromodel simulation. A straightforward calculation of labour reduction based on reduced ratio of rubber to oil palm areas would not have provided simultaneous information on the increase in labour demand in the non-agricultural sector.

As the replanting conversion ratio is increased, as can be seen from the three Tables 8.2 - 8.4, GDP, export revenue and agricultural income continue to increase during the 1970-1983 period. The net present values for GDP and export revenue increase from 1319 million ringgit to 4019 million ringgit and from 618 million to 1874 million ringgit respectively. Although there is a corresponding decline in agricultural labour, the net reduction in total labour is only a fifth of the decline in agricultural labour.

The above observation implies that for the 1970-1983 period, the direction of optimal policy could be towards maximum conversion from rubber to oil palm for areas available for new planting and replanting. It also points to a need for further evaluation towards a policy of accelerated replanting by which a fraction of the less productive areas could be replanted before its normal replanting time which is about 25 years.

8.4.2 Experiment 2: Accelerated Replanting

To speed up the conversion of rubber to oil palm as suggested by the previous experiment, one could assume that over a certain planning period, a target area of rubber was removed and replanted with oil palm even though the rubber trees had not have reached their replanting age. There are penalties with this type of policies as the rubber areas to be removed are either going to be in production or are still in production, and replanting them with oil palm will result in an immediate or a slightly delayed, albeit temporary, loss of revenue. These and other effects are incorporated in the model for the simulation runs. The target areas for accelerated replanting being evaluated by the simulation procedure are 10,000, 20,000, 30,000, 40000, and 50000 Ha per year.

The results for the accelerated replanting simulation experiments are shown in Tables 8.5, 8.6, and 8.7. As the rate of accelerated replanting is increased, the contributions to GDP and export revenue decrease. It appears that interrupting the productive areas incurs a higher level of loss compared to the eventual gains from increased acreage of oil palm. Thus, the results from the runs involving the accelerated replanting of 40,000 and 50,000 hectares are not reported as the results indicate much greater economic losses compared to those shown for 10,000 to 30,000 hectares as indicated in Tables 8.5 - 8.7.

It is therefore clear that based on past pattern of price movements during the 1970-1983 period, the macromodel simulation experiments suggest that the optimal policy should have been to

a) plant oil palm instead of rubber for all newly opened lands in the land development schemes.

b) plant oil palm instead of rubber for the areas becoming available for replanting each year.

c) do not replace productive rubber plantations prematurely.

The above conclusions to the simulation analysis might not have been easily predicted in advance during the sixties and seventies as the industry continued to debate on the issue of how much of oil palm to be planted relative to rubber. However, if quantitative models and information similar to those available for the present study were available, a clearer planting policy could perhaps be formulated. The rewards for being able to forecast and plan the crop allocation optimally could be considerable. In terms of the potential gains, an optimal crop allocation policy if implemented over the 1970-1983 period would have benefited the country by some M$ 4 billion in addition to an almost half that amount in terms of export revenue.

It is interesting to note that the estate sector, by planting the minimal amount of rubber during this period, has adopted a strategy that is close to optimal. The smallholders in contrast appear to have foregone the opportunity of increasing their earning through increase planting of oil palm. Agricultural income which directly relates to the smallholders would have increased considerably if they were engaging in oil palm planting to the extent practised by the estate sector.

The analysis refers to a planning duration of 14 years. This is a just over half the productive cycle of the two crops. As the policy is not allowed to run through the full cycle of the crops' productive life, there is a danger that future pattern of crop distribution emerging from such sub-optimal allocation policies may not be optimal. An optimal policy that works for 14 years may even be counter-productive for the next 14 years. If no replanting of rubber takes place in a given period there would be no rubber plantation of the corresponding age vintages to come into production in future years, and there would be no trees to replant in 25 years time.

One way of overcoming the apparent planning difficulty in practice is to proceed with the normal medium term planning of five to ten years duration, and review the plans regularly for any changes which should be introduced to adapt the plan to changing situations. Concepts such as 'rolling plans' are some of the familiar techniques used to overcome the need to make adjustments to existing plans. Thus, the concept of medium term planning as explored in the present simulation exercise may remain applicable in the planning for the development of the rubber and oil palm industry, provided there are re-evaluations of the plans and strategies on a regular basis. The revisions may for convenience be planned to coincide, for instance, with the preparation of the national five year plans.

8.4.3 Risk Analysis and Crop Allocation Strategies

Although the planning of the development of rubber and oil palm plantations can be regarded as a series of medium term plans, as suggested above, planting of oil palm or rubber is nevertheless, a long term investment. The decision making process of whether to invest in rubber or oil palm usually requires the investor to consider the relative long term profitability of each crop. Expectation of the level of profitability involves the prediction of future prices of the two commodities.

In turn, the forecast of future prices requires at least two other expectations: the supply demand relationship that will prevail in such future period, and the price fluctuation usually associated with the commodity market.

The crop with a higher potential profitability may face an over-supply situation as investors will choose to plant such a crop while the prospect of the less profitable crop may improve as decreasing supply may lead to increasing prices. This suggests that the analysis of crop allocation policies should take into account the risks in terms of the direct losses as well as opportunity losses arising from price changes.

A comprehensive analysis of the impact of adverse price changes in the crop allocation experiments may require numerous simulations, under different combinations of rubber and palm oil price scenarios. However by making certain simplifying assumptions, it is possible to limit the number of simulation runs to those that would provide critical information relating to each crop allocation policy option.

To gain a better perspective of the simulation exercise, one should imagine that the policy evaluation was carried out in the year 1970 and that the planning period was from 1970-1983. Further, it could be assumed that the price expectations of the planners were exactly the actual realised historical prices for this period and the values for the other variables of the economy corresponded exactly to the results of the base solution of the macroeconomic model. If no price changes are introduced in the simulation of the various crop allocation policies, the outcome will be exactly as reported in the previous two series of experiments.

In this section, the analysis is extended to include the effect of hypothetical price changes for rubber and palm oil. Since the objective is to evaluate the potential losses resulting from possible price falls of the more profitable crop (oil palm), or price increases of the less profitable crop (rubber), or both, only certain relevant combinations of price changes need be evaluated. The timing and the level of these price changes are critical in the assumptions. They are arbitrarily determined in this study based on certain rational assumptions. Later, it will be shown that the assumptions are not so critical in relation to the objective of identifying the optimal crop allocation pattern for rubber and oil palm.

Accordingly, one can propose a scenario such that there would be a 40 % decline in the price of palm oil, and this would occur from the 11th year of planning. It is argued that if a price fall were to occur it would probably take place towards the end of the planning period when implementation of crop conversion policy would have resulted in increased production of palm oil and such an increase might lead to an oversupply of the commodity. The chosen level of price fall of 40 % is a practical figure which the market is accustomed to through the normal short term deviation of palm oil prices in the world market. It is a realistic quantum of price fall and such a price change would put the price close to the cost of production of palm oil (see Chapter 5). Given the nature of the highly competitive oils and fats market as explained in Chapters 4 and 5, a 40 % semi-permanent decrease in palm oil price represents a pessimistic scenario. A price fall for palm oil by 40 % would imply a world-wide decline in oil and fat prices by a similar amount. A permanent price fall of such magnitude would put many producers of other oils and fats in difficult financial position.

The simulation results (Table 8.8) show that a 40 % price decline for palm oil during the 1980-1983 period, while maintaining an unchanged price trend for rubber, appears not to have affected the conclusions reached in the previous two series of experiments. Full conversion of crops to oil palm over the 1970-1983 period would still be the optimal crop allocation policy. Over-conversion of rubber to oil palm through accelerated replanting yields lower economic gains. It is also shown in Table 8.8, that by not following any crop conversion policy, the economy, under the current scenario, would have lost some M$ 1.4 billion in GDPC and M$ 1.12 billion in export revenue.

One can easily extend the analysis by an additional change of 20 % rise for rubber prices over the same period. This evaluates the opportunity loss resulting from reduced acreages of rubber, when its prices happen to increase. After years of observing secular price decline in rubber, a proposed 20 % price increase may be reasonable scenario to analyse.

The results (Table 8.8 third column) indicate that the price changes introduced in the present analysis do not alter the position of the optimal crop allocation policy as stipulated from the outcome of the previous three experiments.

It is noted that the assumption of the fall or rise in prices of rubber and oil palm is critical in the above analysis. It can also be argued that other patterns of prices changes could be introduced in the simulation to generate different results. However, the occurrence of major price changes in a random way would be less plausible as they may contradict the logical tendency for price changes to occur only towards the latter part of the planning period when there are already major reallocations in planted areas to influence actual supply of the commodities concerned.

It is also noted that other combinations of price changes may produce more favourable outcome, or that the outcome is of no direct consequence to the analysis as far as the determination of optimal crop allocation ratio is concerned. For example, a moderate fall in the price of rubber would not alter the finding of the simulation experiments as this would tend to enhance the effectiveness of the optimal crop allocation policy of "full conversion to oil palm, without resorting to accelerated replanting for the 1970-1983 period". With these propositions, it is possible to restrict the simulation experiments to a few runs that provide the critical results.

8.5 Performance of Past Policies and Conclusions

Each of the simulation runs in the previous section requires a computing time of 1 hour and consequently there is a limit to the number of experimental runs that could be feasibly carried out. By introducing some suitable simplifying assumptions, it is shown that it is possible to generate useful policy analysis results using only a few critical scenarios in the simulation.

The simulation analysis has generated a number of important findings. Firstly, it is shown that the past pattern of crop allocation has not been optimal nationally. In terms of the subsectors, it is shown that the estate sector has established a crop allocation pattern that is close to optimal. If allowance is made for the fact that certain small areas of the rubber estates are only suited to planting of rubber and not oil palm, then the minimal amount of rubber planted by the estate sector may constitute the optimal planting regime.

A second main outcome of the simulation analysis is that the planting pattern of the smallholding sector is not optimal. This has implications on the planning efficiency of agencies responsible for the planning in the smallholding sector. There appeared to exist a big potential for increasing the income of the smallholders and eradicate poverty if they could be mobilised to improve their ability to participate in planting a more profitable crop such as the oil palm.

It is noted that the optimal allocation policy is for maximum conversion to oil palm for all planting carried out during the period 1970-1983. Based on the yardsticks of GDP and export earning as the criteria for measuring the effectiveness of the policy options, it has been shown that the optimal policy is not sensitive to moderate price changes introduced to the model during the period under scrutiny. This insensitivity suggests that planners in 1970 could have a higher chance of arriving at the optimal allocation policy if development planning for allocation of rubber and oil palm areas had been carried out in 1970 using a similar simulation technique. Provided a suitable macromodel could be constructed and successfully simulated, planning for the optimal allocation of rubber and oil palm in the Malaysian plantation sector may not have been too difficult, even in quantitative terms.

Finally, the analysis presented in this chapter has demonstrated the ability of macroeconomic models to assist in the analysis of policy planning for sectoral development. The model has been shown to be useful for use in policy analysis for planning an optimal growth of the rubber and oil palm sector, even though these are perennial crops which have long productive cycles. To overcome the rigidity associated with long term planning and to harmonise the results into the usual medium term plans, such as the country's five year plans, a concept of "regular revisions of plans" was suggested.

Results of the simulation analysis using a macroeconometric model reveal the direct and indirect impact of policies and such information can be superior, as far as policy analysis is concerned, to results obtained from single equation or other forms of naive projection models. It is shown for example, that although agricultural labour decreases with increasing conversion of rubber lands to oil palm, the total demand for labour decreases only slightly owing to the off-setting effect of increasing labour demand from the simultaneous expansion of economic activities in other parts of the economy. All of these observations exemplify the considerable benefits and insights to be obtained from conducting a quantitative planning analysis for the development of major sectors of the economy.

Some of the major planning goals of the country, especially in the agricultural sector, have been to increase national income and eradicate poverty. This study has shown that if optimal planning could be carried out, the national goals could have been better achieved. The benefit that could be derived in terms of increased income to the smallholders who were the target of so many development projects seemed to compare favourably to the small amount of resources that might have to be employed to prepare a set of quantitative plans and targets for ensuring optimal sectoral development. It is also noted that the attainment of national goals through increased income is feasible, even if there is price instability as simulated in Section 8.4.3. This suggests that resource reallocation may be a viable way of overcoming the effect of income instabilities as conjectured in Chapter 1.

Table 8.1 Mature and Newly Planted Areas for Rubber and Oil Palm in Malaysia (thousand hectares)

YEAR	Existing Mature Areas			Planting in Current Year		
	Rubber small-holdings	Rubber estates	Oil palm	Rubber small-holdings	Rubber estates	Oil palm
1960	635	586	44	na.	na.	na.
1961	626	574	45	78.4	44.8	3.9
1962	617	567	49	38.4	0.4	5.0
1963	605	570	55	48.2	3.6	11.3
1964	602	566	57	51.9	5.9	11.4
1965	599	561	62	55.2	9.8	15.7
1966	627	559	75	45.1	17.4	26.3
1967	652	561	83	64.8	28.6	34.8
1968	692	562	97	46.8	29.4	41.6
1969	747	568	123	39.1	21.0	52.1
1970	791	545	176	40.5	9.7	49.0
1971	829	534	219	37.7	4.1	43.9
1972	853	522	266	48.3	9.6	58.9
1973	855	508	300	54.3	6.7	65.0
1974	859	490	340	34.2	2.6	80.5
1975	850	472	401	41.2	6.8	79.6
1976	851	462	471	23.7	0.2	76.6
1977	860	452	566	29.8	4.1	72.7
1978	873	442	642	43.1	6.2	72.8
1979	886	443	715	34.3	5.8	80.7
1980	910	443	788	39.4	6.5	84.0
1981	927	417	859	41.2	6.2	85.2
1982	944	404	943	35.7	0.7	84.0
1983	954	390	1023	33.3	2.6	74.8

Sources: PORLA Palm oil Statistic Handbook, and Update, various issues, Statistic Department :Rubber Statistical Bulletin.

Table 8.2 Results of Hypothetical Replacement of Rubber with Oil Palm for Rubber Areas Planted Between 1970-1983: 33% Conversion

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	NPV
Change in:															
Gross domestic product															
GDPC, actual (M$ million)	0	0	0	29	104	147	204	293	372	410	396	489	523	562	1319
GDPC, %	0	0	0	0.18	0.46	0.56	0.70	0.93	1.01	0.89	0.79	1.02	0.97	0.86	-
Export of goods and services															
EXPGNFC, actual (M$ million)	0	0	0	29	99	114	138	192	217	186	101	153	126	104	618
EXPGNFC, %	0	0	0	0.34	0.88	1.02	0.97	1.21	1.17	0.71	0.32	0.53	0.41	0.28	-
Agricultural income															
YAC, actual (M$ million)	0	0	0	78	168	291	386	429	463	453	465	492	538	593	1723
YAC, %	0	0	0	0.64	1.36	2.37	2.72	2.86	2.89	2.54	2.5	2.53	2.53	2.67	-
Agricultural labour															
LABAGIR, actual (thousand)	0	0	0	-1.8	-3.1	-4.8	-7.5	-9.6	-12.5	-14.9	-17.3	-20.4	-22.6	-24.9	-
LABAGIR, %	0	0	0	-0.09	-0.17	-0.26	-0.39	-0.5	-0.65	-0.76	-0.92	-1.07	-1.16	-1.27	-
Total labour															
LABTOT, actual (thousand)	0	0	0	-.9	-0.4	-0.9	-01.7	-1.6	-3.2	-5.1	-7.1	-8.6	-10.2	-11.7	-
LABTOT, %	0	0	0	-0.02	-0.01	-0.02	-0.04	-0.04	-0.08	-0.12	-0.16	-0.18	-0.20	-0.22	-
Consumer price index															
PCI, actual (1970 = 100)	0	0	0	0	0.04	0.16	0.31	0.49	0.70	0.94	1.14	1.21	1.31	1.37	-
PCI, %	0	0	0	0	0.03	0.11	0.21	0.32	0.44	0.57	0.64	0.65	0.67	0.68	-

Table 8.3 Results of Hypothetical Replacement of Rubber with Oil Palm for Rubber Areas Planted Between 1970-1983: 67% Conversion

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	NPV
Change in:															
Gross domestic product															
GDPC, actual (M$ million)	0	0	0	60	212	299	414	597	758	836	806	997	1065	1145	2686
GDPC, %	0	0	0	0.37	0.93	1.132	1.431	1.899	2.048	1.804	1.609	2.077	1.971	1.75	-
Export of goods and services															
EXPGNFC, actual (M$ million)	0	0	0	60	201	231	280	391	440	378	204	310	257	211	1255
EXPGNFC, %	0	0	0	0.70	1.80	2.08	1.97	2.45	2.38	1.44	0.66	1.08	0.83	0.56	-
Agricultural income															
YAC, actual (M$ million)	0	0	0	158	342	591	784	871	941	920	944	999	1092	1204	3499
YAC, %	0	0	0	1.3	2.76	4.82	5.52	5.8	5.86	5.15	5.08	5.13	5.13	5.43	-
Agricultural labour															
LABAGIR, actual (thousand)	0	0	0	-3.6	-6.3	-9.8	-15.3	-19.6	-25.5	-30.2	-35.1	-41.3	-45.8	-50.6	-
LABAGIR, %	0	0	0	-0.19	-0.34	-0.52	-0.8	-1.02	-1.31	-1.53	-1.86	-2.17	-2.36	-2.58	-
Total labour															
LABTOT, actual (thousand)	0	0	0	-1.8	-0.8	-1.8	-3.4	-3.3	-6.5	-10.4	-14.3	-17.5	-20.7	-23.8	-
LABTOT, %	0	0	0	-0.05	-0.02	-0.05	-0.08	-0.08	-0.15	-0.23	-0.32	-0.37	-0.41	-0.45	-
Consumer price index															
PCI, actual (1970 = 100)	0	0	0	0	0.1	0.3	0.6	1	1.4	1.9	2.3	2.5	2.7	2.8	-
PCI, %	0	0	0	0	0.06	0.21	0.42	0.65	0.9	1.16	1.3	1.31	1.36	1.38	-

Table 8.4 Results of Hypothetical Replacement of Rubber with Oil Palm for Rubber Areas Planted Between 1970-1983: 100% Conversion

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	NPV
Change in:															
Gross domestic product															
GDPC, actual (M$ million)	0	0	0	89	317	447	618	892	1133	1251	1208	1494	1596	1715	4019
GDPC, %	0	0	0	0.55	1.39	1.69	2.14	2.84	3.06	2.70	2.41	3.11	2.95	2.62	-
Export of goods and services															
EXPGNFC, actual (M$ million)	0	0	0	89	300	345	418	583	658	564	306	464	384	315	1874
EXPGNFC, %	0	0	0	1.04	2.68	3.10	2.94	3.65	3.56	2.16	0.98	1.61	1.25	0.84	-
Agricultural income															
YAC, actual (M$ million)	0	0	0	236	510	882	1170	1300	1404	1373	1408	1492	1630	1798	5221
YAC, %	0	0	0	1.94	4.12	7.19	8.24	8.66	8.75	7.68	7.59	7.66	7.67	8.10	-
Agricultural labour															
LABAGIR, actual (thousand)	0	0	0	-5.3	-9.4	-14.6	-22.8	-29.2	-38	-45.1	-52.4	-61.7	-68.4	-75.5	-
LABAGIR, %	0	0	0	-0.28	-0.50	-0.77	-1.19	-1.52	-1.96	-2.28	-2.78	-3.24	-3.52	-3.85	-
Total labour															
LABTOT, actual (thousand)	0	0	0	-2.6	-1.2	-2.7	-5.1	-4.9	-9.7	-15.5	-21.4	-26.2	-30.8	-35.6	-
LABTOT, %	0	0	0	-0.07	-0.03	-0.07	-0.13	-0.12	-0.23	-0.35	-0.47	-0.55	-0.60	-0.67	-
Consumer price index															
PCI, actual (1970 = 100)	0	0	0	0	0.12	0.48	0.94	1.47	2.13	2.86	3.46	3.66	3.97	4.13	-
PCI, %	0	0	0	0	0.09	0.32	0.63	0.97	1.34	1.73	1.94	1.96	2.04	2.05	-

Table 8.5 **Results of Hypothetical Replacement of Rubber with Oil Palm at 100% Conversion Plus 10,000 Ha per Year Accelerated Replanting**

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	NPV
Change in:															
Gross domestic product															
GDPC, actual (M$ million)	5	10	11	122	424	584	719	988	1195	1217	990	1256	1230	1050	3883
GDPC, %	0.04	0.07	0.08	0.76	1.86	2.21	2.49	3.14	3.23	2.63	1.98	2.62	2.28	1.61	-
Export of goods and services															
EXPGNPC, actual (M$ million)	1	1	1	113	379	431	460	628	674	509	134	371	277	102	1842
EXPGNPC, %	0.01	0.02	0.03	1.32	3.39	3.87	3.24	3.93	3.65	1.95	.43	1.29	0.90	0.27	-
Agricultural income															
YAC, actual (M$ million)	2	4	7	307	654	1108	1342	1443	1529	1492	1526	1592	1716	1854	5864
YAC, %	0.03	0.05	0.08	2.53	5.28	9.04	9.45	9.61	9.53	8.3	8.22	8.17	8.07	8.35	-
Agricultural labour															
LABAGIR, actual (thousand)	0.02	0.07	0.13	-06.5	-11.6	-17.7	-29.6	-39.2	-51.0	-60.9	-70.9	-83.1	-92.5	-100	-
LABAGIR, %	0	0	0.01	-0.35	-0.62	-0.94	-1.55	-2.04	-2.62	-3.09	-3.77	-4.36	-4.76	-5.13	-
Total labour															
LABTOT, actual (thousand)	1.4	2.8	3.9	1.5	4.6	4.1	-0.88	-2.58	-9.6	-17.3	-27.4	-35.7	-42.8	-47.8	-
LABTOT, %	0.05	0.08	0.11	0.04	0.1	0.11	-0.02	-0.06	-0.22	-0.39	-0.6	-0.74	-0.84	-0.89	-
Consumer price index															
PCI, actual (1970 = 100)	0	-0.03	-0.08	-0.15	-0.1	2.2	0.62	0.98	1.44	1.89	2.08	1.71	1.58	1.25	-
PCI, %	0	-0.02	-0.07	-0.14	-0.07	0.15	0.41	0.65	0.91	1.15	1.17	0.92	0.81	0.62	-

Table 8.6 Results of Hypothetical Replacement of Rubber with Oil Palm at 100% Conversion Plus 20,000 Ha per Year Accelerated Replanting

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	NPV
Change in:															
Gross domestic product															
GDPC, actual (M$ million)	11	20	22	155	531	722	819	1083	1256	1182	772	1020	867	391	3750
GDPC, %	0.09	0.15	0.16	1	2.3	2.7	2.8	3.4	3.4	2.6	1.5	2.1	1.6	0.6	-
Export of goods and services															
EXPGNPC, actual (M$ million)	1	2	3	137	459	516	502	672	691	454	-38	278	170	-111	1809
EXPGNPC, %	0.03	0.04	0.05	0.16	0.41	0.46	0.35	0.42	0.37	0.17	-0.12	0.97	0.55	-0.3	-
Agricultural income															
YAC, actual (M$ million)	3	8	13	377	797	1335	1514	1586	1655	1612	1645	1693	1803	1912	6507
YAC, %	0.06	0.1	0.15	3.1	6.4	10.9	10.7	10.6	10.3	9.0	8.9	8.7	8.5	8.6	-
Agricultural labour															
LABAGIR, actual (thousand)	0	0.1	0.3	-7.6	-13.8	-20.8	-36.4	-49.1	-63.9	-76.7	-89.5	-104.5	-116.7	-125.3	-
LABAGIR, %	0	0	0	-0.4	-0.7	-1.1	-1.9	-2.6	-3.3	-3.9	-4.8	-5.5	-6.0	-6.4	-
Total labour															
LABTOT, actual (thousand)	2.8	5.5	7.8	5.7	10.5	11.0	3.3	-0.3	-9.5	-19.1	-33.4	-45.2	-54.7	-60.0	-
LABTOT, %	0.1	0.2	0.2	0.2	0.3	0.3	0.0	0.0	-0.2	-0.4	-0.7	-0.9	-1.1	-1.1	-
Consumer price index															
PCI, actual (1970 = 100)	0	-0.05	-0.15	-0.3	-0.32	-0.04	0.30	0.50	0.76	0.93	0.7	-0.23	-0.8	-01.6	-
PCI, %	0	-0.05	-0.14	-0.02	-0.03	0.00	0.2	0.3	0.5	0.6	0.4	-0.1	-0.4	-0.8	-

Table 8.7 Results of Hypothetical Replacement of Rubber with Oil Palm at 100% Conversion Plus 30,000 Ha per Year Accelerated Replanting

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	NPV
Change in :															
Gross domestic product															
GDPC, actual (M$ million)	16	29	33	187	539	858	919	1177	1316	1145	554	784	504	-263	3550
GDPC, %	0.13	0.22	0.24	1.16	2.80	3.25	3.18	3.75	3.56	2.47	1.11	1.63	0.93	-0.40	-
Export of goods and services															
EXPGNFC, actual (M$ million)	2	4	4	160	538	602	544	717	707	399	-209	186	64	-323	1778
EXPGNFC, %	0.04	0.07	0.07	1.87	4.81	5.41	3.83	4.49	3.83	1.52	-0.67	0.65	0.21	-0.86	-
Agricultural income															
YAC, actual (M$ million)	5	11	20	448	941	1562	1686	1729	1781	1732	1764	1795	1892	1972	7153
YAC, %	0.08	0.15	0.23	3.69	7.60	12.74	11.88	11.51	11.10	9.69	9.50	9.21	8.90	8.88	-
Agricultural labour															
LABAGIR, actual (thousand)	0.1	0.2	0.4	-9	-16	-24	-43	-59	-77	-93	-108	-126	-141	-150	-
LABAGIR, %	0.01	0.01	0.02	-0.48	-0.85	-1.27	-2.25	-3.07	-3.96	-4.71	-5.73	-6.61	-7.25	-7.66	-
Total labour															
LABTOT, actual (thousand)	4.2	8.3	11.7	9.8	16.4	17.8	7.4	2	-9.4	-21	-40	-55	-67	-72	-
LABTOT, %	0.13	0.25	0.34	0.27	0.43	0.46	0.18	0.05	-0.22	-0.47	-0.87	-1.14	-1.31	-1.35	-
Consumer price index															
PCI, actual (1970 = 100)	0	-0.1	-0.2	-0.5	-0.5	-0.3	0.0	0.0	0.1	0.0	-0.7	-2.2	-3.2	-4.4	-
PCI, %	0.00	-0.07	-0.21	-0.41	-0.38	-0.20	-0.01	0.01	0.04	-0.02	-0.38	-1.15	-1.61	-2.20	-

Table 8.8 Results of Crop Allocation Analysis under Changing Prices for Rubber and Palm Oil in Malaysia, 1970-1983 (Net Present Values of the resulting changes, M$ million)

Policy option	No price change		40% decrease in palm oil price for 1980-83		40% decrease in palm oil price + 20% increase in rubber price for 1980-83	
Changes in :	GDPC	EXPGNFC	GDPC	EXPGNDFC	GDPC	EXPGNFC
No conversion of rubber to oil palm	0	0	-1409	-1120	-246	-182
33% conversion of rubber to oil palm	1319	618	-300	-663	-	-
67 % conversion of rubber to oil palm	2686	1255	848	-192	-	-
100% conversion of rubber to oil palm	4019	1874	1968	266	2906	1021
10000 Ha Accel. Replanting to oil palm	3883	1841	1685	109	2489	764
20000 Ha Accel. Replanting to oil palm	3749	1809	1406	1.5	2077	509
30000 Ha Accel. Replanting to oil palm	3613	1778	1129	-200	1670	255
40000 Ha Accel. Replanting to oil palm	-	-	854	-353	1267	3.3
50000 Ha Accel. Replanting to oil palm	-	-	582	-506	871	-247

CHAPTER 9: AN ANALYSIS OF THE CROP ALLOCATION PROBLEM USING THE OPTIMAL CONTROL TECHNIQUE

9.1 Introduction

This chapter sets out to examine the applicability of the optimal control technique in solving the crop allocation problem for rubber and oil palm in Malaysia using the consistent framework provided by the macroeconometric model which was constructed in Chapter 6. As described earlier in Chapter 8, the historical simulation of the model under various crop allocation schemes had revealed the direction towards the attainment of optimal crop allocation for rubber and oil palm. In this chapter, the crop allocation problem is solved by using the optimal control technique to generate optimal trajectories of the relevant policy variables for the 1984-1995 planning period. By selecting appropriate state and control variables to be included in the objective function, the optimal control routine can ascertain the optimal achievable growth path for the variables of the model, given the set of trajectories corresponding to the desired levels of economic growth and investment to be carried out for future development of oil palm and rubber. The evaluation will indirectly take into account the behaviour of the Malaysian economy as projected by the macroeconometric model. The results are then compared with the pattern of optimal crop allocation as suggested in the simulation analysis of the preceding chapter.

As described in Chapter 2, the evaluation of an optimal control problem requires that the macromodel be cast into a standard set-up comprising a quadratic objective function with a linear set of constraints. The solution procedure involves i) the formulation of the problem in terms of linear constraints and quadratic objective function, ii) the derivation of the optimal control equations, and iii) the application of the technique to the crop allocation problem. These steps will be presented in this chapter. The programme to solve the optimal control problem is presented in Appendix B.

In applying the technique to policy planning, as earlier described in Chapter 2, the linear or linearised macroeconometric model acts as the linear constraints while an appropriate quadratic objective function has to be separately formulated. In addition, a set of control variables from among the exogenous variables of the model must be specified, and the target values of the variables of the models must be supplied. Given these inputs, the optimal control algorithm can be employed to generate the optimal paths of the control variables with respect to the optimal growth trajectories of the endogenous state variables of the system. Thus, to apply the technique to the Malaysian plantation sector, the macroeconometric model developed in Chapter 6 is used as the set of constraints and an objective function, based on quadratic function for GDP, export revenue and employment is formulated. Finally, the relevant exogenous variables of the model, particularly the planted area for rubber and oil palm, are selected to be the control variables.

The application of the technique involves a considerable amount of preparation to convert the macroeconomic model into the reduced form and to provide base forecast values which will be used as a basis for generating target trajectories for the variables in the optimal control problem. These preparatory stages involve essentially three main steps. Firstly, the optimal control problem is set up and its solutions are verified against data for a selected historical period or against simulated values of a forward forecast period. It is essentially a calibration procedure to ensure that the formulated problem can be effectively solved using the constructed computer programme and that the results could show the expected response over the chosen period. Secondly, the target for the growth paths of the variables of the model for a selected future period must be determined. Unless prior information is available regarding these targets, it is necessary to experiment with simulated forecasts of the macroeconometric model to obtain a reasonable desired economic scenario for the future. Thirdly, once the targets are determined, the optimal control technique can be used to experiment with various ways of achieving the desired targets using different control variables and selecting the most desirable paths for policy adoption.

The setting-up of the optimal control problem is an important part of the optimal control technique. Thus, to facilitate a better appreciation of the application of the technique, an outline of the theoretical background is presented and this describes the derivation of the feedback equation used in the optimal control procedure. The sections that follow consider how the macroeconometric model can be adapted for crop allocation analysis using the optimal control technique. The major application of the optimal control technique in this study is restricted to an evaluation of the optimal planting pattern for rubber and oil palm for the period 1984 to 1995.

9.2 Optimal Control of Macroeconometric Models

The optimal control procedure usually deals with a quadratic objective function and linear constraints because of the simplicity in deriving a solution procedure. To use the macro-econometric model as the set of constraints, the model is transformed into its state-variable form. This means working with the reduced form of the model and creating new state variables to replace those variables that appear in the model with lags of more than one period. After defining the new state variables and adding their definitional equations to the system, a system of first-order difference equations is obtained, and one can then apply the optimal control computation directly.

Accordingly, the macroeconometric model can be represented as a set of reduced form equations as follows:-

$$y_t = A_1 y_{t-1} + \dots + A_m y_{t-m} + C_0 x_t + \dots + C_n x_{t-n} + b + u_t \tag{9.1}$$

where y_t is a vector of endogenous or dependent variables, x_t

is a vector of variables subject to control; A_i and C_i are given constant matrices, and u_t is a serially uncorrelated disturbance vector with mean zero and covariance matrix V. Exogenous variables in the system that are not subject to control are treated as part of b which is also assumed to be a set of given constants. A higher order term $y_{i,t-2}$ can be replaced by a lower order term $y_{n+1,t-1}$ by defining a new equation of the form

$$y_{n+1,t-1} = y_{i,t-2}.$$

Thus, by replacing all higher order terms in y and x in the form of new state variables, equation (9.1) above can be written as a system of first order difference equations of the following form:-

$$\begin{bmatrix} y_t \\ \hline y_{t-1} \\ \cdot \\ \cdot \\ \cdot \\ y_{t-m+1} \\ \hline x_t \\ \hline x_{t-1} \\ \cdot \\ \cdot \\ \cdot \\ x_{t-n+1} \end{bmatrix} = \left[\begin{array}{cccccccc} A_1 & A_2 & \cdots & A_m & C_1 & \cdots & & C_n \\ \hline I & 0 & \cdots & 0 & 0 & \cdots & & 0 \\ \cdot & \cdots & & \cdot & \cdot\cdot & \cdots & & \cdot \\ & & & \cdot & & & & \cdot \\ & & & \cdot & & & & \cdot \\ 0 & 0 & I & 0 & 0 & \cdots & & 0 \\ \hline 0 & 0 & \cdots & 0 & 0 & \cdots & & 0 \\ \hline 0 & 0 & \cdots & 0 & I & \cdots & 0 & 0 \\ \cdot & \cdots & \cdot & \cdot & \cdot\cdot & \cdots & & \cdot \\ & & & \cdot & & & & \cdot \\ & & & \cdot & & & & \cdot \\ 0 & 0 & & 0 & 0 & & I & 0 \end{array}\right] \begin{bmatrix} y_{t-1} \\ \hline y_{t-2} \\ \cdot \\ \cdot \\ \cdot \\ y_{t-m} \\ \hline x_{t-1} \\ \hline x_{t-2} \\ \cdot \\ \cdot \\ \cdot \\ x_{t-n} \end{bmatrix}$$

$$
\cdot \; + \begin{bmatrix} C_0 \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \\ \hline I \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \end{bmatrix} x_t + \begin{bmatrix} b \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \\ \hline 0 \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \end{bmatrix} + \begin{bmatrix} u_t \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \\ \hline 0 \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \end{bmatrix}
$$

which is redesignated in the state-variable form as

$$
y_t = A\, y_{t-1} + C\, x_t + b + u_t \qquad (9.2)
$$

The newly defined variable y_t includes current and any relevant lagged dependent variables as well as the current and any relevant lagged control variables, whereas x_t remains the same as before. By dealing with first order equations, the expressions for deriving the control solutions contain only first order terms, and by including the control variables in the y vector, the arguments of the objective functions have only terms involving y_t even when some control variables x_t are in fact included. This procedure which has been advocated by Chow (1975) will simplify the derivation of the solutions in terms of the optimal feedback equation. Furthermore, the computation for the solutions will involve matrices of smaller sizes as opposed to the longer approach adopted by Pindyck (1973) where x_t is not included in y_t and the vector b is not compressed but presented in its expanded form $b = Bz$ where z is a vector of exogenous variables, and B their coefficients.

The next step in the formulation of the control problem is to formulate the objective function. This involves specifying a welfare function to enable the performance of the system to be measured in terms of the deviation of y_t as defined in (9.2) from the target vectors a_t for $t = 1, \dots T$ where T is the end of the planning period. For a deterministic system in which the error term is zero, the objective function can be expressed as

$$W = \sum_{t=1}^{T} (y_t - a_t)' K (y_t - a_t) \qquad (9.3)$$

where K is a semi-definite positive diagonal matrix which acts as weighting factors for the variables which are selected to be in the objective function. The optimal control problem is to minimise the objective function (9.3), given the econometric model (9.2).

One convenient way of deriving the solutions to the deterministic control problem is through the use of Lagrangian multiplier (r) and the differentiation of the Lagrangian expression, and equating the first derivatives to zeros.

For a deterministic system of equations, let the Lagrangian expression be

$$L = 1/2 \sum_{t=1}^{T} (y_t - a_t)' K (y_t - a_t) - \sum_{t=1}^{T} r'(y_t - A\, y_{t-1} - C\, x_t - b) \qquad (9.4)$$

Equating the vector of derivatives to zero, the resulting expressions are as follows:-

$$dL/dy_t = K\,(y_t - a_t) - r + A' r_{t+1} = 0$$

$$\text{where } (t = 1,\ldots,T;\ r_{T+1} = 0) \tag{9.5}$$

$$dL/dx_t = C' r_t \quad (t=1,\ldots,T) \tag{9.6}$$

$$dL/dr_t = -\,(y_t - A\,y_{t-1} - C\,x_t - b\,) = 0 \quad (t=1,\ldots,T) \tag{9.7}$$

Solving the unknowns y_t, x_t and r_t in the above three equations and setting $H_T = K$ and $h = K\,a_T$ for time $t = T$, one obtains

$$r_T = K\,y_T - K\,a_T + A'\,r_{T+1} = H_T\,y_T - h_T \tag{9.8}$$

From the three equations (9.6), (9.7) and (9.8)

$$C'_T\,r_T = 0 = C'(H_T\,y_T - h_T) = C'_T(H_T\,A\,y_{T-1} + H_T\,C_T\,x_T + H_T\,b - h_T), \tag{9.9}$$

which implies

$$x_T = G_T\,y_{T-1} + g_T \tag{9.10}$$

where

$$G_T = -\,(C'\,H_T\,C)^{-1}\,C'\,H_T\,A \tag{9.11}$$

$$g_T = -\,(C'\,H_T\,C)^{-1}\,C'(\,H_T b - h_T) \tag{9.12}$$

The matrix $C'\,H_T\,C$ is assumed to be non-singular.

By a further substitution for y_T and r_T in the above equations, the expressions for H_t and h_t can be derived as follows.

$$H_{T-1} = K + A'H_T\,(A + C\,G_T) \tag{9.13}$$

$$h_{T-1} = K\,a_{T-1} - A'\,H_T(b + C\,g_T) + A'\,h_T \tag{9.14}$$

The procedure from (9.9) onwards can be repeated with T-1 replacing T, and the recursive structure is established if T is replaced with t in the above optimal control equations.

The values of G_t and g_t are determined from the preceding four equations, by solving the equations backward consecutively from time T, T-1,..., 1.

Given the values of G_t and g_t, the solutions to the deterministic control problem can be derived by solving for x_t, y_t, in equations (9.10) and (9.2) forward in time from t = 1, ..., T. The values of x_t and y_t for the period t= 1,..., T are the optimal paths of the variables and can be compared with the targets originally set for these variables.

9.3 The State-Variable Form of the Model

The structural form of the econometric model as written in Chapter 6, can be represented as

$$y_t = A_0 y_t + A_1 y_{t-1} + C_0 x_t + b_0 \tag{9.15}$$

where the higher order lagged variables have been reduced to first order lagged terms by defining additional equations. The reduced form of the model is given by

$$y_t = (I-A_0)^{-1} A_1 y_{t-1} + (I-A_0)^{-1} C_0 x_t + (I-A_0)^{-1} b_0 \tag{9.16}$$

By noting that

$$A = (I-A_0)^{-1} A_1 \tag{9.17}$$

$$C = (I-A_0)^{-1} C_0 \tag{9.18}$$

$$b = (I-A_0)^{-1} b_0 \tag{9.19}$$

the standard form of the reduced model in the state variable formulation can then be written as:-

$$y_t = A\,y_{t-1} + C\,x_t + b \tag{9.20}$$

In this study, the macromodel has 133 equations and there must be 133 state variables in the vector y_t. Furthermore, seven new equations are added to remove higher order terms from the system. Finally, in the crop allocation experiments, three control variables are introduced so that the vector y_t has 143 variables.

9.4 Solution Procedure for the Optimal Control Technique

The optimal control problem to be solved in this study is a discrete linear system (Equation 9.2) with nonlinear objective function (Equation 9.3). As the disturbance terms in the system of linear equations are assumed to take their expected mean value of zero, the solution is deterministic as opposed to a stochastic solution where estimates of the error term are included in the solution procedure (see Basu, 1981, p. 116 for an example where the stochastic solution procedure is attempted).

The optimal paths for the control variables are obtained by solving for G_t, g_t, H_{t-1}, h_{t-1} from equations (9.11), (9.12), (9.13), and (9.14) respectively, one year at a time backward from 1995 to 1984. The values of G_t and g_t are stored and used in evaluating equations (9.10) and (9.2) for x_t and y_t recursively forward in time from 1984 to 1995. A FORTRAN programme that has been developed for solving the optimal control problem is shown in Appendix B. Chow (1975), Fair (1984) and Anandalingam (1983) had suggested the use of available computer software for solving the optimal control problem, but usually the use of ready-made programmes is restricted because of the individual nature of the problems (see Drud, 1983 where the problems of setting up the software for optimal control are discussed). In this study, it was considered more appropriate to construct the programme for solving the present optimal control problem as was also done by Basu (1981) , Vines et al (1983), Motamen (1979) and Pindyck (1973) in their studies dealing with macroeconomic models.

The computing procedure involves the preparation of the coefficient matrices A_0, A_1, C_0, and b_0 of the model as they are represented in equation (9.16), and simplifying them into the final form of the coefficient matrices A, C, and b as represented in equation (9.20). Although b is a vector in equation (9.16), its values for the 12 periods are read into the programme as a matrix with each column representing the vector for each year of the experimental period. The initial preparation also includes putting into the programme the vector of initial values y_0, the matrix of target values (a_t), and the elements of the weight matrices K_t. The programme ensures that the initial coefficient matrices A_0, A_1, C_1 and b_1 which are of the order of 140x140, 140x140, 140x3 and 140x12 respectively are fully developed into their final reduced forms A, C, and b with the corresponding dimensions of 143x143, 143x3 and 143x12.

The main problem is in the linearization procedure. The model is linearised for three separate periods from 1984-1987, 1988-1991 and 1992-1995. Linearization is through the usual approximation by truncation of the expansion of Taylor series of the nonlinear equation (see Appendix D). Three sets of matrices for each of A_0, C_1 and b_1 are read into the programme to account for the linearization for the three periods and the programme for solving the optimal control problem is also designed to deal with the three linearization periods by using the usual 'implied do' looping technique in FORTRAN programming.

In the iteration procedure in which the optimal control equations are evaluated, the programme performs many rounds of matrix operations, and these are facilitated by the used of the (NAG) subroutines which are available from the computer's library of FORTRAN programmes. Although numerous matrix operations are performed and large matrices are involved, the computations are fairly straightforward as the equations are evaluated recursively. However, large storage capacities are needed to handle and store the matrices. Each of the present experiments requires 2.6 megabytes of storage space and close to 35 minutes of computing time on the VAX/ VMS computer [1].

9.5 Properties of the Optimal Control Solutions.

As the algorithm for the optimal control technique is derived from the minimization of a quadratic objective function, the results obtained are regarded as an optimal set of solutions.

However, for a given model, the solution set is not unique since it can be influenced by the choice of the target trajectories, the initial values (y_0), and the weighting matrices K_t. If the first two items are treated as given, the variability in the solution set is then determined by the choice of the K_t matrices. The optimal solutions are thus interpreted in relation to the assumptions and the constraints of the minimization problem.

The determination of the weighting factors i.e. the elements of the K_t matrix is critical and can be a subjective process in optimal control evaluations. Anandalingam (1983) and Basu (1981) have noted the difficulty involved and they suggest that the weights be derived by an iterative procedure of solving the optimal control problem many times to ensure that reasonable solutions are obtained. This is because of the fact that there exists an infinite choice of K_t and thus there would be an infinite number of optimal solution sets. Meaningful results from the optimal control runs can only be obtained if there is an approach in which a systematic change in the values of K_t can be linked to the manner by which the planner chooses to assign the appropriate penalties for deviations of the state variables from their target paths in the objective function. The weights thus reflect the importance that the planner may attach to the variable in question. The larger the K value the larger will be the penalty for the deviation from the target path in the objective function, and the closer will be the tracking for that variable in the final solution.

It is possible in some applications to select a solution set which corresponds to a minimum value for the cost function. However, this may not always be truly optimal because the value of the cost function reflects the choice of the weights; the inclusion of more target variables will also increase the cost function, but if the target variables must be included by design, the value of the cost function has to increase accordingly.

Usually, in many applications only a few state variables which are important in the planning process are included as target variables in the objective function. In this respect, it is noted that the lagged state variables which enter the model via the definitional equations added to remove higher order terms can be given zero weights because they are not important in terms of their ability to track their target values. In general, the weights are assigned proportionately in terms of percentage deviation values (see Pindyck (1973) p. 111). In this way variables with large absolute values are given smaller weights, and vice versa.

One convenient way of implementing the weighting procedure is to assign weights which are inversely proportional to the square of the target values. This implies that the planner places equal importance to all the state variables. This approach is useful when many state variables are included as targets in the cost function. The squaring in the computation of the weights is to account for the fact that the deviations are squared in the quadratic objective function. The weighting procedure used in the optimal control runs in this study is based on the method of using the inverse of the square of the value of the variable in question, variables with large values receive small weights and vice versa. Thus if the variable GDPC has a value 67,000 in the relevant unit for a particular year, its weight in the K matrix for that year is $1/(67{,}000^2)$.

9.6 Setting Up of the Experiments

Three sets of experiment will be carried out using the optimal control technique. These are as follows:-

a) The optimal allocation for rubber and oil palm is investigated for the period 1984-1995. The objective is to generate the optimal growth paths of rubber and oil palm planted areas for the period 1984-1995 if target trajectories for rubber and oil palm areas, which are the control variables, are identified in advance. Target trajectories for selected key economic (endogenous) state variables are also identified in advance and formulated accordingly in the objective function. The three runs in this experiment attempts to evaluate the sensitivity of the optimal trajectories under different target paths for the control variables. The results from Experiment 1 are expected to indicate i) the optimal trajectories for rubber and oil palm planted areas for the period 1984-1995 under the given set of nominal target trajectories, and ii) how these trajectories will change if more ambitious nominal target growth path for oil palm is introduced.

b) The second experiment is designed to replicate the runs in Experiment 1 except that the target trajectories for the endogenous state variables are altered to a higher set of growth paths. This will indicate the sensitivity of the results of Experiment 1 to changes in the target values of the endogenous state variables. The results will also indicate the optimal trajectories of the planted areas for rubber and oil palm and these can be combined with the results from Experiment 1 to assess the optimal crop allocation for rubber and oil palm for the 1984-1995 period.

c) The third experiment is another sensitivity test of the results from Experiment 1. In this instance, however, the three runs of Experiment 1 will be replicated, but the projected values of the exogenously determined price variables for palm oil and rubber will be altered to a higher level for the former and lower level for the latter during each run of the experiment. The aim is to show the sensitivity of the results from Experiment 1 to changes in the values of the exogenous variables of the model, especially the price variables for rubber and palm oil.

Thus the approach in the setting up of the experiment is to solve the optimal control model for the period 1984 to 1995, using the planted areas for oil palm (MAPALM) and rubber (both the smallholdings, MARUBSH, and the estates, MARUBES) as the control variables. As in Chapter 8, the contribution of the rubber and palm oil industry to the economy can be measured in terms of changes to the GDP, export revenue and employment.

These three variables are commonly used in other studies (Ekaus and Parikh, 1968; Westphal, 1971; and Anandalingam, 1983) to reflect the welfare of a country. Consequently, the three state variables are included in the objective function by assigning non-zero weights to their respective coefficients in the K matrix. The actual weight used, as explained earlier, is the inverse of the square of the absolute value of the variable for any given year during the evaluation period.

9.6.1 Forward Forecast of the Macroeconometric Model

To obtain the target trajectories for the optimal control routine, i.e., the nominal target trajectories for the state and the control variables, it is necessary to have an idea of the forecast scenario of the economy for the forward period under consideration. Such target trajectories could be supplied in advance through policy directives in a planning exercise, or when these are not possible as in this study, the target trajectories can be obtained by first simulating the macroeconometric model over the period 1984 to 1995 using the simulation forecast procedure similar to that described in Chapter 8 for the historical period. Modifications to the forecast scenario can then be introduced to reflect the desired targets by adding a certain percentage sustained increase of the relevant variables in relation to their base forecast values.

Exogenous values of the model have to be supplied to enable the forecast to be generated by the TSP programme [2]. There are 73 exogenous variables of which a large proportion are dummy variables; the rest are time dependent variables and other exogenously determined variables. The values for the dummy variables are quite easily determined in terms of zeros or ones corresponding to whether the condition for the dummy is still present or absent [3]. The exogenous variables representing the residual terms in identities of the model and others that are time dependent are projected using a simple time trend projection. The remaining exogenous variables relating to world prices and indices are projected on the basis of information from other forecasts obtained externally. For example, forecasts of world prices of commodities, GDP of the U.S.A. and interest rates were based on World Bank's projections (see, International Monetary Fund (1985), "Economic Outlook", and 1984 issues). In selecting these projection values, the base forecast corresponding to moderate or medium growth paths were used. Actual values of the exogenous variables are shown in the listing of the computer printout in Appendix C.

In an attempt to generate the forecasts of the endogenous variables of the macroeconometric model using the TSP procedure, it was found that the solution of the model is sensitive to the level of government borrowing which is exogenously determined throughout the simulation of the macroeconometric model. When the level of borrowing (GFFRLC) is projected to be relatively low, the model becomes unstable by showing negative values for net assets of the Central Bank, etc. The model allows for a considerable flexibility in the projected level of government borrowing before becoming unstable. A higher level of borrowing however, will lead to increases in current consumption and GDP (national expenditure) in current values. The rapid rate of growth in GDP in current values may retard real GDP growth because of the increase in the GDP deflator which supresses the growth of real prices and hence real output. The consumer price index (CPI) which is determined by lagged money supply in the model is also affected but to a lesser extent.

Given such behaviour of the model in relation to forecasting the values of the variables for the 1984-1995 period, it is thus necessary to simulate the model using the TSP dynamic simulation procedure a few times in order to arrive at a reasonable projection scenario for the period in question.

The final forecast figures for the variables of the model are derived by solving the model a few times using a set of projected values of government foreign borrowing (GFFRLC) in such a way that the balance of payments and net assets of the Central Bank are showing plausible values. The long computing time required for the simulation of the macroeconometric model (about 1 hour) prevents an exhaustive selection process, and the final set of results chosen to be the base forecast (referred to as "Target ..." in Table 9.1) is a balanced choice that produces rates of growth for GDP, export revenue, employment, inflation etc which reflect the trends in the past.

9.6.2 Targets for the Control and State Variables

Having obtained the nominal base forecast by simulating the macroeconometric model, it is necessary to introduce desired modifications to the base forecasts for all the state and control variables to reflect the desired target paths of the variables as envisaged normally by a planner. Without the modifications, the optimal control problem would not in theory yield any trade-offs, as the targets a_t are equal to the expected values of the state variables y_t in the objective function (9.3). This implies that in the long run the target a_t is equal to the expected value of the state variable Y_t, and the value of the objective function would be zero.

Meaningful and coherent formulation of the optimal control problem is achieved if trade-offs are involved in the evaluation of the objective function which is being minimised. These trade-offs are obtained when higher growth paths for GDP or export revenue etc are desired and the instrument variables are employed to drive the economy to achieve as closely as possible the desired growth paths of the target variables. In many problems costs are incurred in forcing the instrument variables to follow an optimal path as generated by the optimal control routine. In this respect, the controls or instrument variables and their respective desired targets are also included in the objective function to allow the cost involved to be minimised together with the other targets variables included in the objective function [4]. This means that the corresponding control variables are given non-zero weights in the objective function.

In the various experimental runs of this study, the special target trajectories generated by adding the relevant desired perturbations to the base forecasts of the state and control variables were restricted only to those variables selected to be in the objective function. Target trajectories for all other variables were given the base forecast values which had been obtained from forward dynamic simulation of the macroeconometric model as described earlier.

9.6.3 Calibration of the Model

If the base forecasts obtained from the forward dynamic solution of the model using the TSP procedure are used as targets, it is possible to solve the optimal control problem under a special condition and obtain results which correspond to the solution of the reduced form of the macromodel. This is done by using the three control variables as the only targets in the objective function. Since the same control variables are also acting as target state variables, there are therefore three control variables (x_t) and three target variables in the objective function which, according to Chow (1975), will generate a unique set of solutions where the targets are met exactly by the optimal trajectories. Since the target trajectories for the control variables are given the values of their corresponding base forecasts, the optimal values of x_t in equation (9.10) are equal to their base forecast values exactly, and it follows that the values of y_t in equation (9.2) will therefore be the solution of the reduced form of the model. The exact tracking is shown in the target and optimal trajectories of the control variables shown in Table 9.1.

As the reduced form of the model is obtained by linearization of the model's nonlinear equations, the base solution from the reduced form of the model will be expected to deviate from the base (TSP) forecasts of the structural form of the model. The results of the optimal control base run which correspond to the solution of the reduced form of the macromodel are labelled "Optimal ..." in Table 9.1. The values of the base forecasts of the structural form of the macroeconometric model, corresponding to the unperturbed target trajectories used in the optimal base run are labelled "Target ..." in Table 9.1. Comparison of these two sets of results enables the solutions of both the reduced and structural forms of the model to be compared and the differences between them with respect to a particular variable represent the inherent levels of error due to model linearization.

9.7 Experimental Results

9.7.1 Base Solutions

The base solutions from the optimal control base run shown in Table 9.1 with the label "Optimal .." appear to be comparable to the simulation forecast values generated by the macroeconometric simulation forecasts (labelled "Target ..." in Table 9.1). This suggests that the reduced form of the model which generates the optimal solutions is responding adequately and thus it could be used for subsequent optimal control experiments. The relatively large deviations of 'optimal' LABTOT from the corresponding 'target' values may be due to the effect of linearization of the optimal control model. Linearization tends to provide lower values and will underestimate those variables which have high growth rates which are 'convex' in shape.

For subsequent experiments, the results could be compared with respect to the optimal control base solutions (labelled "Optimal .." in Table 9.1) which correspond to the reduced form solution of the macromodel. This enables the relative impact of policy experiments to be consistently compared. In Figure 9.1, the difference (shaded area) between the TSP base run forecast of the macroeconometric model and the optimal control base solution of the optimal control model represents the inherent error in the model due to linearization.

9.7.2 Solutions to the Crop Allocation Problem

Three experiments, each with three to four runs, are carried out to evaluate the crop allocation using the optimal control technique. The aim is to show the trade-offs between increased planting of oil palm at the expense of rubber relative to the base forecast for the period 1984-1995. This implies that if no new policy is introduced, the crop allocation pattern that will emerge is projected to be the same as the results from the TSP base forecast labelled "Target .." in Table 9.1). However, planners may wish to introduce a policy that will favour increased planting of oil palm and decreased planting of rubber relative to that shown by the base forecast trajectories. At the same time, target trajectories which are an improvement to the base forecasts may be desired for the key economic variables of the country such as GDP, export revenue and labour demand. The desired target trajectories for GDP for example may be 20% higher than the TSP base forecast trajectories. In this way, trade-offs are involved in which the planner desires the economy to grow at rates different and more favourable to those projected by the TSP base forecasts, and the instrument variables such as the mature planted areas for rubber and oil palm are used as the control variables to steer the economy towards achieving the targets. The targets will not be met exactly as there are more target variables in the objective function than there are control variables (see Chow, 1975), and thus optimal solution generated through the optimal control run will reflect the best compromise that will minimise the cost function represented by the objective function.

As described earlier, Experiment 1 deals with different target trajectories for the control variables. Thus, each of the three runs of Experiment 1 will be given a different set of target paths for the exogenous state variables. Experiment 2 explores the sensitivity of the solution when the trajectories of the endogenous variables are changed systematically for the three runs while using the same given set of trajectories for the control variables as in Experiment 1. The third experiment is a replication of experiment 1 except that different trajectories for palm oil and rubber prices are used as exogenous inputs to the solution of the model. Finally, verification of the optimal control solution is carried out by simulating, via the TSP procedure, the structural form of the model using as inputs similar pattern of rubber and oil palm planting as those explored in the optimal control experiments described above.

a) <u>Experiment 1: Run 1: An Increase in Oil Palm Area Corresponding to a Simultaneous 20 % Decrease in Rubber Planted Area.</u>

The first experiment is designed to show the trade-off between increased planting of oil palm at the expense of rubber relative to the base forecasts for the period 1984-1995. These desired targets in planted areas for rubber (two variables) and oil palm (1 variable) are combined with other desired targets for the key economic variables of the economy to form an objective function containing six target variables. These other desired targets are increases of 20 % in GDP, 30 % in export revenue and 3 % in employment relative to their respective TSP base forecasts. These are illustrative targets which seem appropriate for testing the response and controllability of the economy through changes in the planted areas for rubber and oil palm from their base forecast trajectories.

The target paths for rubber smallholdings and rubber estates in Experiment 1, Run 1 are 20 % lower than the base forecast and the area removed from rubber is then reallocated to oil palm so that the planted area for the latter crop is increased accordingly relative to its base forecast trajectories. The results of the run would therefore show the kind of response that would be obtained if the planted area for oil palm is increased while the planted area for rubber is simultaneously decreased through a crop reallocation policy which favours increased oil palm planting.

Results: The trajectories for the three endogenous state variables and the three control variables are shown in Table 9.2. The higher optimal trajectories for the three control variables (Figure 9.2) show that the results have responded in the right direction in that planted areas for rubber smallholdings, rubber estates and oil palm would have to be higher than the target trajectories since this is the only way for increases in GDP, export revenue and employment to be achieved.

It is seen from Table 9.2 that the target trajectories set for the three endogenous state variables could not be met fully as shown by the lower optimal paths for these variables even if higher levels of planted areas for rubber and oil palm are indicated in the optimal results. This suggests that there is a limit to the response of the economy implying that the GDP (see Figure 9.1) could not be driven indefinitely to achieve higher growth rates just by increasing the planted areas for rubber and oil palm alone because of lower proportionate gains in GDP per unit increase in the target values of the control variables. The results indicate that the use of a policy in which oil palm areas are targeted to increase as a result of reallocating 20 % of rubber areas from the base trend may not achieve the desired 20 % growth in GDP, 30 % growth in export revenue and 3 % growth in employment originally desired as targets (see Table 9.2). However, a trade-off solution is obtained for all the six variables representing the optimum tracking of the targets trajectories at the lowest cost with respect to the objective function.

Nevertheless, the increase in planted areas for rubber and oil palm contributes positively to the economy as can be seen if the optimal trajectories in Table 9.2 are compared with the optimal base solution trajectories labelled "Optimal .." in Table 9.1. In this sense, the model has responded appropriately.

Under the conditions of Experiment 1, Run 1, the optimal trajectories for oil palm planted areas are considerably higher than their targets when compared with the deviations of the optimal paths of rubber from their corresponding targets (see Figure 9.2). Thus a proportionately higher area of oil palm has to be planted relative to rubber to achieve the goals stipulated for the experimental run. The results also suggest that rubber has a higher marginal contribution to the economy since only a small increase in rubber area would contribute toward achieving the targets compared with a much larger increase needed for oil palm. It is noted however, that the observation is partly influenced by the weighting factor used in the K matrix of the objective function although the weights employed for the K matrix follows the "equivalent weighting" procedure used to assign weights to the variables in the objective function as described earlier. Such weighting procedure is designed to give equal importance or equivalent penalties to a unit deviation of rubber or oil palm areas from their target trajectories.

It is necessary to examine the results to determine whether the reallocation of rubber areas to oil palm has resulted in an improvement in GDP, export revenue and total employment, and whether the cost function value of the objective function can be reduced. These will require further runs of the experiment, apart from the optimal base run solution already discussed above, to test the sensitivity of the results with respect to changes in the targets for the control variables.

Nevertheless, the potential utilization of the optimal control techniques is clearly illustrated by the results discussed above. If the macroeconometric model has been representative of the economy, the planner can gain a further insight into the behaviour of the economy when the effects of policies involving desired deviations from the base projections are evaluated, while the base projections are themselves generated by the conventional simulation procedure such as through the use of the TSP procedure. Direct forward simulation of a macroeconometric model with similar increases in the projected growth paths of the exogenous (control) variables would not lead to the same results as there are no provisions for setting up the desired targets for the state variables and there are no optimal trade-offs to reflect the priorities of the planner.

Thus, in the remainder of this chapter the investigation will be concerned with

i) analysing the response of the optimal control runs when different sets of targets are used.

ii) analysing the sensitivity of the results with respect to parameter changes in the macroeconometric model.

iii) how the formulation of the problem can be improved to provide more realistic policies for the crop allocation of rubber and oil palm in the Malaysian plantation industry.

b) Experiment 1: Run 2: An Increase in Oil Palm Planted Area Corresponding to a Simultaneous 50 % Decrease in Planted Area for Rubber.

The purpose of this run is to observe the response of the optimal trajectories for more severe changes in reallocation targets favouring oil palm rather than rubber. Thus an increase in planted area for oil palm from rellocation of 50 % of the area for rubber relative to their respective base projections were employed as targets for the control variables in the optimal control run. The targets for the three state variables and those for the remaining state variables remained unchanged from their corresponding values used in Run 1.

The results are shown in Table 9.3. Changing the target paths for oil palm and rubber more drastically in favour of oil palm when compared with those used in Run 1 appear to have mixed effects, with GDPC values being higher for the first part of the planning period between 1984 and 1990 and generally lower thereafter compared to the corresponding values in Run 1. This can be clearly seen if the residuals representing the optimal solution minus the optimal solution from the base run are compared as in Figure 9.6.

Introducing changes in the target trajectories appear to have a relatively small impact in relation to the total absolute value of GDP as shown in Figure 9.3. where the plots of GDPC from the different runs lie very close together. It must be remembered however, that the impact is expected to be small as only reallocations of fairly productive crops are involved. Since the measurement is made within the consistent framework of the model, any peculiar error or pattern of response of the model is carried through consistently, and the changes detected between various runs, in relation to the base solution of the optimal control model, represent a fair measure of the response from the changes in inputs introduced at each run since only the values of the relevant inputs are altered in each run. Usually, economic analysts aim to evaluate the impact of a change in a set of variables while 'other things remain constant'. Such concepts are reflected in the optimal control procedures and hence in the results obtained between the various runs of the experiments in this study. When plotted in terms of the residuals relative to the optimal base run, as in Figure 9.6, the relative merits of the various crop allocation policies can be more easily compared.

The trend in the response of the results to changes in crop allocation strategy may also be detected by the value of the objective function generated at the end of each run. A lower value in the objective function implies lower cost or loss and thus indicates a more optimal allocation ratio. To compare the values of the objective function a third run of Experiment 1 was carried out in which the targets for the control variables were changed to favour increased planting of rubber at the expense of oil palm. The areas for rubber were targeted to increase resulting from reallocation of 20 % oil palm area relative to values of their respective base forecasts.

The results of Run 3 are shown in Table 9.5 and plotted in various ways in Figures 9.3 and 9.6. The values of the objective functions in the three runs are compared in Table 9.4. By attempting to increase the planting of rubber relative to oil palm though changing the target trajectories accordingly in Run 3, growth in GDPC as in Figure 9.6 is initially lower than those from Runs 1 and 2 but after 1988-89 the GDPC values from Run 3 are relatively higher.

The results of the three runs in Experiment 1 may be summarised as follows.

i) the model provides results which reflect the optimal trade-off for tracking the target trajectories as close as possible. This demonstrates the usefulness of the technique for selecting policy options based on specified desired targets.

ii) by employing different nominal target trajectories under the various runs of the experiment, the results also suggest an optimal crop allocation pattern which favours increased planting of oil palm for the first part of the planning period while rubber planting is favoured toward the 1990s (see Figures 9.3 and 9.6). As this represents a shift in the pattern of optimal crop allocation from the results of the historical policy simulation analysis in Chapter 8, it is necessary to evaluate further the assumptions used to see that the results are consistent and comparable with respect to the results from the simulation analysis in Chapter 8.

iii) The results therefore raise questions which need further exploration. Firstly, it is necessary to investigate the response of the model when the target for the endogenous state variables are changed systematically as was done for the control variables. This allows the sensitivity of the model response to changes in the target trajectories for GDP, export revenue and labour demand to be measured. Secondly, it is necessary to explore the outcome of the experiment if the exogenously determined prices of rubber and palm oil are altered systematically to reflect alternative forecast scenarios for world prices of these commodities. Imposing different price trajectories also allow the response to changes in the input values of some exogenous variables of the model to be evaluated.

c) <u>Experiment 2: Sensitivity to Changes in the Targets for the Endogenous Variables</u>

The purpose of Experiment 2 is to evaluate the sensitivity of the optimal control results to changes in the target trajectories of the endogenous state variables. The three runs in this experiment attempt to repeat the corresponding runs of Experiment 1 except that the trajectories for the three state variables are subjected to higher target growth changes. For the three runs of Experiment 2, the targets for GDPC, export revenue and employment are kept at 40 %, 50 % and 10 % higher respectively in relation to their corresponding base forecast trajectories.

The results of Runs 1, 2, and 3 of Experiment 2 are shown in Tables 9.6, 9.7, 9.8 respectively. The optimal trajectories show three discerning trends. Firstly, it is more costly to achieve a higher growth policy and this is reflected in the higher values of the cost function relative to those in the corresponding runs of Experiment 1. Secondly, the ability of the control variables to steer the endogenous state variables to track their targetted growth paths remains restricted. Despite the increase of more than 100 % in the perturbations in the trajectories of the state variables compared with Experiment 1, only a small response in the optimal trajectories was observed in the results. Thirdly, the trend that rubber planting is more favourable than oil palm towards the end of the planning period, as observed in Experiment 1, is also indicated in this present experiment (see Figures 9.4 and 9.7).

9.8 Sensitivity of the Model to Parameter Changes

It is expected that the model behaviour will be sensitive to certain parameters i.e. the coefficients of Y_t, and b_t of the model as represented by Equation 9.2. Since these parameters are statistically estimated, they in turn are random variables with certain means and variances and these are subject to some margins of error. The model would be more sensitive to some of these parameters than to others. The investigation of the sensitivity including the model's response to changes in values of the exogenous variables, is possible, but it is highly demanding on computing time in view of the 35 minutes of computing time needed for each run. Thus a limited test serving the dual purposes of evaluating the sensitivity aspect and exploring the solution to the crop allocation problem is carried out as elaborated in the next section.

a) Experiment 3: Sensitivity of the Results to Price Changes for Rubber and Palm Oil

A more useful indication of the sensitivity of the model to parameter changes can be obtained by employing price changes for rubber and palm oil in the test. This will also simultaneously answer the question of how the crop allocation problem will response if world prices of rubber, RSS1 and RSS3 which are exogenous variables in the model, were to fall by 60 % while prices of palm oil were increased by the same percentage during the 1984-1995 evaluation period. Thus three runs corresponding to those of Experiment 1 are carried out for the present experiment under the new price trajectories.

The results are shown in Tables 9.9, 9.10, 9.11, where the values of the individual objective functions are also indicated. Increasing the prices of palm oil stimulates oil palm planting and the trajectories for oil palm planted area is seen to be higher than those shown in Run 1 of Experiment 1. The optimal paths for GDPC and export revenue are lower than those for the corresponding runs in Experiment 1. It appears that a 60 % reduction in the prices of rubber throughout the planning period had a much more negative impact on the economy than would a corresponding 60 % increase in oil palm prices.

To explore further the impact of price changes, a fourth run of the experiment was carried out where the prices of rubber were reduced to 10 % of their base forecast values while those for palm oil were increased by 260 % for the 1984-1995 period. The imposition of the large shocked changes resulted in the expected large increase in GDPC and export revenue, as seen by comparing Table 9.12 with Table 9.9 (see also Figure 9.5). The large increase in GDPC and export revenue is expected as the increase in palm oil prices is proportionately much larger than the reduction in the price of rubber.

b) <u>Simulation of the Macroeconometric Model, 1984-1995</u>

To confirm the results of the various optimal control experiments in the previous sections, in which oil palm appears to contribute less than rubber towards the end of the planning period, a forward dynamic simulation forecast of the macroeconometric model was carried out using the TSP procedure. A 50 % hypothetical removal of rubber area from the level shown in the base forecast was reallocated to oil palm. The results

(Table 9.13) show that GDPC and export revenue (labelled "Solution ..") decline relative to their corresponding base forecast as reported in Table 9.1 while labour demand increases slightly. Replacing a large fraction of rubber area with oil palm for the 1984-1995 period seems to incur a loss to the economy from 1986 onwards. The results are generally consistent with those from the optimal control runs. It thus appears that for the period 1984-1995, the model characteristic behaviour is such that increased planting of rubber towards the end of the planning period is favourable. This deviates from the finding in Chapter 8 which suggested that oil palm cultivation should have been maximised.

Since the results of the optimal control techniques are consistent with the scenario projected by the TSP simulation forecasts, it can be deduced that the results of the optimal control experiments are consistent; the observed change in profitability trend of the two crops is not due to the optimal control model but more from the behaviour of the macroeconometric model itself, under the environment of the 1984-1995 period. This means that the structural behaviour of the equations of the model and the input values of the exogenous variables used to enable the forecast to be carried out are important determinants influencing the outcome of the results in the optimal control experiments.

As mentioned earlier, sensitivities with respect to model parameters and changes in input values of the exogenous variables require substantial tests which could not be carried out to the full in this study, due to the constraint mainly of the 1 hour computing time needed per simulation of the model. Reliance is thus placed on the test of the sensitivity of the optimal control results on changes to prices as in Experiment 3, as this represents a test of the response of the model to exogenous variable changes; and some importance must also be attached to the fact that the input values of the exogenous variables used in the forecasts are medium growth trajectories. Evaluation of high and low growth scenarios for the exogenous variable trajectories to give the corresponding high and low growth scenarios in the model simulation results would lead to an equally major extension to the chapter without adding more to the objective of trying to show that the optimal control procedure is able to provide the policy maker with quantitative information with respect to the crop allocation problem.

9.9 Using the Optimal Control Technique for Analysing the Dynamic Behaviour of Models

It has been demonstrated that the optimal control technique employs the reduced form of the macroeconometric model. This in itself provides an alternative solution in comparison to that provided by simulating the structural form of the macroeconometric model.

The most apparent benefit gained from using the optimal control is that optimal trajectories are generated when variables are forced to track as closely as possible their nominal trajectories, while emphasizing trade-offs reflecting the priorities of the decision maker. These trade-offs are obtained under explicit delineations of the effects of specific variables which are dynamic in time, while keeping other variables unchanged.

The interrelationship and the complementarity aspects of the simulation and optimal control method is clearly implied when Pindyck (1975, p. 152) noted that

"..in theory there is nothing that could be learned from an optimal policy solution that could not be learned by performing simulation experiments - if one were willing to perform enough simulations. If one had the time and stamina to perform a large enough number of simulations, he would eventually come up with a solution i.e. a set of paths for both the control and endogenous variables that match the optimal policy solution."

This clearly implies the superior efficiency of optimal control procedures in situations where the problem of trade-offs are involved in policy analysis, as encountered in the crop reallocation problem for rubber and palm oil.

9.10 Policy Implications of the Optimal Control Results

The basis of policy evaluation in this study is through simulating and experimenting with the macroeconometric model. A significant amount of model behaviour has been learnt from the validation and policy simulation experiments of Chapters 7 and 8. The historical analysis provides an indication of the validity of the model. Subsequently, the predictive power of the model for a future planning period is assumed to follow from the acceptable degree of the goodness of fit of the model as demonstrated by its tracking ability during the historical simulation and validation exercises in Chapters 7 and 8. Comparison of the optimal control results with actual values is not possible unless the optimal policies have been tried out.

The results of the forward period simulation and optimal control would have been easily interpreted if the indicated trend in crop allocation pattern is similar to the historical situation. The findings from the optimal control experiments however represent a slight departure for the past pattern of optimal crop allocation. In particular, there appears to be a tendency for rubber planting to become attractive economically relative to oil palm during the 1990s. The policy implications from these results are as follows:-

i) Assuming the 'best-effort- medium-forecast' scenario is representative of the economy, the optimal control results suggest that future policies for crop allocation for rubber and oil palm must be reviewed to take into consideration the apparently superior contribution from rubber projected to occur during the 1990s. Past policies such as those favouring very low ratio of rubber to oil palm areas must be reexamined for possible policy changes favouring rubber cultivation for the 1990s.

ii) The optimal control technique could not be used to determine explicitly the optimal ratio for the allocation of rubber to oil palm. However, it can be used by planners to determine the optimal planted areas of the two crops if targets trajectories for the planted areas and for other major variables of the economy are stipulated in advance. This has been illustrated by the experiments of reallocating rubber land to oil palm and vice versa.

iii) The results indicate the lower marginal contribution of oil palm cultivation relative to rubber for the future. This trend arises partly from the relative price projections given to the two commodities and partly due to the interactions within the model structure. As recent low prices of palm oil had led to some sectors of the oil palm industry reporting losing money, it is not inconceivable that overproduction of palm oil will be detrimental to the Malaysian economy. In some respects, the golden age in which Malaysia had led other countries and benefitted greatly from the production of oil palm is nearing an end as these other countries, such as Indonesia are fast catching up with their increasing output of palm oil.

iv) As in all modelling studies involving simulation and forecasts, the solutions obtained are just one set of numerous possibilities. Another analyst could well choose a different weighting matrix K, different values of the exogenous variables and different set of equations for the model. However, the findings in this study show that the solution to the crop allocation problem is quite robust; in the historical simulation in Chapter 8, the optimal crop allocation pattern was easily identified, and in the projected planning period the results were also shown to be not too sensitive to assumptions made in the exogenous values of the model such as prices. This would enhance the validity of the results and the conclusions that could be drawn from them.

It is also noted that in real application of the optimal control model, the optimal control solution to the planning problem can be updated each planning period to take into account any new information becoming available. In the 'opened-loop' optimal control technique as suggested by Fair (1984), annual revision of the solution is necesssary as the principle of "certainty equivalent" [5] and hence the optimality of the solution is restricted only to the first period in the optimal control solution. In the deterministic 'closed-loop' approach, as in this study, the optimal path of the trajectories of the model can be already established at the beginning of the planning period. This is because of the way that the feedback control equation is used in deriving the solution procedure (see Chow, 1975). In this respect, the deterministic optimal control solution can provide optimal trajectories given the information available at the beginning of the planning period.

9.11 Conclusions

In this chapter, the use of macroeconometric simulation and optimal control has been illustrated to be a mutually beneficial and complementary set of tools which could be employed in policy analysis, and the techniques have been adequate in solving the crop allocation problem for rubber and oil palm in the Malaysian plantation sector. The optimal control technique is useful in providing an alternative set of solutions to the macro model but more importantly, it is valuable in providing an insight to the optimal trajectories of the endogenous and control variables of the model when trade-off situations are involved regarding policy options under certain identified desired target paths of the variables.

The analysis in this chapter provided a surprising finding with regard to the optimal allocation problem in that rubber planting was shown to be increasingly more favourable relative to planting of oil palm in the 1990s. This represents a slight shift from the historical trend as reported in Chapter 8. Interestingly, the results agree with the prediction of prominent members of the industry who participated in a Delphi Survey in 1979 (see Basiron, 1982). In that survey, the panel of experts were unanimous in predicting that oil palm cultivation would be more profitable than that of rubber up to 1990, but they were divided in their opinions whether oil palm cultivation would continue to be profitable in the 1990s. As in most occasions when unexpected findings are encountered, suspicion is placed on the model accuracy rather than the true implications. Thus more sensitivity tests were conducted but these have not altered the findings.

If the results had been totally in favour of oil palm planting, there would have been little difficulty in concluding in support of maximizing oil palm planting as was the situation in adequate in solving the crop allocation problem for rubber and oil palm in the Malaysian plantation sector. The optimal control technique is useful in providing an alternative set of solutions to the macro model but more importantly, it is valuable in providing an insight to the optimal trajectories of the endogenous and control variables of the model when trade-off situations are involved regarding policy options under certain identified desired target paths of the variables.

The analysis in this chapter provided a surprising finding with regard to the optimal allocation problem in that rubber planting was shown to be increasingly more favourable relative to planting of oil palm in the 1990s. This represents a slight shift from the historical trend as reported in Chapter 8. Interestingly, the results agree with the prediction of prominent members of the industry who participated in a Delphi Survey in 1979 (see Basiron, 1982). In that survey, the panel of experts were unanimous in predicting that oil palm cultivation would be more profitable than that of rubber up to 1990, but they were divided in their opinions whether oil palm cultivation would continue to be profitable in the 1990s. As in most occasions when unexpected findings are encountered, suspicion is placed on the model accuracy rather than the true implications. Thus more sensitivity tests were conducted but these have not altered the findings.

If the results had been totally in favour of oil palm planting, there would have been little difficulty in concluding in support of maximizing oil palm planting as was the situation in the analysis in Chapter 8. However, as in hypothesis testing in statistical analysis where "errors of the first kind" (rejecting when the event is true) are less costly to deal with than "errors of the second kind" (accepting when the event is false) , the unexpected findings for the period 1984-1995 suggest two main possible conclusions:

i) if indeed the model predicts the true situation, the results call for caution and there should be a further investigation so that eventually it is possible (without committing an "error of the first kind") to reverse the policy of pursuing an increase in oil palm planting as projected by the policies of the Malaysian government in recent years.

ii) if there are major doubts in the predictive value of the results then perhaps a more elaborate study is also necessary to confirm or dispute the finding shown in this chapter. There are other studies (MRRDB, 1983, p. 37) which have concluded that rubber planting is approaching the profitability attained in oil palm cultivation especially in marginal areas which are unsuitable for oil palm. More recently, Lee (1986) has argued that with the drastic fall in palm oil prices in recent months, the golden era for palm oil may be over, and although future allocation of crops will continue to be skewed towards oil palm, rubber will still be a major crop to be grown perhaps in the less prime environment in Malaysia. These findings are based on updated investment appraisal analyses, and despite their lack of accountability for sectoral interactions between different strategies, the results suggest a policy of refraining from going completely for oil palm and in this respect, the results concur with the observation from the analysis in the present study.

However, further confirmation of the results would be necessary to avoid making "errors of the second kind." There is the possibility that the present optimal control model may impose very restrictive response in certain variables to result in the pattern of response indicated so far. It could also be that the particular selection of exogenous trajectories and hence the simulation behaviour of the model for the forward period 1984-1995 is favouring rubber as shown in Table 9.13.
An improvement can be made by 'fine tuning' the model to provide better forecasts for the 1984-1995 period; better results could be expected if the linearization procedure for the reduced form of the model could be improved.

The results also illustrate the complex nature of the crop allocation problem. Apart for the assumptions of the exogenous values of the variables of the model and the behaviour of the various equations in responding to a forecast period, the optimal control results are also dependent on the weighting procedures used in the optimal control programme. In this study, the adopted approach is to apply the percentage weighting system where 1 % change in GDP is given equal weight to 1 % change in export revenue, labour demand, planted area for rubber or planted area for oil palm. Other weighting systems may be preferred by other analysts.

As often asserted by econometric model builders, there is no way of ascertaining the relationship between the performance of statistical estimation of the individual equations and coefficients and the performance of the model when taken as a whole. Usually, coefficients of the variables in the estimated equations are included on the basis of its low statistical standard error (thus indicating its high level of significance) but the objective of the multiequation model is to provide an accurate structural representation of the real world. Often the model builder may have to sacrifice statistical fit and statistical significance and retain the variables and their questionable coefficients as referred to in Chapter 6 in relation to admitting the prices of rubber and palm oil and some other variables into the model. This type of assumptions may be a possible cause of unexpected results at the end. On the other hand, econometrics is also often asserted as an art as it is a science while simulation is a learning process of dealing with the real situation using a computer. Where theoretical rules are missing, the model builder will combine the tool of analysis such as simulation and optimal control with rough rule-of-thumb guidelines and his own intuition. As more of the simulation exercises and optimal control evaluations are performed - and this study is probably one of the first of its kind on the Malaysian economy - the art part of the modelling effort will be more perfected and the science will be more proven.

Note to the Chapter

[1] Pindyck (1973) reported a computing time of less than 2 minutes for his 28 equation model under 20 planning periods, while Basu (1981) noted a time of 28 minutes for a model with 125 state variables and 5 planning periods.

[2] The Time Series Processor (TSP) (see Hall, 1983) programming package was used to simulate the model and to

prepare data file for use in the FORTRAN programme for the optimal control problem.

[3] See Section 6.11.1 on the use of dummy variables

[4] The control variables are usually included in the objective function to prevent singularity in the matrix inversion stage of the solution but without the control variables in the objective function, singularity can be avoided if there are enough state variables included in the objective function. In the formulation of the optimal control problem as suggested by Pindyck (1973), the control variables must be included in the objective function.

[5] See Chow (1975), p. 173; and Theil (1957).

TABLE 9.1 BASE RUN; WITH THE THREE CONTROL VARIABLES AS THE ONLY TARGETS IN THE OBJECTIVE FUNCTION TO PRODUCE OPTIMAL "BASE SOLUTIONS"

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	959	960	959	959	961	966	973	981	988	994	998	999
Optimal Smallholding Rubber Area	954	959	960	959	959	961	966	973	981	988	994	998	999
Target Rubber Estate Area	390	381	373	364	355	346	337	328	320	312	304	296	288
Optimal Rubber Estate Area	390	381	373	364	355	346	337	328	320	312	304	296	280
Target Oil Palm Area	1023	1106	1189	1274	1359	1445	1532	1619	1707	1795	1884	1973	2062
Optimal Oil Palm Area	1023	1106	1189	1274	1359	1445	1532	1619	1707	1795	1884	1973	2062
State Variables													
Target GDP (Current)	7051	6751	7037	6928	7670	8445	9539	10552	11808	13190	14357	15895	17923
Optimal GDP (Current)	7051	6983	7378	7610	8581	7925	8157	8781	9892	9088	10668	13563	17898
Residual	0	-232	-341	-682	-911	520	1382	1771	1916	4102	3689	2332	25
Target Export Revenue	3892	3581	3587	3689	3735	3918	4291	4700	5071	5433	5707	6009	6537
Optimal Export Revenue	3892	3623	3730	4032	4242	3961	4126	4341	4488	5393	5675	6017	6434
Residual	0	-42	-143	343	-507	-43	165	359	583	40	32	-8	103
Target Labour Demand	5328	5325	5550	5970	6141	6317	6484	6639	6713	6799	6883	6948	7009
Optimal Labour Demand	5328	5447	5622	5991	6101	6017	5877	5775	5629	5582	5396	5236	5102
Residual	0	-122	-72	-21	40	300	607	864	1084	1217	1087	1712	1907
Target Agricultural Output	7375	7670	8178	8373	8299	8446	8597	8801	8996	9232	9450	9677	9889
Optimal Agricultural Output	7375	7753	8158	8317	8184	8233	8377	8567	8775	8934	9147	9371	9590
Residual	0	-83	20	56	115	213	220	234	221	298	303	306	299

Note: The 'target' refers to base forecasts of the macroeconomic model, and the 'optimal' are base solutions of the reduced form of the model. Note also that the residuals for the control variables are zeros.

TABLE 9.2 **EXPERIMENT 1. RUN 1 WITH HIGHER OIL PALM AREA, FROM A 20% EQUIVALENT DECLINE IN RUBBER AREA, AND 20%, 30% and 3% HIGHER TARGETS FOR GDPC, EXPGNFC AND LABTOT RESPECTIVELY RELATIVE TO BASE FORECASTS.**

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	767	768	767	767	769	773	779	785	791	795	798	800
Optimal Smallholding Rubber Area	954	828	821	813	808	804	802	803	804	805	806	806	805
Target Rubber Estate Area	390	305	299	291	284	277	270	263	256	249	243	237	231
Optimal Rubber Estate Area	390	334	323	311	300	289	279	270	261	253	245	238	231
Target Oil Palm Area	1023	1374	1456	1538	1622	1706	1792	1879	1967	2055	2143	2232	2320
Optimal Oil Palm Area	1023	1629	1706	1779	1847	1867	1941	2015	2090	2138	2219	2302	2320
State Variables													
Target GDP (current)	7051	8101	8444	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7074	7528	7803	8811	8196	8590	9288	10485	9602	11661	14707	19239
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	3706	3825	4122	4325	4003	4162	4375	4520	5413	5695	6041	6455
Target Labour Demand	5328	5485	5716	6149	6325	6507	6678	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5516	5711	6085	6195	6104	5961	5856	5709	5657	5469	5307	5161

TABLE 9.3 EXPERIMENT 1. RUN 2 WITH HIGHER OIL PALM AREA, FROM A 50% EQUIVALENT DECLINE IN RUBBER AREA, AND 20%, 30% AND 3% HIGHER TARGETS FOR GDPC, EXPGNFC AND LABTOT RESPECTIVELY RELATIVE TO BASE FORECASTS.

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	479	480	480	480	481	483	487	490	494	497	499	500
Optimal Smallholding Rubber Area	954	503	501	498	496	495	495	496	498	500	501	502	502
Target Rubber Estate Area	390	191	187	182	177	173	168	164	160	156	152	148	144
Optimal Rubber Estate Area	390	202	196	190	184	178	172	167	162	157	153	149	144
Target Oil Palm Area	1023	1776	1856	1935	2016	2098	2183	2270	2357	2445	2533	2620	2706
Optimal Oil Palm Area	1023	2207	2267	2322	2371	2349	2411	2474	2539	2567	2641	2719	2706
State Variables													
Target GDP (current)	7051	8101	8441	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7122	7595	7873	8879	8258	8624	9286	10441	9865	11480	14419	18819
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	3749	3861	4143	4332	3963	4115	4321	4461	5337	5614	5956	6360
Target Labour Demand	5328	5485	5716	6149	6325	6507	6678	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5566	5768	6137	6241	6142	5992	5884	5733	5678	5487	5325	5172

Table 9.4 Values of the Objective Functions of Optimal Control Runs for Experiment 1

Run	Experimental conditions: Endogenous state variables	Experimental conditions: Control variables	Objective function value
1.	GDP_b x 1.2	$MARUBSH_b$ x 0.8)	
	$EXPMERC_b$x 1.3	$MARUBES_b$ x 0.8)	7414
	$TOTLAB_b$ x 1.03	$MAPALM_b$ + 0.2(MARUBSH+ MARUBES)	
2.	GDP_b x 1.2	$MARUBSH_B$ x 0.5)	
	$EXPMERC_b$x 1.3	$MARUBES_b$ x 0.5)	7427
	$TOTLAB_b$ x 1.03	$MAPALM_b$ + 0.5(MARUBSH+ MARUBES)	
3.	GDP_b x 1.2	$MARUBSH_b$ + 0.2x 0.75x MAPALM	
	$EXPMERC_b$ x 1.3	$MARUBES_b$ + 0.2X 0.25X MAPALM	7907
	$TOTLAB_b$ x 1.03	$MAPALM_b$ x 0.8)	

Note: The subscript 'b' refers to base forecast of the variable.

TABLE 9.5 EXPERIMENT 1. RUN 3 WITH 20% LOWER OIL PALM AREA AND AN EQUIVALENT INCREASE IN RUBBER AREA, UNDER 20%, 30% AND 3% HIGHER TARGETS FOR GDPC, EXPGNFC AND LABTOT RESPECTIVELY RELATIVE TO BASE FORECASTS.

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	1125	1138	1150	1163	1178	1196	1216	1237	1258	1277	1294	1309
Optimal Smallholding Rubber Area	954	1247	1247	1245	1248	1253	1260	1270	1282	1290	1302	1313	1323
Target Rubber Estate Area	390	437	433	428	423	418	413	409	405	402	398	295	392
Optimal Rubber Estate Area	390	492	479	466	455	444	436	425	417	409	404	398	393
Target Oil Palm Area	1023	885	951	1019	1087	1156	1225	1295	1365	1436	1507	1578	1650
Optimal Oil Palm Area	1023	983	1051	1117	1180	1223	1289	1354	1420	1473	1542	1612	1650
State Variables													
Target GDP (current)	7051	8101	8444	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7034	7475	7751	8766	8199	8652	9421	10708	10341	12213	15473	20274
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	3668	3798	4112	4329	4067	4239	4462	4618	5538	5833	6192	6627
Target Labour Demand	5328	5485	5716	6149	6325	6507	6628	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5465	5654	6032	6148	6065	5927	5827	5684	5635	5449	5290	5151

TABLE 9.6 EXPERIMENT 2. RUN 1 REPEAT OF EXPERIMENT 1, RUN 1 BUT WITH 40%, 50% and 10% HIGHER TARGETS FOR GDPC, EXPGNFC AND LABTOT RESPECTIVELY RELATIVE TO BASE FORECASTS (VALUE OF OBJECTIVE FUNCTION = 7962).

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	767	768	767	767	769	773	779	785	791	795	798	800
Optimal Smallholding Rubber Area	954	844	835	826	818	811	808	807	808	807	808	808	806
Target Rubber Estate Area	390	305	299	291	284	277	270	263	256	249	243	237	231
Optimal Rubber Estate Area	390	341	329	315	303	291	281	271	262	253	246	239	232
Target Oil Palm Area	1023	1374	1456	1538	1622	1706	1792	1879	1967	2055	2143	2232	2320
Optimal Oil Palm Area	1023	1697	1773	1845	1907	1901	1969	2039	2110	2157	2235	2315	2320
State Variables													
Target GDP (current)	7051	9451	9851	9699	10737	11824	13354	14773	16531	18466	20100	22253	25093
Optimal GDP (current)	7051	7095	7566	7854	8874	8306	8724	9449	10680	10252	12006	15118	19735
Target Export Revenue	3892	5371	5380	5531	5603	5877	6437	7050	7606	8150	8560	9013	9806
Optimal Export Revenue	3892	3725	3850	4149	4350	4022	4180	4392	4538	5432	5716	6064	6480
Target Labour Demand	5328	5858	6105	6567	6755	6949	7132	7302	7384	7479	7572	7643	7710
Optimal Labour Demand	5328	5529	5730	6106	6217	6123	5978	5873	5726	5675	5486	5325	5176

TABLE 9.7 EXPERIMENT 2. RUN 2 REPEAT OF EXPERIMENT 1, RUN 2 BUT WITH 40%, 50% and 10% HIGHER TARGETS FOR GDPC, EXPGNFC AND LABTOT RESPECTIVELY RELATIVE TO BASE FORECASTS (VALUE OF OBJECTIVE FUNCTION = 8100).

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	479	480	480	480	481	483	487	490	494	497	499	500
Optimal Smallholding Rubber Area	954	509	506	502	499	497	497	498	500	501	502	503	502
Target Rubber Estate Area	390	191	187	182	177	173	168	164	160	156	152	148	144
Optimal Rubber Estate Area	390	205	198	192	185	179	173	167	162	158	153	149	145
Target Oil Palm Area	1023	1776	1856	1935	2016	2098	2183	2270	2357	2445	2533	2620	2706
Optimal Oil Palm Area	1023	2316	2371	2422	2458	2396	2449	2506	2565	2592	2663	2736	2706
State Variables													
Target GDP (current)	7051	9451	9857	9699	10737	11824	13354	14773	16531	18466	20100	22253	25093
Optimal GDP (current)	7051	7150	7643	7938	8958	8394	8789	9483	10677	10219	11897	14914	19414
Target Export Revenue	3892	5371	5380	5534	5603	5877	6437	7050	7606	8150	8560	9013	9806
Optimal Export Revenue	3892	3775	3892	4175	4362	3984	4134	4340	4481	5359	5638	5982	6389
Target Labour Demand	5328	5858	6105	6567	6755	6949	7132	7302	7384	7479	7572	7643	7710
Optimal Labour Demand	5328	5585	5793	6165	6269	6165	6014	5904	5754	5699	5509	5346	5190

TABLE 9.8 EXPERIMENT 2. RUN 3 REPEAT OF EXPERIMENT 1, RUN 3 BUT WITH 40%, 50% AND 10% HIGHER TARGETS FOR GDPC, EXPGNFC AND LABTOT RESPECTIVELY RELATIVE TO BASE FORECASTS (VALUE OF OBJECTIVE FUNCTION = 8455).

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	1125	1138	1150	1163	1178	1196	1216	1237	1258	1277	1294	1309
Optimal Smallholding Rubber Area	954	1283	1280	1276	1274	1272	1274	1281	1291	1298	1309	1319	1325
Target Rubber Estate Area	390	437	433	428	423	418	413	409	405	402	398	395	392
Optimal Rubber Estate Area	390	508	493	472	463	450	438	428	419	411	405	399	394
Target Oil Palm Area	1023	885	951	1019	1087	1156	1225	1295	1365	1436	1507	1578	1650
Optimal Oil Palm Area	1023	1014	1082	1148	1210	1241	1304	1367	1431	1483	1551	1619	1650
State Variables													
Target GDP (current)	7051	9451	9857	9699	10737	11824	13354	14773	16531	18466	20100	22253	25093
Optimal GDP (current)	7051	7052	7507	7796	8823	8301	8779	9576	10896	10624	12549	15877	20763
Target Export Revenue	3892	5371	5380	5534	5603	5877	6437	7050	7606	8150	8560	9013	9806
Optimal Export Revenue	3892	3685	3820	4136	4353	4088	4259	4482	4638	5559	5854	6216	6652
Target Labour Demand	5328	5858	6105	6567	6755	6949	7132	7302	7384	7479	7572	7643	7710
Optimal Labour Demand	5328	5476	5669	6049	6166	6082	5944	5843	5701	5652	5466	5306	5166

TABLE 9.9 EXPERIMENT 3. RUN 1 REPEAT OF RUN 1 OF EXPERIMENT 1 BUT WITH PALM OIL PRICE INCREASED BY 60% AND RUBBER PRICE REDUCED BY 60% RELATIVE TO THEIR BASE FORECAST TRAJECTORIES.

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	767	768	767	767	769	773	779	785	791	795	798	800
Optimal Smallholding Rubber Area	954	834	826	818	812	807	805	805	806	806	807	807	805
Target Rubber Estate Area	390	305	299	291	284	277	270	263	256	249	243	237	231
Optimal Rubber Estate Area	390	337	325	312	301	290	280	270	261	253	245	238	231
Target Oil Palm Area	1023	1374	1456	1538	1622	1706	1792	1879	1967	2055	2143	2232	2320
Optimal Oil Palm Area	1023	1652	1729	1802	1869	1881	1953	2026	2099	2143	2222	2304	2320
State Variables													
Target GDP (current)	7051	8101	8444	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7052	7489	7748	8728	8065	8400	9034	10136	9510	11123	14044	18409
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	3686	3791	4082	4271	3976	4117	4320	4445	5389	5667	5997	6392
Target Laboru Demand	5328	5485	5716	6149	6325	6507	6678	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5526	5721	6095	6205	6105	5953	5845	5693	5632	5440	5276	5126

TABLE 9.10 EXPERIMENT 3, RUN 2 REPEAT OF RUN 2 OF EXPERIMENT 1 BUT WITH PALM OIL PRICE INCREASED BY 60% AND RUBBER PRICE REDUCED BY 60% RELATIVE TO THEIR BASE FORECAST TRAJECTORIES.

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	479	480	480	480	481	483	487	490	494	497	499	500
Optimal Smallholding Rubber Area	954	506	503	499	497	496	496	497	499	500	502	502	502
Target Rubber Estate Area	390	191	187	182	177	173	168	164	160	156	152	148	144
Optimal Rubber Estate Area	390	203	197	190	184	178	173	167	162	157	153	149	145
Target Oil Palm Area	1023	1776	1856	1935	2016	2098	2183	2270	2357	2445	2533	2620	2706
Optimal Oil Palm Area	1023	2243	2302	2356	2403	2369	2428	2489	2551	2574	2646	2722	2706
State Variables													
Target GDP (current)	7051	8101	8444	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7102	7559	7822	8801	8136	8444	9045	10106	9437	10967	13785	18023
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	3732	3829	4105	4280	3937	4070	4267	4387	5315	5587	5913	6298
Target Labour Demand	5328	5485	5716	6149	6325	6507	6678	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5579	5780	6150	6253	6144	5986	5874	5719	5655	5460	6294	5138

TABLE 9.11 EXPERIMENT 3, RUN 3 REPEAT OF RUN 3 OF EXPERIMENT 1 BUT WITH PALM OIL PRICE INCREASED BY 60% AND RUBBER PRICE REDUCED BY 60% RELATIVE TO THEIR BASE FORECAST TROJECTORIES.

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	1125	1138	1150	1163	1178	1196	1216	1237	1258	1277	1294	1309
Optimal Smallholding Rubber Area	954	1259	1258	1255	1257	1261	1266	1275	1286	1292	1304	1315	1323
Target Rubber Estate Area	390	437	433	428	423	418	413	409	405	402	398	395	392
Optimal Rubber Estate Area	390	497	484	470	458	446	435	426	418	410	404	398	393
Target Oil Palm Area	1023	885	951	1019	1087	1156	1225	1295	1365	1436	1507	1578	1650
Optimal Oil Palm Area	1023	993	1061	1127	1190	1230	1295	1360	1424	1476	1544	1613	1650
State Variables													
Target GDP (current)	7051	8101	8444	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7011	7433	7694	8680	8064	8458	9163	10353	9883	11666	14801	19434
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	3648	3763	4071	4275	4041	4194	4408	4543	5515	5804	6148	6563
Target Labour Demand	5328	5485	5716	6149	6325	6507	6678	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5475	5663	6041	6156	6064	5918	5815	5668	5610	5420	5258	5116

TABLE 9.12 EXPERIMENT 3, RUN 4 REPEAT OF RUN 1 EXPERIMENT 1 BUT WITH PALM OIL PRICE INCREASED BY 2.6 TIMES AND RUBBER PRICE REDUCED TO 0.1 TIMES RELATIVE TO THEIR RESPECTIVE BASE FORECAST TROJECTORIES.

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Target Smallholding Rubber Area	954	767	768	767	767	769	773	779	785	791	795	798	800
Optimal Smallholding Rubber Area	954	769	770	768	768	770	775	781	787	792	797	801	802
Target Rubber Estate Area	390	305	299	291	284	277	270	263	256	249	243	237	231
Optimal Rubber Estate Area	390	306	300	292	285	277	271	264	257	250	244	237	231
Target Oil Palm Area	1023	1374	1456	1538	1622	1706	1792	1879	1967	2055	2143	2232	2320
Optimal Oil Palm Area	1023	1386	1466	1545	1629	1715	1809	1901	1994	2075	2175	2278	2320
State Variables													
Target GDP (current)	7051	8101	8444	8314	9204	10135	11446	12663	14169	15828	17228	19074	21508
Optimal GDP (current)	7051	7449	7826	8187	9265	9472	10307	11576	13430	14747	17750	22404	28963
Target Export Revenue	3892	4655	4663	4796	4856	5094	5579	6110	6592	7063	7419	7811	8498
Optimal Export Revenue	3892	4030	3996	4303	4495	4416	4588	4857	5027	6172	6524	6940	7442
Target Labour Demand	5328	5485	5716	6149	6325	6507	6678	6838	6914	7003	7090	7157	7219
Optimal Labour Demand	5328	5490	5685	6063	6185	6105	5977	5896	5777	5736	5566	5424	5300

TABLE 9.13 MACROECONOMETRIC MODEL SIMULATION WITH 50% OF RUBBER AREA REALLOCATED TO OIL PALM RELATIVE TO THE BASE FORECAST FOR 1984-1995.

YEAR		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Control Variables													
Base:	Smallholding Rubber Area	959	960	959	959	961	966	973	981	988	994	998	999
Solution:	Smallholding Rubber Area	479	480	480	480	481	483	487	490	494	497	499	500
Base:	Rubber Estate Area	381	373	364	355	346	337	328	320	312	304	296	288
Solution:	Rubber Estate Area	191	187	182	177	173	168	164	160	156	152	148	144
Base:	Oil Palm Area	1106	1189	1274	1359	1445	1532	1619	1707	1795	1884	1973	2062
Solution:	Oil Palm Area	1776	1856	1935	2016	2098	2183	2270	2357	2445	2533	2620	2706
State Variables													
Base:	GDPC	6751	7037	6928	7670	8445	9539	10552	11808	13190	14357	15895	17923
Solution:	GDPC	6778	7043	6905	7597	8312	9308	10209	11315	12574	13561	14871	16617
Base:	Export Revenue	3581	3587	3689	3735	3918	4291	4700	5071	5433	5707	6009	6537
Solution:	Export Revenue	3606	3569	3648	3665	3830	4174	4563	4906	5287	5551	5832	6334
Base:	Labour Demand	5325	5550	5970	6141	6317	6484	6639	6713	6799	6883	6948	7009
Solution:	Labour Demand	5370	5599	6017	6183	6359	6526	6687	6769	6868	6966	7046	7124

FIG 9.1 TRAJECTORIES
FOR GDPC: EXPT.1, RUN 1

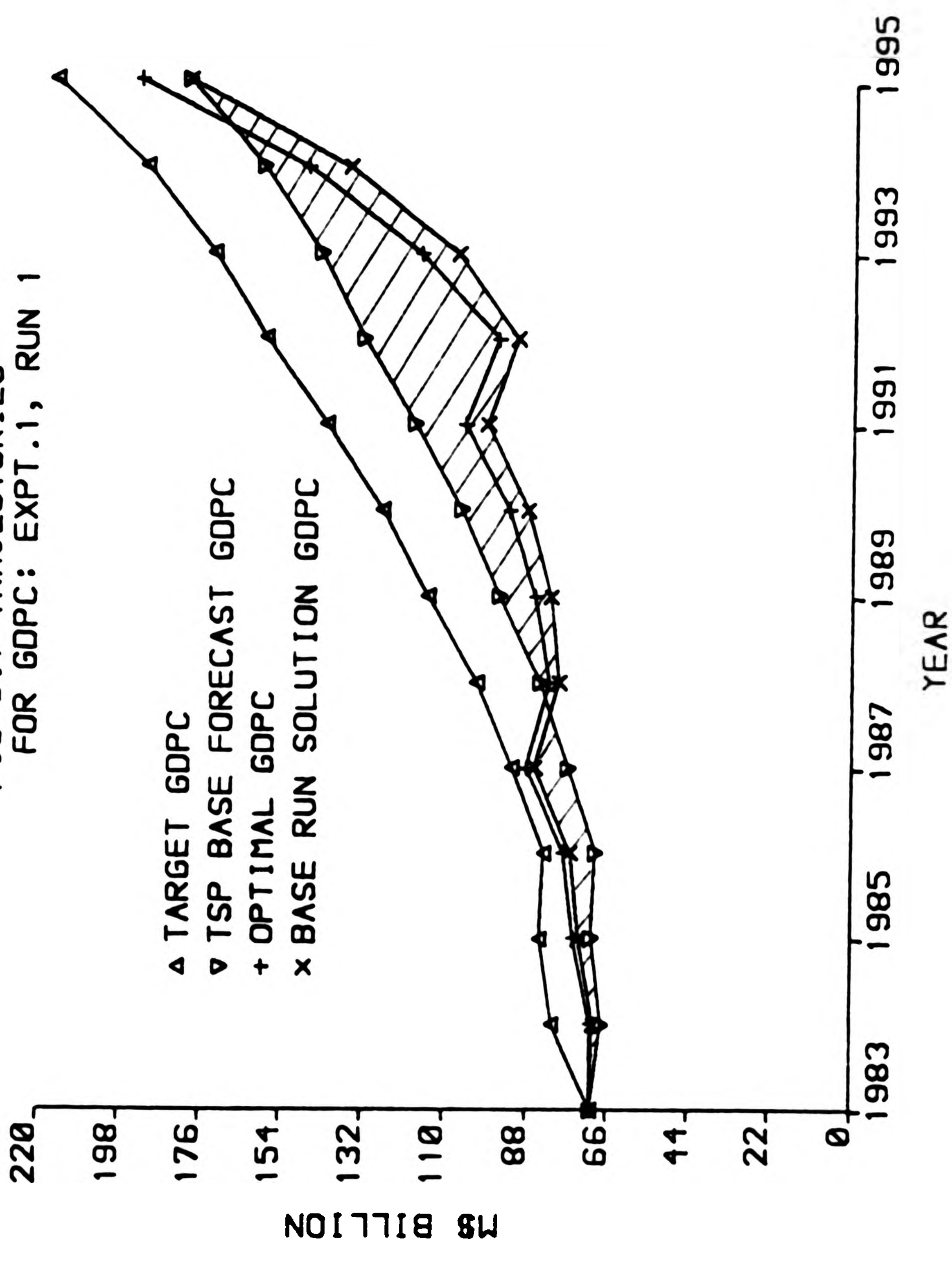


FIG 9.2 TRAJECTORIES
FOR CONTROL VARIABLES: EXPT. 1, RUN 1

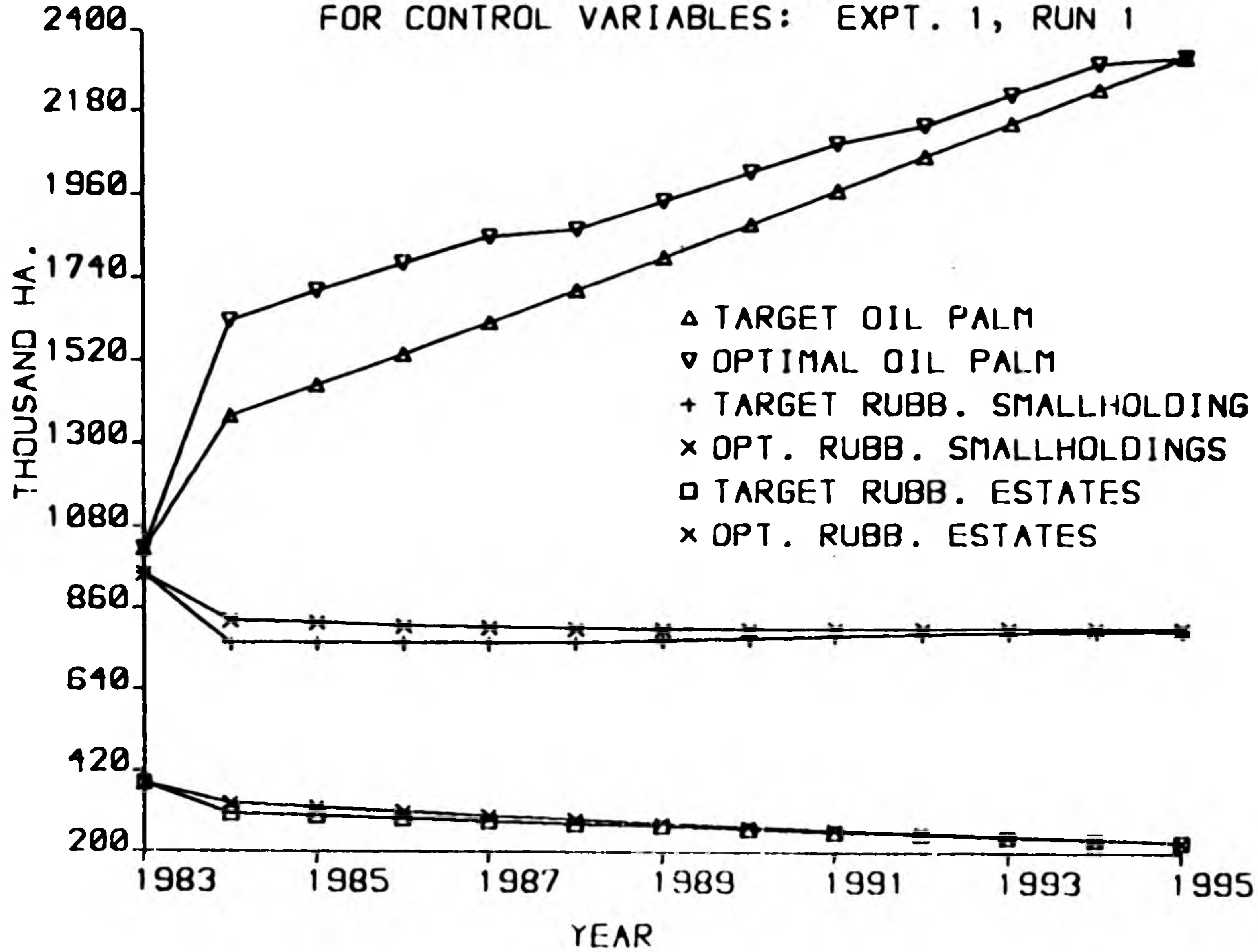
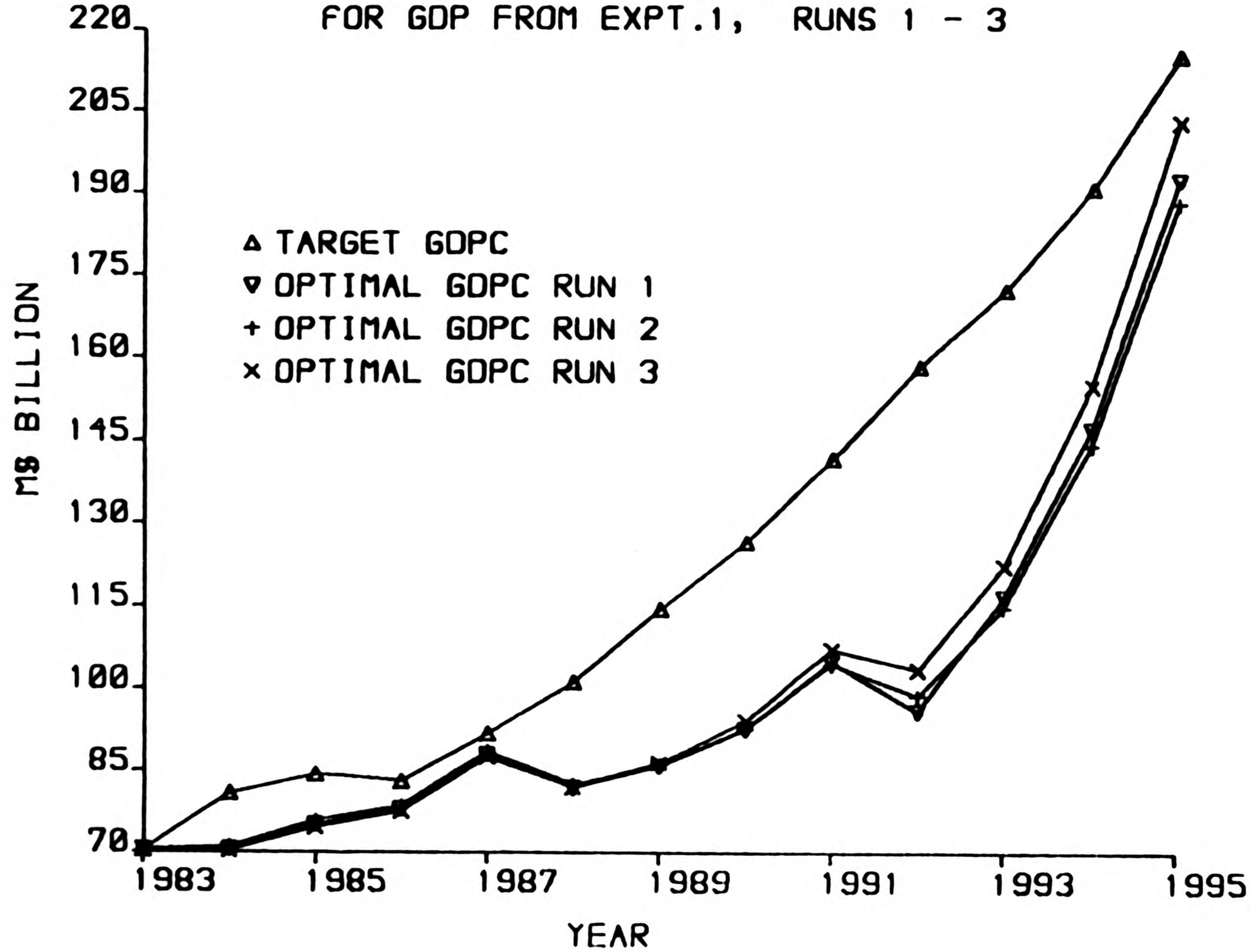


FIG 9.3 TRAJECTORIES
FOR GDP FROM EXPT.1, RUNS 1 - 3



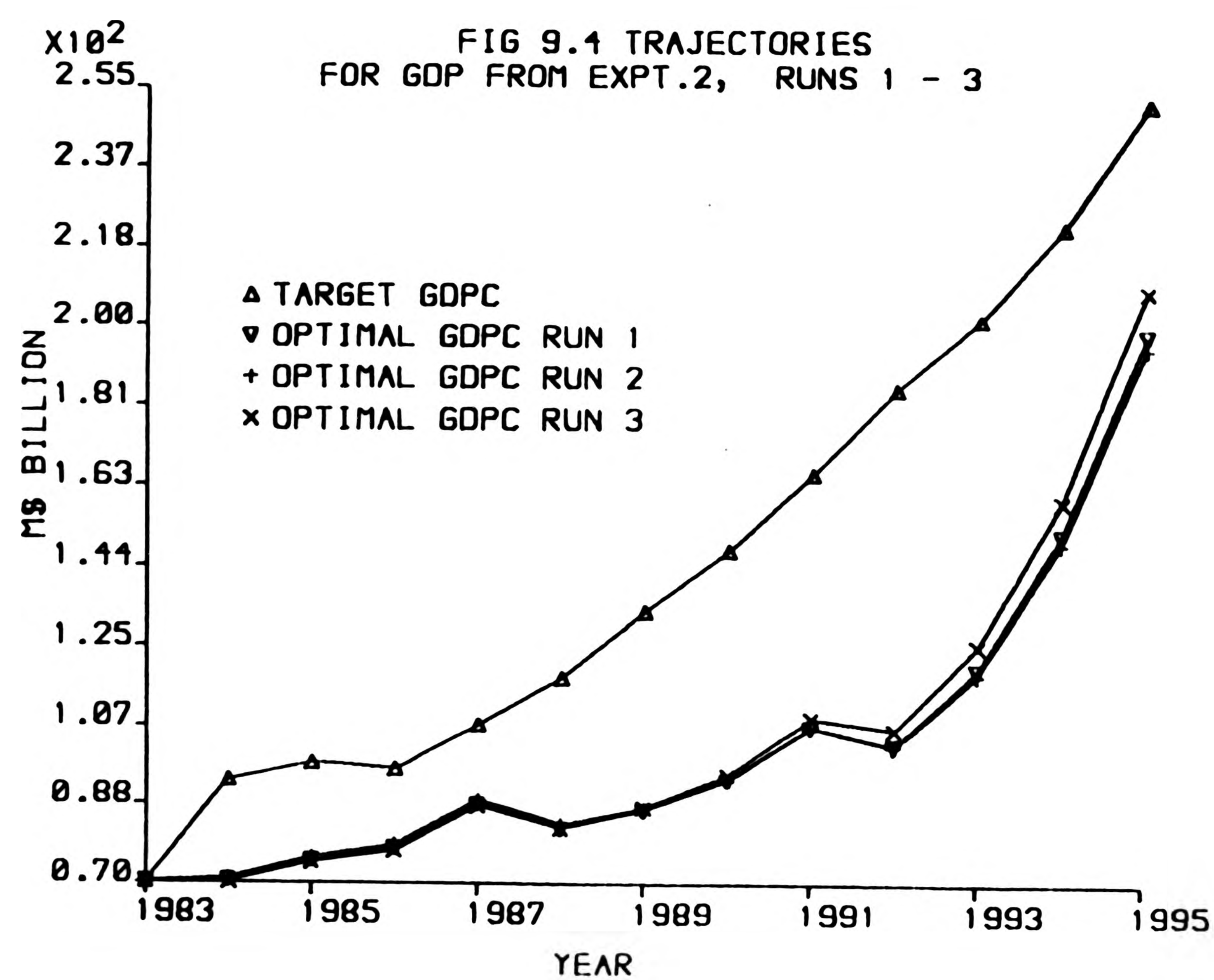
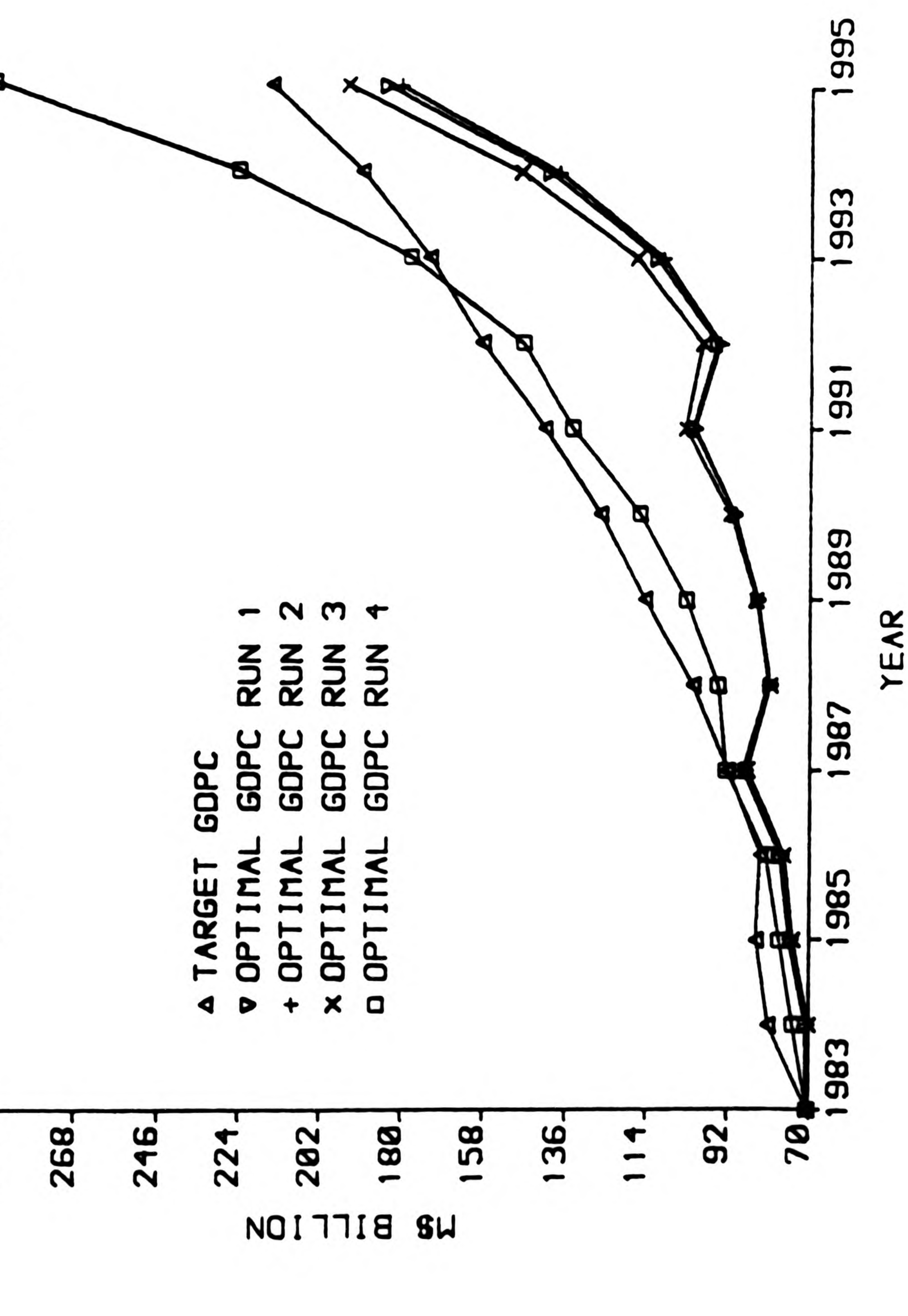


FIG 9.4 TRAJECTORIES
FOR GDP FROM EXPT.2, RUNS 1 - 3
X10^2
2.55
2.37
2.18
2.00
1.81
1.63
1.44
1.25
1.07
0.88
0.70
M$ BILLION
△ TARGET GDPC
▽ OPTIMAL GDPC RUN 1
+ OPTIMAL GDPC RUN 2
× OPTIMAL GDPC RUN 3
1983
1985
1987
1989
1991
1993
1995
YEAR

FIG 9.5 TRAJECTORIES
FOR GDP FROM EXPT.3,   RUNS 1 - 3



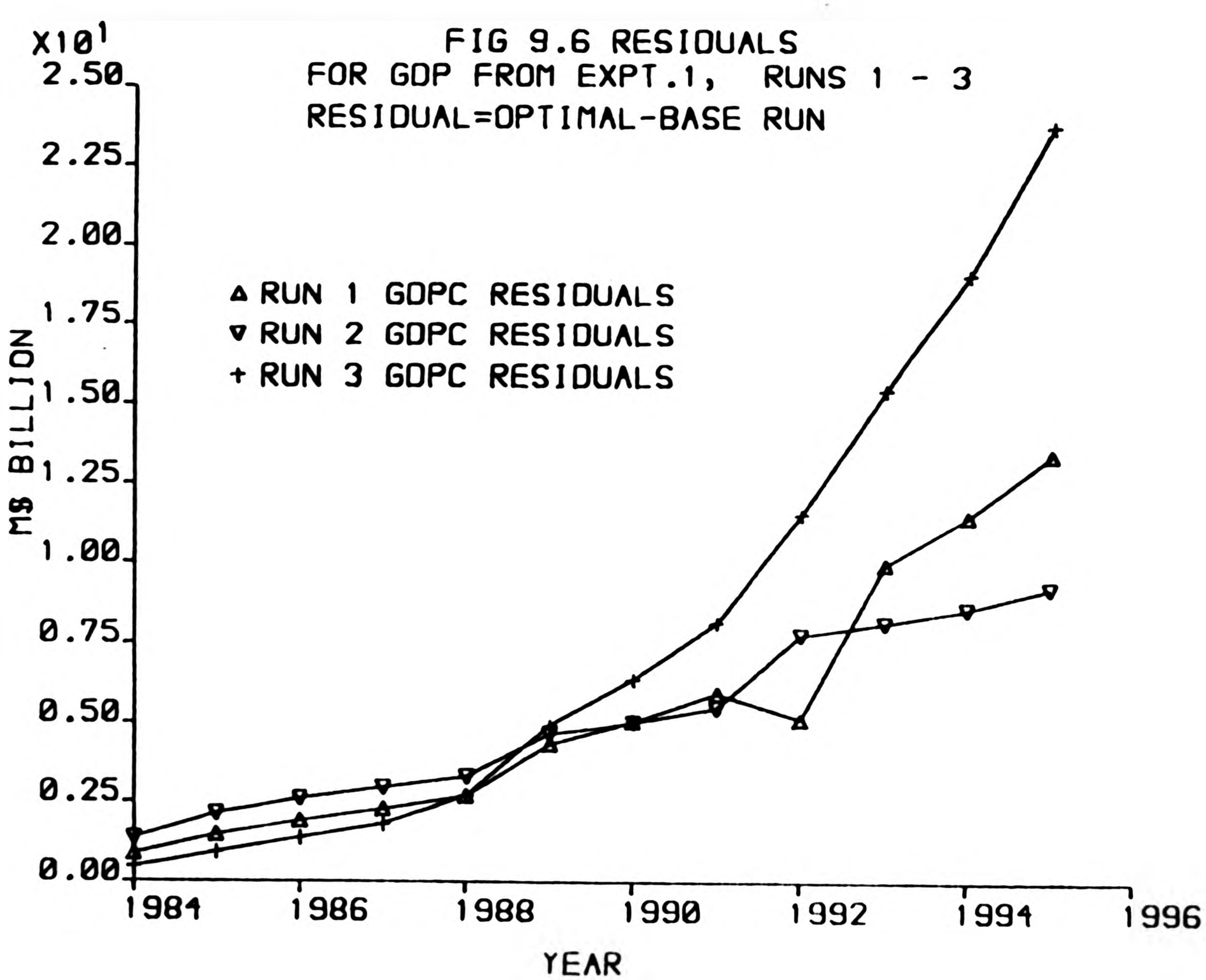
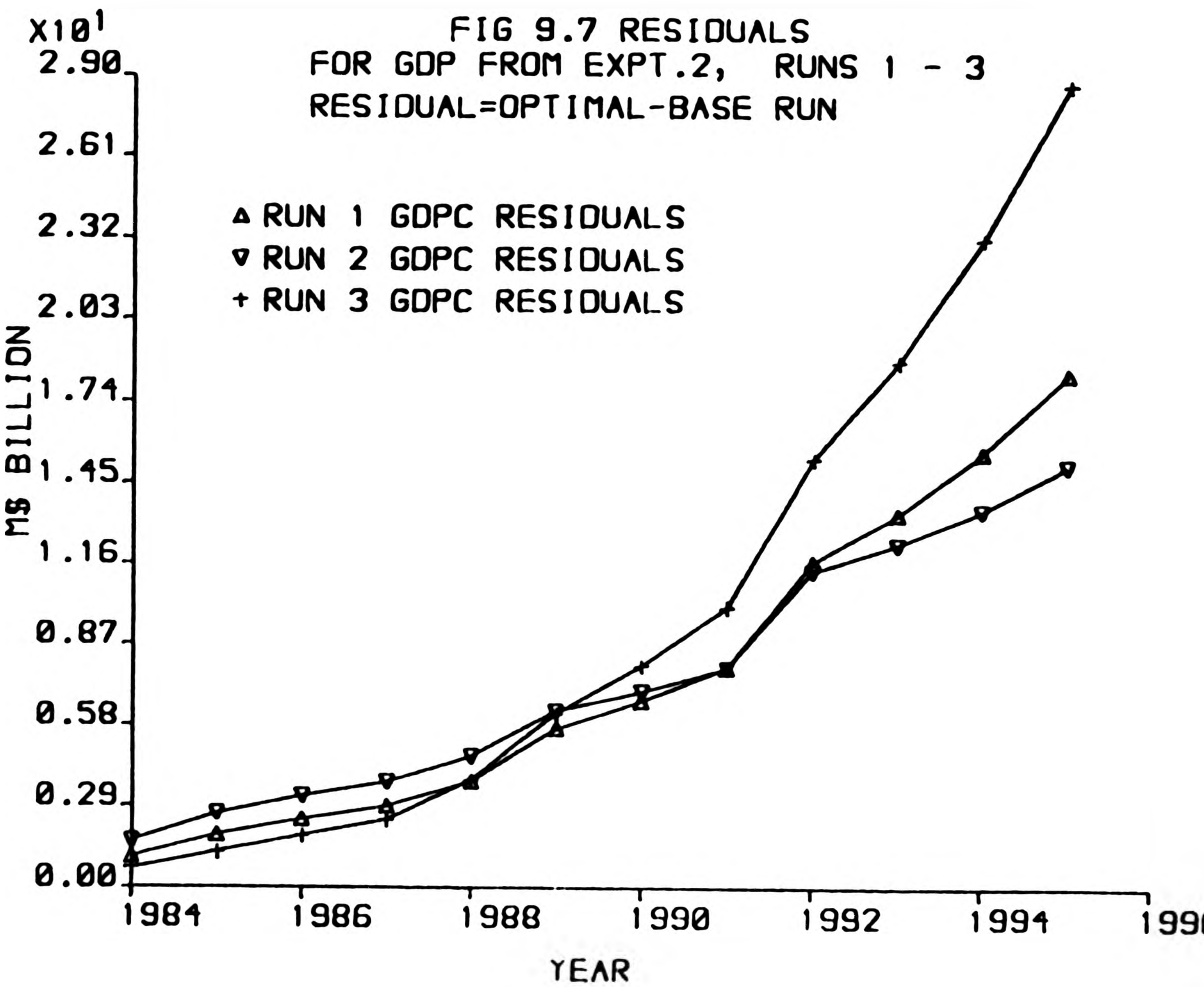


FIG 9.6 RESIDUALS
FOR GDP FROM EXPT.1, RUNS 1 - 3
RESIDUAL=OPTIMAL-BASE RUN
X10¹
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
M$ BILLION
RUN 1 GDPC RESIDUALS
RUN 2 GDPC RESIDUALS
RUN 3 GDPC RESIDUALS
1984
1986
1988
1990
1992
1994
1996
YEAR

FIG 9.7 RESIDUALS
FOR GDP FROM EXPT.2, RUNS 1 - 3
RESIDUAL=OPTIMAL-BASE RUN



CHAPTER 10 : POLICY IMPLICATIONS AND CONCLUSIONS

10.1 Introduction

The aim of this chapter is to bring together the findings from the earlier analyses and examine their policy implications for the Malaysian plantation industry. In particular, the findings from the competitive analysis of Chapters 4 and 5 and the results from the simulation and optimal control experiments of Chapters 8 and 9 will be used to assess the efficacy of past and present policies in the development of the Malaysian rubber and palm oil industry. Where appropriate, suggestions are made for improvements in these policies and strategies.

10.2 Macroeconomic Perspectives of the Crop Allocation Problem

This study has attempted to evaluate two interrelated problems which are commonly encountered by economic planners in the Less Developed Countries. These are i) the formulation of appropriate strategies in sectoral development planning and ii) the use of macroeconometric model simulation and optimal control techniques as possible analytical tools in the formulation of the planning strategies. These aspects of the problem are evaluated in the context of the need for optimal crop allocation for rubber and oil palm in the Malaysian plantation sector. The crop allocation problem, in turn, has been viewed throughout this study as an illustration of a broader set of problems of income instability, as experienced by many developing countries, resulting from their overdependence on the exports of primary commodities whose prices are subject to fluctuations.

Consequently, as often debated in the development economics literature, many of the developing countries are confronted with two development policy options: i) to continue specialising in the production of primary commodities, or ii) to diversify their economies by venturing into the developments of the countries' secondary and tertiary sectors, especially through producing and exporting manufactured goods. This study has explored a third option which is essentially a marriage of the above two options, that is to diversify the production of primary commodities in an optimal way such as through optimal allocation of crops, while keeping the options open for diversifying into other economic sectors.

In attempting to evaluate the crop allocation problem for rubber and oil palm, it was necessary to review the environment in which these commodities are produced and marketed, emphasising in particular their relative competitive positions and long term potential. Because rubber and palm oil contribute substantially to the Malaysian economy, the evaluation of their contributions has been carried out within the framework of the macroeconometric model. Thus a comprehensive macroeconometric model of Malaysia has been constructed and it has been used together with simulation and optimal control techniques for evaluating policies related to the crop allocation problem.

The study has shown that it is feasible to evaluate sectoral development problems and formulate strategies using the optimal control and model simulation techniques. More importantly, it has been demonstrated that the two techniques can be employed in a complementary manner with each method making up for the deficiencies usually found in the other.

The macro approach to evaluating sectoral development planning has been shown to be a useful alternative to micro analysis approach of studying the relative profitability between the production units of the Malaysian plantation sector. Direct investment appraisal and other forms of micro studies often ignore the interrelationships between industries, and policies based entirely on such calculations are often incomplete and can be misleading. The macro approach, aided further by simulation and optimal control techniques could complement the micro studies in policy planning.

10.3 Competitiveness of Rubber and Palm Oil and Their Policy Implications.

The competitive aspects of the production and exports of rubber and palm oil have been reviewed in Chapters 3, 4 and 5, both in qualitative and quantitative terms. The analyses revealed that while the overall contribution of the agricultural sector, of which oil palm and rubber are the major crops, has declined from a share of 40 % of GDP in 1960 to 22 % in 1983, the absolute level of agricultural output has continued to grow at about 4 % per annum. The situation has two main implications:

i) the agricultural sector will continue to be an important component of the Malaysian economy, and ii) the share of agriculture in the economy appears to have reached a level which could be regarded as representing a diversified economy. A further decline in the contribution of the agricultural sector would lead to under-diversification. This in turn implies the need for sustaining the growth of the agricultural sector in line with the overall economic growth of the country.

Planning for optimal allocation of resources for the agricultural sector will become more important in the near future, given the limited choices on major commercial crops which could be promoted viably under Malaysian conditions. There is already a clear trend that rubber production has been stagnating because of increased planting of oil palm at the expense of rubber cultivation in the past two decades. The future trend however, will be determined by the relative prices and profitability of the two commodities, and usually investors' perceptions on future profitability are partly influenced by past trends.

The competitive positions of the two crops are summarised below:

<u>Palm oil</u>

i) palm oil is competitive in relation to other oils and fats in the world market owing mainly to the high yield of the oil palm and relatively low cost of production for the oil.

ii) the demand for oils and fats in general tends to be less than production, owing to the saturation in consumption level in the developed countries, and the lack of foreign exchange in the developing countries.

iii) production of palm oil, though continuing to be profitable relative to rubber in Malaysia, has increased rapidly in other countries. This will add further to the potential oversupply situation projected for the future.

iv) in the highly competitive situation, there is a greater tendency for palm oil to replace other costly oils and fats from the market although soyabean oil production is also projected to expand as rapidly.

v) a policy of solving the potential oversupply situation for palm oil is necessary in the future, and in this regard the potential use of palm oil as diesel substitute is generally promising except that the recent fall in petroleum prices did not augur well for the pursuit of such policy.

Rubber

i) the threat of a further decline in the share of NR in the world rubber market appears to be diminishing and there is a tendency towards the stabilization of the trend for replacement of NR by SR in the last ten years. Very pessimistic forecasts show that the share of NR will continue to remain at about 32 % up to the year 2000. Possibly, the present market share has reflected the lowest techno-economic limit in the substitution process of NR by SR.

ii) The demand for NR has been projected, as in many other studies, to be higher than what NR producers are prepared to produce under the prevailing expectations of prices and profitability. This in turn will firstly leave a gap between NR demand and supply, leading to a situation as in the past, where NR would lose its market share by default through a shortfall in its supply. Secondly, poor profit expectations in rubber production will encourage investors to replant their rubber land or other newly available lands with oil palm or other more profitable crops. This will reduce the supply situation for NR as planted area diminishes.

In view of these unsatisfactory competitive positions, it would be necessary for the authorities concerned with the development of rubber and oil palm industry in Malaysia to devise policies to promote a balanced development of the rubber and oil palm sectors, while achieving various national economic goals. Most of the government policies have been instrumental in shaping the present structure and crop allocation pattern in the plantation sector, but a few of the policies are somewhat ineffective and not self-consistent. The implications of some of the more important policies are discussed below.

i) Diversification Policy: Crop diversification in particular and economic diversification in general had been successfully introduced in Malaysia. As a consequence, the country had become less dependent in the exports of rubber and tin which had been the country's major commodities for decades. Diversification no doubt will continue to be an appropriate future development policy for Malaysia but it implies that there must be a limit to the amount that each economic sector is developed. In particular there should be an optimal balance in the allocation of rubber and palm oil even though optimality may not be compatible with the revenue maximizing objective in the short run.

ii) Agricultural Modernization Policy: This policy contains two major elements: a) land development, and b) rubber replanting. Of the two, land development has appeared to be the most successful. By starting with newly claimed areas, the land development authorities can implement an optimal crop allocation policy more easily. In contrast, rubber replanting, though a sound policy, is difficult to implement effectively. Firstly, the target groups, i.e. the smallholders are scattered throughout the country and providing extension services is usually costly, difficult and ineffective. Secondly, the crop to be promoted is itself of low profitability. This naturally leads to problems of promoting rubber replanting to the smallholders.

Such fundamental problems are not effectively tackled by existing policies. Some planners believe that good management and organization of the smallholders are crucial in an attempt to improve the productivity of rubber cultivation. But such views are incompatible and not self-consistent. Firstly, cultivation of rubber may mean propagating poverty and this is incompatible with the poverty eradication policy of the government. Secondly, a well organised group of smallholders with competent management may logically elect to plant more profitable crops such as the oil palm instead of rubber.

There are also other policies of dubious effectiveness. The price stabilization policy for rubber could be ineffective, as lamented by Professor Ahmad (1985), (see page 16) while export duty reduction may only have a marginal beneficial effect (see Chapter 8).

10.4 Model Simulation Results and Their Implications

By employing the macroeconometric model simulation technique, it was possible to show the losses or gains to the economy from past pattern of crop allocation. A 're-run of history' may appear futile especially where hindsight makes a difficult planning task look simple, but the simulation techniques nevertheless have shown the following implications.

i) It is relatively easy to find a region of optimal crop allocation for rubber and palm oil for the historical period under review. This means that it would have been viable and probably highly rewarding if planning for crop allocation and formulation of policies were based partly on the use of a modelling technique as exemplified in this study.

ii) The results of the simulation analysis indicate that past plantings of rubber and oil palm had not been optimal nationally and that the optimal pattern should have been to maximise planting of oil palm. This finding appears to concur with the planting pattern in the estate sector where maximum planting of oil palm on available lands had been carried out. Thus it was only the smallholding sector that appears to depart from the optimal crop allocation pattern. However, the smallholders are affected by socioeconomic considerations which could not be modelled and simulated easily. Their small plot size, lack of capital and technical knowhow prevent them from venturing into other more profitable crops. Not surprisingly, many of the smallholders appear to act optimally by leaving their holdings for better jobs in other sectors.

iii) Government incentive policies such as reducing export duty, as mentioned above, appear to have only minor beneficial effects on the long term competitive position of rubber against palm oil during the 1970-1983 period.

The simulation procedure has thus provided two tangible results. Firstly, the successful use of the model in arriving at an optimal policy for crop allocation is rather surprising as normally a simulation procedure would not lead to the identification of an optimal scenario unless many number of simulations are carried out. In this study it happened that the optimal crop allocation pattern could be easier to derive because of the rigid structural trend and the long time needed for crop rehabilitation.

It was shown that the cumulative gains to the economy from optimal crop allocation could have reached M$4 billion in terms of contributions to GDP and close to M$2 billion for export revenue during the 1970-1983 period (see Table 8.8). Thus the potential rewards for being able to formulate and implement an optimal crop allocation is substantial, and provided policies could be efficiently implemented, the important role of simulation analysis as illustrated in this study is clearly indicated.

10.5 Optimal Control Results and Their Implications

The use of the optimal control technique has been shown to be appropriate for solving the crop allocation problem in that it provides responses which are detectable and of the right order of magnitude. The results of the optimal control experiments are much more difficult to interpret. While optimal target trajectories of the state and control variables can be obtained, the results are dependent on a number of other factors. These include the way that the model has been formulated, the linearization process for simplifying the computation and most importantly, the weighting procedure used to penalize the variables for deviating from their nominal targets. Furthermore, the optimal control has been used in a forward period where a full set of actual values are not yet available. This limitation will add to the susceptibility of the optimal control results to the assumptions imposed by the model builder.

The first significant conclusion to the usability of the optimal control technique is the way that it could be employed in conjunction with the simulation procedure to complement the weaknesses of the techniques when used on their own. The forecast solution from the simulation of the econometric model for the forward period of 1984-1995 provided a basic scenario on which targets for the optimal control problems can be generated. The optimal control approach on the other hand, provided an optimization of the trade-offs involved when

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The first set of experiments on the optimal control problems indicate that it is more advantageous to plant oil palm for the first part of the planning period but the situation seems to favour rubber planting in the 1990s. As this represents a deviation from the findings of the historical simulation experiments, it was necessary to test exhaustively the sensitivity of the results. Thus, further tests were conducted, including varying the targets for the state and control variables, and finally testing the impact of drastic price changes in favour of palm oil.

Despite these tests, the optimal control solutions indicated clearly the beneficial effect if more rubber is planted instead of palm oil during the 1990-1995 period. This observation can imply the following:-

i) the period 1990-1995 may become more favourable for rubber planting compared to the trend observed for the previously analysed period of 1970-1983. These could be due to the assumptions made in the exogenous variables used in the forecasts to generate the targets trajectories in the optimal control routine, even though changing the trajectory values of some of the exogenous variables did not appear to suggest a different effect. If however, the results are reflecting the true scenario of the future, then the policy of maximising the planting of oil palm as presently adopted in Malaysia has to be reversed. At the very least, there should be a review of present policies towards the end of the 1980s, and further studies to rexamine the problem then may be necessary.

ii) it could also be that the model is not responding correctly. The model behaviour is dictated by the structural relationships of the equations and the values of the exogenous variables used in the forecast. The optimal control model may also introduce additional complications but in this study the optimal solutions are found to be consistent and comparable with solutions obtained from direct simulation of the econometric model.

A notable weakness in forecasting based on macroeconometric models is that a substantial amount of model builder's intuition has to be applied to ensure that the structural interrelationships are behaving as expected. Intuition is relatively simple in historical analysis because of hindsight, but in a forward forecast situation, combining model simulation and intuition becomes more of an art.

iii) Finally, the results are subject to the influence of the weighting system used in allocating priorities in the objective function. The method employed to assign weighting factors places equal importance to each percentage deviation of the variables from their target trajectory values so that 1 % change each for rubber and oil palm planted area from their corresponding trajectories would be penalized equally. The use of a different weighting scheme would result in different optimal trajectories, but the weakness of the optimal control method is that there is no theoretical basis for selecting the weighting system in a particular favourable way.

10.6 Trade-offs on Policy Options and Other Policy Implications

Optimal control analysis provides results which can indicate trade-offs between the various policy options. Usually, it is desirable that these policy options are tabulated and presented in a "menu" form where the trade-offs are indicated and the decision maker can then make his own decision in selecting the desired policy. Such trade-off situations on policies pertaining to the crop allocation problem are tabulated below where trade-offs between maximising of GDP against that of labour demand are involved when policy options 3 and 4 are compared.

Given such a menu of options, a policy maker who is keen to promote a higher level of employment may choose policy option number 3 rather than 4 as the former option will give a higher level of labour demand even though its GDP values are lower than the corresponding values in option 4. The ability of the optimal control procedure to generate these competing options is seen as a major advantage of the technique. It may be noted however, that the linearization procedure has introduced a certain level of inherent linearization error for variables such as labour demand (see Table 9.1) but the error is consistently present in all the policy options shown in the tabulation below, and comparisons of competing policies do not appear to be affected by the

Tabulation of Trade-offs for the Various Crop Allocation Policy Options

Policy Option	Objective Function Value	Gross Domestic Product $M billion			Labour Demand '000 units		
		1985	1990	1995	1985	1990	1995
Policy No.1 Normal Projected Trend in Crop Allocation (Base Solution)	0	73.78	87.81	178.98	5562	5775	5102
Policy No. 2 Moderately High Replacement of Rubber by Oil Palm (Run 1, Expt.1)	7414	75.28	92.88	192.39	5711	5856	5161
Policy No.3 Very High Replacement Rate of Rubber by Oil Palm (Run 2, Expt.1)	7429	75.95	92.86	188.19	5768	5884	5172
Policy No.4 Moderately High Replacement Rate of Oil Palm by Rubber (Run 3, Expt.1)	7907	74.75	94.21	202.74	5654	5827	5152

linearization error. The value of the objective function is also a possible measure for comparing trade-offs between policy options but the objective function is itself a complex measure of costs and hence it is difficult to make meaningful comparisons based on the cost function values alone.

Sectoral policies are normally formulated with socio-economic and political considerations in mind and rarely are such policies formulated on the basis of quantitative modelling results alone. In view of the difficulty in achieving very good quantitative results, the continued popularity of qualitative approach to policy planning is not surprising. But in the process of formulating sectoral policies, it is often unavoidable that the expert representatives of the sectors concerned are invited to contribute or even help to draft the policies, and often only qualitative analyses are carried out. There is also the tendency for the policy to be influenced by unintentional biased opinion and vested interest. The use of quantitative model simulation provides an alternative assessment of sectoral policies, and results from such studies are thus useful for verifying decisions made on the basis of the qualitative analysis.

Policies must also be developed with a set of strategies. For example, it may well be feasible to produce palm oil in much greater quantities than at present provided there is a strategy on how the excess supply can be removed from the market. Such a strategy may even require government interventions through legislation etc. The possibility of a combined strategy based on the rapid growth in palm oil production in conjunction with a deliberate policy of palm diesel production has been discussed as a possible option while for the rubber industry price stability strategy could be combined with utilization of timber from the rubber woods, as advocated in the report of the Task Force of Experts on Natural Rubber (MRRDB, 1983). While such refined strategies have not been evaluated in detail in this study, they could possibly form the basis for an extension to this work.

10.7 General Disclaimers and Qualifications

The model constructed in this study, while providing realistic practical results, represents a useful start to link sectoral planning with macroeconometric model simulation and optimal control analysis for the Malaysian economy. The work could be expanded in various ways to obtain a more refined model for implementation in an actual planning situation. Areas where improvements are most desired have been partly highlighted in the text whenever the shortcomings of the model construction and problems of model application are discussed. Additional qualifications regarding the model utilization are discussed below.

a) Expectation Process

The expectation process, as highlighted by the Lucas (1976) critique (see Chapter 2) is still a source of controversy which confronts macroeconometric modelling studies. In this study, the expectation problem can be illustrated by the situation where the estate sector might have behaved differently if they anticipated that the government would introduce a certain crop allocation policy which would affect the future planting pattern of the smallholding sector. The results of the historical simulation for crop allocation in Chapter 8 show that policy changes introduced for the plantation industry during 1970-1983 appear to have no major impact on the pattern of the crop allocation which could have been adopted by the estate sector. This is due partly to the overwhelming preference for planting oil palm instead of rubber during that period not only in Malaysia but also in other palm oil producing countries. Future crop allocation policies, as discussed in Chapter 9, may have to allow for the implication of the expectation process. However, the impact of rational expectation on the crop allocation strategy for rubber and oil palm may continue to be minor as policy planning will focus more on the less efficient smallholding sector which lags behind the estate sector in implementing an optimal crop allocation strategy. Furthermore, production intentions are already revealed in advance to a large extent because of the long gestation period involved in rubber and palm oil production so that the estate and smallholding sectors know in advance the production trends of each other.

b) Uncertainty in the Results of Macroeconometric Modelling

Model reliability is a major problem confronting the model builder. This study has attempted to overcome the problem by evaluating the level of simulation errors and testing the tracking ability of the model as described in Chapter 7. Analysis of the response of the model to shocked changes in its key parameter and variables, as illustrated in Chapter 7, provides further means of testing the model reliability. However, the validation tests carried out in this study are not exhaustive even though they are perhaps adequate for purposes of illustrating the model response with regard to the crop allocation analysis. Additional sensitivity analysis would be highly desirable in practice to test further the impact of changes in some other sets of variables such as exchange rates etc. on the outcome of policy analysis experiments.

More sensitivity tests and further work are generally desirable in addition to those which have been explored in Chapters 8 and 9 to ensure that policies which are finally formulated are robust and not too sensitive or too unstable to changes in the relevant key variables and parameters of the model.

c) Risk Analysis

The risks associated with each policy option are important and they may have vastly different characteristics from those of another policy option. The risks associated with the policy options presented through the experiments carried out in Chapter 9 are not exhaustively evaluated although the sensitivity of the policy options with respect to price changes during the planning period has been evaluated as shown in Tables 9.9 to 9.12. The risks associated with the policy options on the historical crop allocation analysis in Chapter 8 have been evaluated in somewhat greater detail (see Table 8.8). In practice, it would be highly desirable to evaluate the risks exhaustively, given the higher level of resources and facilities usually available in a typical planning department which normally carries out such analysis. A thorough evaluation of risks is important when national policies are being formulated.

d) Linearization of the Macroeconometric Model

Linearization of the model as discussed in Chapter 9 is necessary to enable optimal solutions to be derived from a system of quadratic objective function and linear constraints where the implications of certainty equivalence lead to the derivation of optimal solutions over the planning period. However, linearization errors are introduced as a result of the "interval" linearization procedure employed in Chapter 9. Such inherent linearization errors (see Figure 9.1) are present in the results of the individual policy experiments regardless whether there is increased crop allocation favouring rubber or oil palm. Thus the errors from model linearization, though significant in terms of absolute values, do not have any major impact on the results of the crop allocation analysis and the policy implications which could be derived from the analysis. As shown in Section 9.8, the results from the optimal control technique are consistent with those from forward simulation of the nonlinear structural form of the macroeconometric model.

e) Use of Dummy Variables

The use of dummy variables has been discussed in Section 6.11.1. Usage of such variables presents problems to the planner as it may be difficult to predict events requiring the use of similar dummy variables when the model is used for future projection analysis. Excessive use of dummy variables also weakens the structural relationships of the model. However, many externally determined events introduce short-term changes to the Malaysian economy and these could be adequately captured through the use of dummy variables. Dummy variables also improve the fit of the regression, reduce the level of simulation errors and remove components which will bias the regression coefficients. Thus a balanced approach should be adopted in employing dummy variables in macroeconometric model construction. The number of dummy variables used in this study (22) is much lower than that (29) used by Obidegwu and Nziramasanga (1981) in their macroeconometric model of comparable size for Zambia.

10.8 Suggestions for Further Work

Model building effort is rarely regarded as a once-off affair. This is because of the fact that the value of the model as an analytical tool is enhanced if the model itself is subsequently improved through re-estimation using more recent data and better formulated equations.

In using the simulation technique for solving the crop allocation problem, it is desirable to build more integrated models as suggested by Adams and Behrman (1982). This means possibly attaching the commodity market models for rubber and palm oil to the macromodel so that any additional possible mutual influence of the supply and prices of Malaysian rubber and palm oil on the world market can be dynamically accounted for by the simulation procedure.

There are a number of refinements which could be pursued in using the optimal control model in terms of solving the optimal crop allocation problem. A method of rationalising the selection of the weight matrix could lead to more meaningful results. The weights could be determined in a practical situation through an interrogation process using a panel of experts as suggested in the concepts displayed through Figure 6.1. In addition to the deterministic solution technique used in this study, it may be useful to simulate the variability of the results when the error terms are included as was illustrated in the work of Basu (1981) though his results showed that the refinements might not be worth the additional computing complications.

More important advances in the use of the optimal control technique must lie in the ability to use the nonlinear methods of solving the problem as well as the use of other more suitable forms of objective function. In this respect, the suggestions of Chow (1975) for the nonlinear technique and Fair (1984) on using the 'opened loop' technique for optimal control are worth pursuing. These approaches do require the use of more specialised computer packages and greater amount of computer capacity which were not readily available for this study.

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APPENDIX A: LISTING OF THE EQUATIONS, VARIABLE NAMES AND IDENTITIES OF THE MACROMODEL OF MALAYSIA

Equations are given names for use during simulation of the model and variables are also given names which, as far as possible, are descriptive abbreviations of the actual words, with the ending letters R and C usually indicating real and current values respectively. The adjusted R squared values, the t statistics and the period of fit (PF) are not shown as they have been presented for each estimated equation in Chapter 6. The rho value to show the degree of autocorrelation in the error term is reported together with the relevant equation to show that the equation has been estimated by the AR1 method in the TSP procedure, and the rho value would have to be incorporated in the simulation of the equation in question.

The equations in Section B are listed according to the ordering which reflects the recursive and simultaneous structure of the model. As mentioned in Chapter 6, there are three blocks of equations: the first and third blocks, each with 44 and 12 equations respectively, are made up of recursive equations, while the second block contains 77 simultaneous equations.

The first three equations shown in Section A below are the modified equations for planted mature areas for rubber and oil palm showing the inclusion of lagged annual planted areas (ANARUB, ANARES and CUTAREA) to facilitate the simulation of crop allocation problem.

Variable definitions, in alphabetical order, are shown in the next Section C together with a listing subsequently of the model identities which are presented in Section D according to the economic blocks as described in Chapter 6.

Section A : Modified equations for mature planted area for rubber and oil palm

1) Equation to generate mature area for oil palm

```
MAPALM = MAPALM +  0.67*(ANARUB(-3)
+ ANARUB(-4) + ANARUB(-5) + ANARUB(-6) + ANARUB(-7)
+ ANARUB(-8) + ANARUB(-9) + ANARUB(-10) + ANARUB(-11)
+ ANARUB(-12) + ANARUB(-13)) + (CUTAREA(-3)
+ CUTAREA(-4) + CUTAREA(-5) + CUTAREA(-6) + CUTAREA(-7)
+ CUTAREA(-8) + CUTAREA(-9) + CUTAREA(-10)
+ CUTAREA(-11) + CUTAREA(-12 + CUTAREA(-13))
```

2) Equation to generate mature area for rubber estates

```
MARUBES = MARUBES  - 0.001* 0.67*(ANARES(-6)
+ ANARES(-7) + ANARES(-8) + ANARES(-9) + ANARES(-10)
+ ANARES(-11) + ANARES(-12) + ANARES(-13))
- 0.001* 0.5* (CUTAREA(-3) + CUTAREA(-4) + CUTAREA(-5)
+ CUTAREA(-6) + CUTAREA(-7) + CUTAREA(-8) + CUTAREA(-9)
+ CUTAREA(-10) + CUTAREA(-11) + CUTAREA(-12
+ CUTAREA(-13))
```

3) Equation to generate mature area for rubber smallholdings

```
MARUBSH = MARUBSH  - 0.001* 0.67*(ANARUB(-6)
+ ANARUB(-7) + ANARUB(-8) + ANARUB(-9) + ANARUB(-10)
+ ANARUB(-11) + ANARUB(-12) + ANARUB(-13))
- ANARES(-6)  - ANARES(-7) - ANARES(-8) - ANARES(-9)
- ANARES(-10) - ANARES(-11) - ANARES(-12) - ANARES(-13))
- 0.001* 0.5* (CUTAREA(-3) + CUTAREA(-4) + CUTAREA(-5)
+ CUTAREA(-6) + CUTAREA(-7) + CUTAREA(-8) + CUTAREA(-9)
+ CUTAREA(-10) + CUTAREA(-11) + CUTAREA(-12)
+ CUTAREA(-13))
```

Section B: Equations of the Model by Structural Blocks

a) **Block 1: Recursive equations**

1) EEXPPETQ : Equation for petroleum exports

EXPPETQ = -2231.6182 + 0.1153*OPETQ +
1469.2533*DUM6070 - 75.1700*DUM7175 + 0.3657*IMPPETQ
(rho = 0.835080)

2) EEXPFS : Equation for exports of factor services

EXPFS = -255.6785 + 0.1558*MASEBNC(-1) +
32.2170*INRBOND(-1) -76.4178*DUM7483 - 165.3351*DUM8283
(rho = 0.629661)

3) IEXPPETC : Identity for export value of petroleum

EXPPETC = PPET * EXPPETQ/1000.0/0.5437

4) EGFDMLC : Equation for domestic borrowing

GFDMLC = 121.8423 + 3.4993*TEPFPOS
- 599.7924*DUM78 - 0.2572GFDMLC(-1)

5) ETXDINDC : Equation for individual taxes

TXDINDC = -197.7585 + 0.0395*INCINDC(-1)

6) ETXDCORC : Equation for corporate taxes

TXDCORC = 169.5485 + 0.2142*INCCORC(-1)

7) ITXDCOPC : Identity for petroleum company taxes

TXDCOPC = 0.45*PRFCOPC

8) IDTAX : Identity for direct taxes

DTAX = TXDINDC + TXDCORC + TXDCOPC

9) IGFDDEBC : Identity for government debt

GFDDEBC = GFDDEBC(-1) + GFDMLC + REDLONC

10) EPXRUB1 : Equation for export price of RSS1 rubber

PXRUB1 = 354.3944 + 0.6493*WRSS1E
(rho = 0.766451)

11) EPXRUB3 : Equation for RSS3 rubber price

PXRUB3 = 296.0262 + 0.6632*WRSS3E

(rho = 0.801479)

12) IPRUB : Identity for price of rubber

PRUB = 0.5514*PXRUB3 + 0.4486*PXRUB1

13) EPXPALM : Equation for price of palm oil

PXPALM = 197.7061 + 0.6947*WPALME

14) EPXSLOG : Equation for PXSLOG

PXSLOG = 17.1537 + 0.5810*WPSLGE

(rho = 0.268052)

15) EPXSTIM : Equation for price of sawn timber

PXSTIM = 11.8814 + 0.6405*WPSTME

(rho = 0.093895)

16) EPTIN : Equation for price of tin

PTIN = 3880.067 + 0.6820*WPTINE

(rho = 0.823838)

17) IPPRIMI :Identity for export price of primary commodities

PPRIMI = (0.0700(0.5514*PXRUB3 + 0.4486*PXRUB1) + 0.05653*PXPALM + 0.098513*PXSTIM + 0.546*PXSLOG + 0.2249*PPET + 0.004057*PTIN)/2.3456

18) EPMCONGI : Equation for price of consumption goods

PMCONGI = 55.7591 + 0.4109*WEXPIE + 48.1860*DUM7483

19) EPMINTGI : Equation for PMINTGI

PMINTGI = -27.4286 + -1.3733*WPRIME + 3.2231*WEXPIE

20) EPIMMCHI : Equation for price of investment goods

PIMMCHI = 46.2119 + 0.2818*WPMFGI + 35.8498*DUM7483

21) IPIMIN : Identity for price index of imported goods

PIMIN = 0.4577176*PMCONGI + 0.293514*PIMMCHI

22) EPIMI : Equation for PIMI

PIMI = 36.5221 + 0.7809*PIMIN + 18.2577*DUM7483 - 5.5860*DUM8283

23) IINVCRER : Identity for investment credit

INVCRER = (MLONBKC)/(0.0100*PIMI)

24) EGFDETOC :Equation for government development expenditure

GFDETOC = -407.5933 + 0.1511*PLANTAR + 0.1007*PLANTAR(-1) + 0.0504*PLANTAR(-2) + 1.6889*GFDMLC

25) EPCI : Equation for consumer price index

PCI = 76.0885 + 0.1847*PIMI + 0.0019*M3Q(-1) + 15.4908*DUM7483

26) EPCOPRI : Equation for private consumption deflator

PCOPRI = -7.0444 + 1.0064*PCI

(rho = 0.776873)

27) IPRUB3R : Identity to generate producers' price, PRUB3R

PRUB3R = PXRUB3/(0.01*PCI*(1+ETRFRB3))

28) IPRUB1R : Identity for PRUB1R

PRUB1R = PXRUB1/(0.01*PCI)/(1+ ETRFRB1)

29) IPPALMR : Identity to generate PPALMR

PPALMR = PXPALM/(0.01*PCI)/(1+ ETRFPO)

30) IPRICER : Identity for generating PRICER

PRICER = PXRICEP*10/0.65/(0.01*PCI)

31) IPTINR : Identity for PTINR

PTINR = PTIN/(0.01*PCI)/(1+ ETRFTIN)

32) EORUBSH : Equation for rubber output of smallholdings

ORUBSH = -224.0217 + 0.6931*MARUBSH + 0.0139*PRUB3R
+ 5.1509*TIME + 108.0237*DUM7388 +
0.3087*ORUBSH(-1)

33) EORUBES : Equation for rubber output of estates

ORUBES = - 493.2142 + 1.0264*MARUBES + 0.0031*PRUB1R
+9.4293*TIME + 0.7436*ORUBES(-1)

34) EOPALM : Equation for output of palm oil

OPALM = -285.8565 + 0.0025*MAPALM + 0.1767*PPALMR
+ 0.1178*PPALMR(-1) + 0.0589*PPALMR(-2) +
530.1406*DUM82 - 264.6707*DUM7883
+ 0.2421*OPALM(-1)

35) EORICE : Equation for output of rice

ORICE = -1519.2399 + 3.2534*PRICER + 0.0881*POPMSIA
-149.3592*DUMDR78 + 104.0899*DUMSD81 +
0.2671*ORICE(-1)

36) IORUBQ : Identity for total rubber output

ORUBQ = ORUBSH + ORUBSS + ORUBES

37) EOTINQ : Equation for output of tin

OTINQ = -2.5668 + 0.0006*PTINR - 0.5184*TIME
-2.6462*DUM7388 + 5.7237*DUM7879 +
1.0550*OTINQ(-1)

38) EEXPRUBQ : Equation for export of rubber

EXPRUBQ = 83.0340 + 0.9598*ORUBQ
(rho = 0.655291)

39) EEXPOPQ : Equation for palm oil exports

EXPOPQ = 26.5962 + 0.8789*OPALM

40) EEXTINQ : Equation for exports of tin

EXTINQ = -4.5839 + 1.0783*OTINQ +0.9633*IMPTINQ

41) IEXPOPC : Identity for export value of palm oil

EXPOPC = PXPALM * EXPOPQ/1000.0/1.1249

42) IEXPRUBC : Identity for export value of rubber

EXPRUBC = 0.001* PRUB * EXPRUBQ/0.9979

43) IEXPTINC : Identity for export value of tin

EXPTINC = PTIN * EXPTINQ/1000.0/1.1079

44) ITINVR : Identity for TINVR

TINVR = OTINQ*PTIN/(0.01*PCI)/1000

b) Block 2: Simultaneous equations

45) EVAAGRIR : Value added for agriculture

VAAGRIR = 957.5407 + 2.8101*AGPI2

46) EAGPI2 : Equation for agricultural production index

AGPI2 = (0.1782*OPALM + 0.3221*ORUBSH + 0.3221*ORUBSS
+ 0.3381*ORUBES + 0.0423*OSTIM + 0.0178*OSLOG
+ 0.1015*ORICE)

47) EOSTIM : Equation for output of sawntimber

OSTIM = -88.7956 + 0.8957*PSTIMR + 120.6845*TIME
+ 1433.562*DUM83 + 0.5833*OSTIM(-1)

48) IPSTIMR :Identity for price of sawn timber

PSTIMR = PXSTIM/(0.01*PGDPI)/(1+ ETRFSTC)

49) EOSLOG : Equation for output of sawlogs

OSLOG = 1786.0408 + 55.8837*PSLOGR - 2465.5862*DUM7475
-3024.5928*DUM7780 + 4.3876*OSTIM(-1)

50) IPSLOGR : Identity to generate PSLOGR

PSLOGR = PXSLOG/(0.01*PGDPI)/(1+ETRFSLC)

51) EVAMINR : Equation for value added mining sector

VAMINR = 442.6355 + 0.3509*TINVR + 0.2028*PETVR

52) IPETVR : Identity to generate PETVR

PETVR = OPETQ*PPET/(0.01*PGDPI)/1000

53) EVAMFGR : Equation for value added in manufacturing

VAMFGR = -791.6903 + 0.2846*CONEXPR - 1.1055*MINTGI

(rho = 0.839437)

54) ICONEXPR : Identity for CONEXPR

CONEXPR = CONPRIR + CONPUBR

55) EVACONSR : Equation for value added for construction

VACONSR = 137.9466 + 0.1453*INVTR - 23.5344*DUM7576

(rho = 0.586616)

56) EVATRANR : Equation for value added in transportation

VATRANR = -388.4596 + 0.0606*VAAGRIR + 0.0992*TXMERR

(rho = 0.434114)

57) ITXMERR : Identity for TXMERR

TXMERR = ((IMPMERC/PIMI)+(EXPMERC/PEXI))*100.0

58) EVASER : Equation for value added services

VASER = 491.0196 + 0.3555*EXPCNI

(rho = 0.730616)

59) IEXPCNI : Identity to generate EXPCNI

EXPCNI = CONPRIR + CONPUBR + INVPRIR + INVPUBR

60) IGDPR : Identity for total value added ie. GDPR

GDPR = VAAGRIR + VAMINR + VAMFGR + VACONSR
+ VATRANR + VASER - VAIBSR + TXIMR

61) ECONPRIR : Equation for private consumption

CONPRIR = 112.0163 + 0.1481*INCDSPR - 42.4579*RCBLR
+ 0.8132*CONPRIR(-1)

62) IINCDSPR : Identity for INCDSPR

INCDSPR = GDPR - DTAX/(0.01*PGDPI)

63) IRCBLR : Identity for RCBLR
RCBLR = INRA - (PGDPI - PGDPI(-1))/PGDPI(-1)*100

64) ECONPUBR : Equation for public consumption
CONPUBR = 28.4751 + 0.2413*GFREVR + 0.8106*CONPUBR(-1)

65) IGFREVR : Identity for government revenue
GFREVR = (GFTOREV - GFTRC)/(0.01*PGDPI)

66) EINVPRIR : Equation for private investment
INVPRIR = -693.2373 + 0.2008*INVCRER - 1.7606*RCBLR
+ 0.0815*GNPR + 0.0543*GNPR(-1) +
0.0272GNPR(-2)

67) IGNPR : Identity for GNPR
GNPR = GDPR - FPNETR

68) EINVPUBR : Equation for public investment
INVPUBR = 126.7235 + 0.4566*INVPUBR(-1) -
155.2599*CHGDP + 0.2406*DDE + 0.1604*DDE(-1) +
0.0802*DDE(-2)

69) ICHGDP : Identity for change in GDP
CHGDP = (GDPR - GDPR(-1))/GDPR(-1)

70) IDDE : Identity for development expenditure
DDE = GFDETOC/(0.0100*PGDPI)

71) EEXPSTQ : Equation for exports of sawn timber
EXPSTQ = 23.0830 + 0.5387*OSTIM
-214.2887*DUM7475 - 443.3271*DUM8083

72) EEXPSLQ : Equation for exports of saw logs
EXPSLQ = -1007.7433 + 0.5734*OSLOG
(rho = 0.538525)

73) EEXPMFGC : Equation for exports of manufactured goods
EXPMFGC = -2406.0642 + 1.8014*GDPUSC + 13.5772*PXMFGR
- 424.8661*DUM7388

74) IPXMFGR : Identity for price of manufactured goods
PXMFGR = PXMFGI/(0.0100*PIMI)

75) EXSVXIR :Equation for exports of non-factor services
XSVXIR = - 686.9057 + 3.8755*PXSERR + 0.0948*TXMERR
(rho = 0.784554)

76) IPXSERR : Identity for price of services
PXSERR = PXSERI/(0.01*PGDPI)

77) IEXPGNFC : Identity for non-factor services
EXPGNFC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC +EXPTINC
+ EXPPETC + EXPMFGC + EXSVXIC + EXPLNGC
+ EXPOTC

78) IEXSVXIC : Identity for exports of nonfactor services
EXSVXIC = XSVXIR* 0.01* PXSERI

79) IEXPSLC : Identity for export value of saw logs
EXPSLC = PXSLOG * EXPSLQ/1000.0/0.9537

80) IEXPSTC : Identity for export value of sawn timber
EXPSTC = PXSTIM * EXPSTQ/1000.0/1.0232

81) IEXPMERC : Identity for exports of merchandised goods
EXPMERC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC + EXPTINC
+ EXPPETC + EXPMGFC + EXPRESC + EXPLNGC

82) EIMPCONC : Equation for consumption goods
IMPCONC = 4809.2261 + 0.2070*CONEXPR
- 19051.4551* MTRFF - 25.7025* PMCNGIR
- 123.0680* DUM75 - 352.6989*DUM6972

83) EMIVGC : Equation for imports of investment goods
MIVGC = 3793.7305 + 0.9187*INVTR - 23.0506*PIMCHIR
-18192.2656*MTRFF

84) IPMCNGIR : Identity for import price of consumption goods

PMCNGIR = PMCONGI/(0.01*PGDPI)

85) IINVTR : Identity for INVTR

INVTR = INVPRIR + INVPUBR

86) IPIMCHIR : Identity for price of investment goods

PIMCHIR = PIMMCHI/ (0.01*PGDPI)

87) EMINTGC : Equation for imports of intermediate goods

MINTGC = 7328.884 + 1.6199*VAMFGR - 34768.2695*MTRFF
- 34.9806*PIMINR + -378.8943*DUM6972 + 5688.462*DUM8083
(RHO = 0.3393)

88) EIMPNFS : Equation for imports of non-factor services

IMPNFS = 1759.1320 + 0.0792*XPMC + 0.0528*XPMC(-1)
+0.0264*XPMC(-2) -10.0005*PIMINR - 6.6670*PIMINR(-1)
-3.3335*PIMINR(-2)

89) IPIMINR : Identity for PIMINR

PIMINR = PIMIN/(0.01*PGDPI)

90) IIMPGNFC : Identity for imports of goods and non-factor services

IMPGNFC = IMPMERC + IMPNFS

91) IIMPMERC : Identity for imports of merchandised goods

IMPMERC = IMPC -IMPRES

92) IIMPC : Identity for imports of goods

IMPC = IMPCONC + MIVGC + MINTGC + IMPFREX

93) ITGREV : Identity for total government revenue

GFTOREV = DTAX + IDTAX + NTAX

94) ITXEXPC : Identity for export duties

TXEXPC = -91.6914 + 0.0923*EXPRIMC

95) ITXIMC : Identity for import duties

TXIMC = 183.9997 + 0.0777*IMPC

96) IEXPRIMC : Identity for exports of primary commodities

EXPRIMC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC
+ EXPTINC + EXPPETC + EXPOTC

97) IVAMFGC : Identity for IVAMFGC

VAMFGC = VAMFGR* 0.01 * PGDPI

98) ETXEC : Equation for excise duty

TXEC = 18.3296 + 0.0995*VAMFGC + 3.3156*PCGDPC

99) IPCGDPC : Identity for PCGDPC

PCGDPC = (GDPC - GDPC(-1))/GDPC(-1)*100

100) ETXSALE : Equation for sale tax

TXSALE = -136.4810 + 0.0429*VASEC + 1.3004*DUM7183

101) IIDTAX : Total indirect taxes

IDTAX = (((TXEXPC + TXIMC) + TXEC) + TXSALE) + TIDOTH

102) IVASEC : Identity for value added of services sector

VASEC = VASER*(0.0100*PGDPI)

103) EWGRI : Equation for wages and salaries index

WGRI = -1.1569 + 0.1176*NPRODI + 0.0191*PGDPI
-0.0302*DUM75 + 0.3249*DUM8083

104) INPRODI : Identity for NPRODI

NPRODI = GDPR/LABTOT

105) ELABAGIR : Equation for agricultural employment

LABAGIR = 1511.370 + 0.0877*VAAGRIR - 27.0345*DUM6970
- 1935.700*WGRIR - 1290.4669*WGRIR(-1)
- 645.2334*WGRIR(-2) - 0.67*0.24*0.001*(ANARUB(-3)
+ ANARUB(-4) + ANARUB(-5) + ANARUB(-6) + ANARUB(-7)
+ ANARUB(-8) + ANARUB(-9) + ANARUB(-10) + ANARUB(-11)
+ ANARUB(-12) + ANARUB(-13))

+ 0.385* 0.001*(CUTAREA(-3) + CUTAREA(-4) + CUTAREA(-5)
+ CUTAREA(-6) + CUTAREA(-7) + CUTAREA(-8) + CUTAREA(-9)
+ CUTAREA(-10) + CUTAREA(-11) + CUTAREA(-12)
+ CUTAREA(-13))

106) IWGRIR : Identity for WGRIR
WGRIR = WGRI/PPRIMI

107) ELABNAGR : Equation for non agricultural labour
LABNAGR = 671.0067 + 0.1276*VAGDPNA - 941.1574*WGRR
(RHO = 0.691272)

108) IVGDPNA : Identity for VGDPNA
VAGDPNA = GDPR + VAIBSR - VAAGRIR - TXIMR

109) IWGRR : Identity for WGRR
WGRR = WGRI/INRA

110) ILABTOT : Identity for total labour
LABTOT = LABAGIR + LABNAGR

111) IPGDPI : Identity for generating PGDPI
PGDPI = 100 * GDPC/GDPR

112) IGDPC : Identity for generating GDPC
GDPC = (CONPRIR*PCOPRI + CONPUBR*PCOPBI
+ INVPRIR*PINPRI + INVPUBR*PINPBI)*100.0 + EXPGNFC
- IMPGNFC

113) EPXMFGI :Equation for price of manufactured goods
PXMFGI = 34.8374 + 0.3457*PMINTGI + 27.6019*WGRI
(RHO = 0.303018)

114) EPSERI : Equation for price of services exported
PXSERI = 12.0025 + 0.9335*PGDPI

115) IPEXI : Identity for export price index
PEXI = 0.4180*PXMFGI + 0.5820*PPRIMI

116) EPCOPBI : Equation for public consumption deflator

PCOPBI = 50.7049 + 0.2165*PCI + 22.8185*WGRI

117) EPINPRI: Equation for private investment

PINPRI = 33.66695 + 0.3256*PIMMCHI + 29.7966*WGRI

118) EPINPBI : Equation for public investment deflator

PINPBI = 33.6518 + 29.7980*WGRI + 0.3257*PIMMCHI

119) IXPMC : XPMC = IMPMERC + EXPMERC

120) ITXIMR TXIMR = TXIMC* 100 * 522/577.1000/IMTXDFI

c) <u>Block 3: Recursive Equations</u>

121) EIMTXDFI: IMTXDFI = 48.3055 + 0.5422*PGDPI+ 0.0594*PIMI
(RHO = 0.890160)

122) IPPRIMIR : PPRIMIR = PPRIMI/(0.01*PGDPI)

123) IYWSC : YWSC = LABTOT*WGRI

124) EYAC : Equation for agricultural income

YAC : -11661.955 + 4.3968*VAAGRIR + 30.4555*PPRIMIR
+ 0.67*0.385*0.001*(ANARUB(-3) + ANARUB(-4)
+ ANARUB(-5) + ANARUB(-6) + ANARUB(-7) + ANARUB(-8)
+ ANARUB(-9) + ANARUB(-10) + ANARUB(-11) + ANARUB(-12)
+ ANARUB(-13)) + 0.385* 0.001*(CUTAREA(-3)
+ CUTAREA(-4) + CUTAREA(-5) + CUTAREA(-6) + CUTAREA(-7)
+ CUTAREA(-8) + CUTAREA(-9) + CUTAREA(-10)
+ CUTAREA(-11) + CUTAREA(-12) + CUTAREA(-13))
(RHO = 0.683695)

125) IINCCORC : Identity for corporate income

INCCORC = GDPC - YWSC - YAC -PRFCOPC
+ 0.67*0.385*0.001*(ANARUB(-3) + ANARUB(-4)
+ ANARUB(-5) + ANARUB(-6) + ANARUB(-7) + ANARUB(-8)
+ ANARUB(-9) + ANARUB(-10) + ANARUB(-11) + ANARUB(-12)
+ ANARUB(-13)) + 0.385* 0.001*(CUTAREA(-3)

+ CUTAREA(-4) + CUTAREA(-5) + CUTAREA(-6) + CUTAREA(-7)
+ CUTAREA(-8) + CUTAREA(-9) + CUTAREA(-10)
+ CUTAREA(-11) + CUTAREA(-12) + CUTAREA(-13))

126) IINCINDC : Identity for individual income
INCINDC = YWSC + YAC + 0.67*0.385*0.001*(ANARUB(-3)
+ ANARUB(-4) + ANARUB(-5) + ANARUB(-6) + ANARUB(-7)
+ ANARUB(-8) + ANARUB(-9) + ANARUB(-10) + ANARUB(-11)
+ ANARUB(-12) + ANARUB(-13))
+ 0.385* 0.001*(CUTAREA(-3) + CUTAREA(-4) + CUTAREA(-5)
+ CUTAREA(-6) + CUTAREA(-7) + CUTAREA(-8) + CUTAREA(-9)
+ CUTAREA(-10) + CUTAREA(-11) + CUTAREA(-12)
+ CUTAREA(-13))

127) EFPDTC : Equation for imports of factor services
FPDTC = -855.9629 +0.0779*GDPC + 4.7890*PPRIMIR
(RHO = 0.736868)

128) IMINTGR : Identity for MINTGR
MINTGR = MINTGC/(0.01*PMINTGI)

129) EBPCOINC : Equation for foreign corporate investment
BPCOINC = - 203.9345 + 31.5174*INRA + 0.5746*FPDTC
- 212.5702*DUM73 + 427.6225*DUM74

130) IBPCBRC : Identity for balance of payments
BPCBRC = EXPGNFC + EXPFS - (IMPGNFC + FPDTC)
+ GFFRLC + BPCOINC - BSPEROM + BPSDR + BPIMF

131) ECHM3Q : Equation for broadly defined change quarsi
money M3Q
CHM3Q = -12.0971 + 1.0873*BPCBRC + 0.9164*GFDMLC

132) IM3Q : Identity to generate M3Q
M3Q = M3Q(-1) + CHM3Q

133) IMASEBNC : Identity for Central Bank External Assets
MASEBNC = MASEBNC(-1) + BPCBRC + OTASBNC

APPENDIX A(cont): VARIABLE DEFINITIONS AND MODEL IDENTITIES

Section C: Variable Definitions

a) Endogenous Variables

AGPI2	:	Agricultural production index
BPCOINC	:	Corporate investment
BPCBRC	:	Balance of payments
CHGDP	:	Annual Change in GDP
CHM3Q	:	Change in money supply
CONEXPR	:	Consumption expenditure, public and private sector
CONPRIR	:	Consumption, private sector
CONPUBR	:	Consumption, public sector
DDE	:	Development expenditure, real
DTAX	:	Direct taxes
EXPCNI	:	Total investment and consumption
EXPFS	:	Export of factor services
EXPGNFC	:	Exports of goods and non-factor services
EXPMERC	:	Exports of merchandised goods
EXPMFGC	:	Export value of manufactured goods
EXPOPC	:	Export value of palm oil
EXPOPQ	:	Export quantity of palm oil
EXPPETC	:	Export value of petroleum
EXPPETQ	:	Export quantity of petroleum
EXPRIMC	:	Exports of primary commodities
EXPRUBC	:	Export value of rubber
EXPRUBQ	:	Export quantity of rubber
EXPSLC	:	Exports value of sawlogs
EXPSLQ	:	Export quantity of sawlogs
EXPSTC	:	Export value of sawn timber
EXPSTQ	:	Export quantity of sawn timber
EXPTINC	:	Export value of tin
EXPTINQ	:	Export quantity of tin
EXSVXIC	:	Export value of services excluding overseas income
FPDTC	:	Net transfer of assets abroad
GDPC	:	Gross domestic product
GDPR	:	Total real value added

GFDDEBC : Government debts
GFDETOC : Total government revenue
GFDMLC : Government domestic loans
GFREVR : Government revenue in real terms
GFTOREV : Government total revenue
GNPR : Gross national product, real
IDTAX : Indirect taxes
IMPC : Total import
IMPCONC : Imports of consumption goods
IMPGNFS : Imports of goods and non-factor services
IMPMERC : Imports of merchandised goods
IMPNFS : Imports of non-factor services
IMTXDFI : Deflator for import tax
INCCORC : Corporate income
INCDSPR : Real disposible income
INCINDC : Individual income
INVCRER : Investment credit
INVPRIR : Private investment
INVPUBR : Public investment
INVTR : Investment total
LABAGIR : Labour employed in agriculture
LABNAGR : Labour employed in non-agricultural sector
LABTOT : Total labour employed
MASEBNC : External assets of the Central Bank
MINTGC : Imports of intermediate goods
MINTGR : Import price index for intermediate goods, deflated
MIVGC : Import of investment goods
M3Q : Money supply, broadly defined
NPRODI : Productivity index
OPALM : Output of palm oil
ORICE : Output of rice
ORUBES : Rubber output of estates
ORUBQ : Total rubber output
ORUBSH : Rubber output of smallholdings
OSLOG : Output of sawlogs
OSTIM : Output of sawn timber
OTINQ : Output quantity of tin
PCGDPC : Percentage change in current GDP
PCI : Consumer price index, 1970 = 100

PCOPBI : Deflator for public investment
PCOPRI : Deflator for private consumption
PEXI : Price index for exports
PETVR : Value of petroleum output
PGDPI : GDP deflator
PIMCHIR : Price index of investment goods, deflated
PIMI : Price index for imports
PIMIN : Price index for imported goods
PIMINR : Price index for imports , deflated
PIMMCHI : Price index for investment goods
PINPBI : Peflator for public investment
PINPRI : Deflator for private investment
PMCNGIR : Price index for consumption goods, deflated
PMCONGI : Price index of consumption goods
PMINTGI : Price index of intermediate goods
PPALMR : Real producers price of palm oil
PPRIMI : Price index of primary commodities
PPRIMIR : Price index of primary commodities, deflated
PRICER : Real producers price of rice
PRUB : Composite price of rubber
PRUB1R : Real producers price of RSS1 grade rubber
PRUB3R : Real producers price of RSS3 grade rubber
PSTIMR : Real producers price of sawn timber
PSLOGR : Real producers price of sawlogs
PXMFGI : Export price index of manufactured goods
PXMFGR : Real export price index for manufactured goods
PXPALM : Export price of palm oil
PXRUB1 : Export price of RSS1 grade rubber
PXRUB3 : Export price of RSS3 grade rubber
PXSERI : Price index of services
PXSERR : Real price of services
PXSLOG : Export price of sawlogs
PXSTIM : Export price of sawn timber
PTIN : Export price of tin
PTINR : Real producers price of tin
RCBLR : Inter bank lending rates
TINVR : Value of tin output
TXDCOPC : Petroleum company taxes
TXDCORC : Corporate taxes

TXDINDC : Individual taxes
TXEC : Excise duties
TXEXPC : Export taxes
TXIMC : Import taxes
TXIMR : Import taxes in real terms
TXMERR : Total exports and imports of merchandised goods
TXSALE : Sale taxes
VAAGRIR : Value added for agriculture
VACONSR : Value added for construction sector
VAGDPNA : Value added in non-agricultural sector
VAMFGC : Value added for manufacturing sector, current
VAMFGR : Value added in manufacturing
VAMINR : Value added for mining sector
VASEC : Value added in services sector, current
VASER : Value added for services sector
VATRANR : Value added in transportation sector
WGRI : Wage rate index
WGRIR : Wage rate index, deflated
WGRR : Wage rate index deflated by primary commodity prices
XPMC : Total sum of exports and imports
XSVXIR : Exports of services, real terms
YAC : Agricultural income
YWSC : Individual wages and salaries

b) Exogenous Variables

ANARUB : Area newly planted with rubber, estates and smallholdings
ANARES : Area newly planted with rubber, estates
BPIMF : Drawing rights with the IMF
BPSDR : Special drawing rights
BSPEROM : Other errors and omissions
CUTAREA : Rubber area cut down for accelerated replanting
DUM6070 : Dummy variable, of values 1 or 0 for relevant years
DUM73 : Dummy variable, of values 1 or 0 for relevant years
DUM6970 : Dummy variable, of values 1 or 0 for relevant years
DUM6972 : Dummy variable, of values 1 or 0 for relevant years
DUM7183 : Dummy variable, of values 1 or 0 for relevant years
DUM73 : Dummy variable, of values 1 or 0 for relevant years
DUM74 : Dummy variable, of values 1 or 0 for relevant years

DUM7383 : Dummy variable, of values 1 or 0 for relevant years
DUM7388 : Dummy variable, of values 1 or 0 for relevant years
DUM7475 : Dummy variable, of values 1 or 0 for relevant years
DUM7483 : Dummy variable, of values 1 or 0 for relevant years
DUM75 : Dummy variable, of values 1 or 0 for relevant years
DUM7576 : Dummy variable, of values 1 or 0 for relevant years
DUM7780 : Dummy variable, of values 1 or 0 for relevant years
DUM78 : Dummy variable, of values 1 or 0 for relevant years
DUM7879 : Dummy variable, of values 1 or 0 for relevant years
DUM8083 : Dummy variable, of values 1 or 0 for relevant years
DUM82 : Dummy variable, of values 1 or 0 for relevant years
DUM8283 : Dummy variable, of values 1 or 0 for relevant years
DUM83 : Dummy variable, of values 1 or 0 for relevant years
DUMDR78 : Dummy variable, of values 1 or 0 for relevant years
DUMSD81 : Dummy variable, of values 1 or 0 for relevant years
ETRFPO : Export duty rate for palm oil
ETRFRB1 : Export duty rate for RSS1 grade rubber
ETRFRB3 : Export duty rate for RSS3 grade rubber
ETRFSLC : Export duty rate for sawlogs
ETRFSTC : Export duty rate for sawn timber
ETRFPO : Export duty rate for palm oil
ETRFTIN : Export duty rate for tin
EXPLNGC : Export value of liquified petroleum gas
EXPOTC : Export of other items
EXPRESC : Residual Exports
FPNETR : Foreign net transfers
GDPUSC : Gross domestic product of the U.S.A.
GFFRLC : Government foreign loans
GFTRC : Government transfers to households
IMPFREX : Imports for re-export
IMPPETQ : Imports quantity of petroleum
IMPRES : Residual imports
IMPTINQ : Import quantity of tin
INRA : Interest rates
INRBOND : Yields of bonds
MAPALM : Mature planted area for oil palm
MARUBES : Mature planted area for rubber estates
MARUBSH : Mature planted area for rubber smallholdings
MLONBKC : Loans of commercial banks

MTRFF	:	Import tariffs
NTAX	:	Indirect taxes
OPETQ	:	Output quantity of petroleum
ORUBSS	:	Rubber output for Sabah and Sarawak
OTASBNC	:	Other assets of Central Bank
POPMSIA	:	Population of Malaysia
PPET	:	Export price of petroleum
PRFCOPC	:	Profit of petroleum companies
PXRICEP	:	Rice equivalent government price of paddy
TEPFPOS	:	Total saving in epf and post office
TIDOTH	:	Other indirect taxes
TIME	:	Time trend with 1960 = 1
VAIBSR	:	Imputed bank charges
WEXPIE	:	Price index of exports from developed countries
WPMFGI	:	World price index for manufactured goods
WPSLGE	:	International price of sawlogs
WPSTME	:	International price of sawn timber
WPRIME	:	World price index for primary commodities
WPTINE	:	International price of tin
WRPALME	:	International price of palm oil
WRSS1E	:	International price of RSS1 grade rubber
WRSS1E	:	International price of RSS3 grade rubber

Section D : Model Identities

1)Output Block

Identity for agricultural production index

```
AGPI2 = (0.1782*OPALM + 0.3221*ORUBSH + 0.3221*ORUBSS
      + 0.3381*ORUBES + 0.0423*OSTIM + 0.0178*OSLOG
      + 0.1015*ORICE)
```

Identity to generate producers' price, PRUB3R

```
PRUB3R  = PXRUB3/(0.01*PCI*(1+ETRFRB3))
```

Identity for PRUB1R

```
PRUB1R  = PXRUB1/(0.01*PCI)/(1+ ETRFRB1)
```

Identity to generate PPALMR

```
PPALMR  = PXPALM/(0.01*PCI)/(1+ ETRFPO)
```

Identity for price of sawn timber

```
PSTIMR = PXSTIM/(0.01*PGDPI)/(1+ ETRFSTC)
```

Identity to generate PSLOGR

```
PSLOGR  = PXSLOG/(0.01*PGDPI)/(1+ETRFSLC)
```

Identity for generating PRICER

```
PRICER  = PXRICEP*10/0.65/(0.01*PCI)
```

Identity for total rubber output

```
ORUBQ  = ORUBSH + ORUBSS + ORUBES
```

Identity for TINVR

```
TINVR  = OTINQ*PTIN/(0.01*PCI)/1000
```

Identity to generate PETVR

```
PETVR  = OPETQ*PPET/(0.01*PGDPI)/1000
```

Identity for PTINR

PTINR = PTIN/(0.01*PCI)/(1+ ETRFTIN)

Identity for CONEXPR

CONEXPR = CONPRIR + CONPUBR

Identity for TXMERR

TXMERR = ((IMPMERC/PIMI)+(EXPMERC/PEXI))*100.0

Identity to generate EXPCNI

EXPCNI = CONPRIR + CONPUBR + INVPRIR + INVPUBR

Identity for total value added ie. GDPR

GDPR = VAAGRIR + VAMINR + VAMFGR + VACONSR
+ VATRANR + VASER - VAIBSR + TXIMR

2)Demand Block

Identity for INCDSPR

INCDSPR = GDPR - DTAX/(0.01*PGDPI)

Identity for RCBLR

RCBLR = INRA - (PGDPI - PGDPI(-1))/PGDPI(-1)*100

Identity for government revenue

GFREVR = (GFTOREV - GFTRC)/(0.01*PGDPI)

Identity for investment credit

INVCRER = (MLONBKC)/(0.0100*PIMI)

Identity for GNPR

GNPR = GDPR - FPNETR

Identity for change in GDP

CHGDP = (GDPR - GDPR(-1))/GDPR(-1)

Identity for development expenditure

DDE = GFDETOC/(0.0100*PGDPI)

3)<u>Export and Import Block</u>

i)<u>Import Sector</u>

Identity for price of manufactured goods

```
   PXMFGR   = PXMFGI/(0.0100*PIMI)
```

Identity for price of services

```
   PXSERR   = PXSERI/(0.01*PGDPI)
```

Identity for non-factor services

```
   EXPGNFC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC +EXPTINC
       + EXPPETC + EXPMFGC + EXPSVXIC + EXPLNGC + EXPOTC
```

Identity for exports of nonfactor services

```
   EXSVXIC   = EXSVXIR* 0.01* PXSERI
```

Identity for export value of saw logs

```
   EXPSLC   = PXSLOG * EXPSLQ/1000.0/0.9537
```

Identity for export value of sawn timber

```
   EXPSTC   = PXSTIM * EXPSTQ/1000.0/1.0232
```

Identity for export value of palm oil

```
   EXPOPC   = PXPALM * EXPOPQ/1000.0/1.1249
```

Identity for export value of rubber

```
   EXPRUBC   = (0.001* PRUB)* EXPRUBQ/0.9979
```

Identity for export value of tin

```
   EXPTINC   = PTIN * EXPTINQ/1000.0/1.1079
```

Identity for export value of petroleum

```
   EXPPETC   = 7.6*PPET * EXPPETQ/1000.0/0.5437
```

Identity for exports of merchandised goods

EXPMERC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC + EXPTINC + EXPPETC + EXPMGFC + EXPRESC + EXPLNGC

ii) Import Sector

Identity for import price of consumption goods

PMCNGIR = PMCONGI/(0.01*PGDPI)

Identity for INVTR

INVTR = INVPRIR + INVPUBR

Identity for price of investment goods

PIMCHIR = PIMMCHI/ (0.01*PGDPI)

Identity for PIMINR

PIMINR = PIMIN/(0.01*PGDPI)

Identity for import price of commodities

PPRIMIR = PPRIMI/(0.01*PGDPI)

Identity for imports of goods and non-factor services

IMPGNFC = IMPMERC + IMPNFS

Identity for imports of merchandised goods

IMPMERC = IMPC -IMPRES

Identity for imports of goods

IMPC = IMPCONC + MIVGC + MINTGC + IMPFREX

4) Government block

Identity for total government revenue

GFTOREV = DTAX + IDTAX + NTAX

Identity for petroleum company taxes

TXDCOPC = 0.45*PRFCOPC

Identity for direct taxes

DTAX = TXDINDC + TXDCORC + TXDCOPC

Identity for exports of primary commodities

EXPRIMC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC + EXPTINC
+ EXPPETC + EXPOTC

Identity for PCGDPC

PCGDPC = (GDPC - GDPC(-1))/GDPC(-1)*100

Identity for IVAMFGC

VAMFGC = VAMFGR* 0.01 * PGDPI

Identity for value added of services sector

VASEC = VASER*(0.0100*PGDPI)

Identity fototal indirect taxes

IDTAX = (((TXEXPC + TXIMC) + TXEC) + TXSALE) + TIDOTH

5)<u>Financial Block</u>

Identity to generate M3Q

M3Q = M3Q(-1) + CHM3Q

Identity for balance of payments

BPCBRC = EXPGNFC + EXPFS - (IMPGNFC + FPDTC)
+ GFFRLC + BPCOINC - BSPEROM + BPSDR + BPIMF

Identity for government debt

GFDDEBC = GFDDEBC(-1) + GFDMLC + REDLONC

Identity for external assets of the Central Bank

MASEBNC = MASEBNC(-1) + BPCBRC + OTASBNC

6)<u>Factor income and employment block</u>

Identity for NPRODI

NPRODI = GDPR/LABTOT

Identity for wages and salaries

YWSC = LABTOT*WGRI

Identity for corporate income

INCCORC = GDPC - YWSC - YAC -PRFCOPC

Identity for individual income

INCINDC = YWSC + YAC

Identity for WGRIR

WGRIR = WGRI/PPRIMI

Identity for VGDPNA

VGDPNA = GDPR + VAIBSR - VAAGRIR - TXIMR

Identity for WGRR

WGRR = WGRI/INRA

Identity for total labour

LABTOT = LABAGIR + LABNAGR

7)**Prices Block**

Identity for generating PGDPI

PGDPI = 100* GDPC/GDPR

Identity for generating GDPC

GDPC = (CONPRIR*PCOPRI + CONPUBR*PCOPBI + INVPRIR*PINPRI +INVPUBR*PINPBI)*100.0 + EXPGNFC - IMPGNFC

Identity for price of rubber

PRUB = 0.5514*PXRUB3 + 0.4486*PXRUB1

Identity for export price of primary commodities

PPRIMI = (0.0700(0.5514*PXRUB3 + 0.4486*PXRUB1) + 0.05653*PXPALM + 0.098513*PXSTIM + 0.546*PXSLOG + 0.2249*PPET + 0.004057*PTIN)/2.3456

Identity for export price index

```
PEXI   = 0.4180*PXMFGI + 0.5820*PPRIMI
```

Identity for price index of imported goods

```
PIMIN  = 0.4577176*PMCONGI + 0.293514*PIMMCHI
```

Identity for MINTGR

```
MINTGR = MINTGC/(0.01*PMINTGI)
```

Identity for XPMC

```
XPMC   = IMPMERC + EXPMERC
```

Identity for TXIMR

```
ITXIMR TXIMR = TXIMC* 100 * 522/577.1000/IMTXDFI
```

Identity for export value of primary commodities

```
EXPRIMC = EXPSLC + EXPSTC + EXPOPC + EXPRUBC
     + EXPTINC + EXPPETC + EXPOTC
```

Identity for foreign loans

```
GFFRLC  = GFDETOC - GFDMLC - REDLONC
```

```
C     PROGRAMME FOR OPTIMAL CONTROL PROBLEM BY FORTRAN
C     ***********************************************
      DOUBLE PRECISION W140B3(140,3),W240B3(140,3),W140SQ(140,140),
     C W240SQ(140,140),W340SQ(140,140),B14014(140,12),
     C B24014(140,12),B34014(140,12),B44014(140,12),W3B143(3,143),
     C W3B243(3,143),W1SQ3(3,3),W2SQ3(3,3),W143B1(143,1),
     C W243B1(143,1),W343B1(143,1),W3B1(3,1),W3BB1(3,1),W3BBB1(3,1),
     C W143SQ(143,143),W243SQ(143,143),W343SQ(143,143),
     C G(3,143,12),SG(3,12),H(143,143),SH(143,1),
     C QK(143,143),Y83(143),Y(143,13),X(3,12),QKK(133)
C
C     DATA Y83 READ IN AS BINARY FROM FORTRAN FILE
C     DATA FROM TSP READ IN AS REAL IN BINARY
C
      REAL INI84(140,140),INI88(140,140),INI92(140,140),
     C MATA1(140,140),MATC1(140,3),MATBB(12,140),
     C  SPSAD(133,12),YY83(133)
C
C     THE A,C,AND B MATRICES ARE DECLARED BELOW
      DOUBLE PRECISION A7(143,143),A9295(143,143),A8891(143,143),
     C A8487(143,143),C7(143,3),C9295(143,3),C8891(143,3),C8487(143,3)
     C SB(143,1),SBD(143,12),SA(143,1),SAD(143,12),
     C A7TT(143,143),C7TT(3,143),ANI84(140,140),ANI88(140,140),
     C ANI92(140,140)
C     DECLARE THE NAG VARIABLES
      DOUBLE PRECISION WKSPCE(3),Z(1)
      INTEGER I,J,K,KY,IFAIL,NOUT,NIN,IA,IUNIT,N,LA,MOVE(143)
C      LOAD IN THE MATRICES
      OPEN (UNIT=10,FILE='INVA84.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (10) ((INI84(I,J), J=1,140),I=1,140)
      OPEN (UNIT=11,FILE='INVA88.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (11) ((INI88(I,J), J=1,140),I=1,140)
      OPEN (UNIT=12,FILE='INVA92.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (12) ((INI92(I,J), J=1,140),I=1,140)
      OPEN (UNIT=17,FILE='FMATA1.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (17) ((MATA1(I,J), I=1,140),J=1,140)
      OPEN (UNIT=18,FILE='FFMATC1.DAT',FORM='UNFORMATTED',STATUS='OLD'
      READ (18) ((MATC1(I,J), J=1,3),I=1,140)
C
      OPEN (UNIT=31,FILE='MMATBB.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (31) ((MATBB(K,I), I=1,140), K=1,12)
      OPEN (UNIT=30,FILE='YY83.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (30) (YY83(I) ,I=1,133)
      OPEN (UNIT=60,FILE='SSPSAD.DAT',FORM='UNFORMATTED',STATUS='OLD')
      READ (60) ((SPSAD(I,K), K=1,12),I=1,133)
      DATA NOUT /6/

      DATA ((SAD(J,K),K=1,12),J=141,143) /
     C 958.7631,959.9376,959.0577,959.1727,961.3162,966.1996,
     C 973.1543,980.9537,988.2503,993.9509,997.6168,999.4138,
     C 381.3954,373.3774,364.0641,354.8643,345.7157,336.8834,
     C 328.3631,320.0238,311.8633,303.8753,296.0643,288.4337,
     C 1105867.4,1189190.9,1273564.9,1358793.8,1444801.4,1531492.4,
     C 1618788.2,1706617.6,1794917.8,1883633.7,1972716.3,2062122.6/
      DATA (Y(I,1),I=134,143) /
     C 497.5984,28689.0,5569.0,9331.0996,148.9478,57569.0,0.01896,
```

```
            C 954.0,390.0,1023306.0/
 C             SSS
               DO 9436 J=1,12
 C               SAD(141,J)= SAD(141,J)+0.0002*SAD(143,J)*0.75
 C               SAD(142,J)= SAD(142,J)+0.0002*SAD(143,J)*0.25
 C               SAD(143,J)=0.8*SAD(143,J)
 C               SAD(141,J)=0.5*SAD(141,J)
 C               SAD(142,J)=0.5*SAD(142,J)
 C               SAD(143,J)=1.5*SAD(143,J)
               SAD(143,J)= SAD(143,J)+200.0*SAD(141,J)+ 200.0*SAD(142,J)
               SAD(141,J)=0.8*SAD(141,J)
               SAD(142,J)=0.8*SAD(142,J)
 9436        CONTINUE
               DO 9445 I=1,133
                 Y(I,1) = YY83(I)
 9445        CONTINUE
 C          FORM MATRIX ANI84,ANI88,ANI92
            IFAIL=0
            CALL F01CAF(W140SQ,140,140,IFAIL)
            DO 7655 I=1,140
               W140SQ(I,I)=1.0
 7655       CONTINUE
            DO 7657 I=1,140
               DO 7658 J=1,140
                  W240SQ(I,J)= INI84(I,J)
 7658          CONTINUE
 7657       CONTINUE

            IFAIL=0
            CALL F01CEF(W340SQ,W140SQ,W240SQ,140,140,IFAIL)
            IFAIL=0

            N=140
            IA=140
            IUNIT =140
            IFAIL =0
            CALL F01AAF(W340SQ,IA,N,ANI84,IUNIT,WKSPCE,IFAIL)
 C          THE INVERSE MATRIX ANI84 IS PREPARED AS ABOVE
            DO 8767 I=1,140
               DO 8768 J=1,140
                  W240SQ(I,J)= INI88(I,J)
 8768          CONTINUE
 8767       CONTINUE

            IFAIL=0
            CALL F01CEF(W340SQ,W140SQ,W240SQ,140,140,IFAIL)
            IFAIL=0

            N=140
            IA=140
            IUNIT =140
            IFAIL =0
            CALL F01AAF(W340SQ,IA,N,ANI88,IUNIT,WKSPCE,IFAIL)
 C          THE INVERSE MATRIX ANI88 IS PREPARED AS ABOVE
            DO 9877 I=1,140
               DO 9878 J=1,140
                  W240SQ(I,J)= INI92(I,J)
```

```
 9878      CONTINUE
 9877   CONTINUE

        IFAIL=0
        CALL F01CEF(W340SQ,W140SQ,W240SQ,140,140,IFAIL)
        IFAIL=0

        N=140
        IA=140
        IUNIT =140
        IFAIL =0
        CALL F01AAF(W340SQ,IA,N,ANI92,IUNIT,WKSPCE,IFAIL)
C       THE INVERSE MATRIX ANI92 IS PREPARED AS ABOVE

C       INITIALISE THE MATRICES AS VECTORS FOR NAG REQUIREMENT
C         CONVERT INTO DOUBLE PRECISION AND EXTEND DIMENSION
C        DO 9876 I=1,133
C        QKK(I) = 11762.25/Y83(I)
C9876    CONTINUE
C        WRITE(NOUT,9875) (QKK(I),I=1,133)
C9875    FORMAT(1H ,8D13.5)

C        DO 1985 I=1,133
C           Y(I,1) = Y83(I)
C1985    CONTINUE
        DO 2001 J=1,3
           DO 2002 I=1,140
              W140B3(I,J)=MATC1(I,J)
 2002      CONTINUE
 2001   CONTINUE
C        CCCC
              W140B3(92,1)=0.000096
              W140B3(93,1)=0.000096
              W140B3(94,1)=0.000096
              W140B3(101,1)=-0.00006
              W140B3(92,2)=0.000096
              W140B3(93,2)=0.000096
              W140B3(94,2)=0.000096
              W140B3(101,2)=-0.00006
C              W140B3(92,1)=-0.000064
C              W140B3(93,1)=-0.000064
C              W140B3(94,1)=-0.000064
C              W140B3(101,1)= 0.00004
C              W140B3(92,2)=-0.000064
C              W140B3(93,2)=-0.000064
C              W140B3(94,2)=-0.000064
C              W140B3(101,2)= 0.00004

          DO 2005 J=1,140
            DO 2006 I=1,140
               W140SQ(I,J)=ANI92(I,J)
 2006       CONTINUE
 2005     CONTINUE
        IFAIL = 0

        CALL F01CKF(W240B3,W140SQ,W140B3,140,3,140,Z,1,1,IFAIL)
```

```
            IFAIL=0
            CALL F01CAF(C9295,143,3,IFAIL)
            CALL F01CMF(W240B3,140,C9295,143,140,3)
              C9295(141,1)= 1.0
              C9295(142,2)= 1.0
              C9295(143,3)=1.0
C           MATRIX C9295 HAS BEEN PREPARED AS ABOVE
            DO 2010 J=1,140
               DO 2011 I=1,140
                  W140SQ(I,J) = ANI88(I,J)
 2011          CONTINUE
 2010       CONTINUE
            IFAIL = 0
            CALL F01CKF(W240B3,W140SQ,W140B3,140,3,140,Z,1,1,IFAIL)
            IFAIL=0
            CALL F01CAF(C8891,143,3,IFAIL)
            CALL F01CMF(W240B3,140,C8891,143,140,3)
              C8891(141,1) = 1.0
              C8891(142,2) = 1.0
              C8891(143,3) = 1.0

               DO 2015 J=1,140
                  DO 2016 I=1,140
                     W140SQ(I,J)= ANI84(I,J)
 2016             CONTINUE
 2015          CONTINUE
            IFAIL = 0
            CALL F01CKF(W240B3,W140SQ,W140B3,140,3,140,Z,1,1,IFAIL)
            IFAIL=0
            CALL F01CAF(C8487,143,3,IFAIL)
            CALL F01CMF(W240B3,140,C8487,143,140,3)
               C8487(141,1) = 1.0
               C8487(142,2) = 1.0
               C8487(143,3) = 1.0
C               VALUES FOR C8891 AND C8487 HAVE NOW BEEN ENTERED
C
C               NOW ENTER VALUES FOR A9295,A8891,A8487
            DO 2025 J= 1,140
               DO 2026 I=1,140
                  W140SQ(I,J) = ANI92(I,J)
                  W240SQ(I,J)= MATA1(I,J)
 2026          CONTINUE
 2025       CONTINUE
            IFAIL=0
            CALL F01CKF(W340SQ,W140SQ,W240SQ,140,140,140,Z,1,1,IFAIL)
            IFAIL=0
            CALL F01CAF(A9295,143,143,IFAIL)
C            A9295(110,141) = -0.4976
C            A9295(111,142) = -0.5315
C            A9295(113,143) = -0.1606

            CALL F01CMF(W340SQ,140,A9295,143,140,140)
C            DO 8344 I=1,7
C            WRITE(NOUT,8345)(A9295(I,J),J=1,143)
C8344         CONTINUE
C8345         FORMAT(1H ,8D13.5)
C            IFAIL=0
```

```
C        CALL F01CAF(B14014,140,12,IFAIL)
         DO 2060 K=1,12
            DO 2061 J=1,140
               B14014(J,K) = MAT88(K,J)
2061        CONTINUE
2060     CONTINUE
        IFAIL=0
        CALL F01CKF(B24014,W140SQ,B14014,140,12,140,Z,1,1,IFAIL)
C         MATRIX A9295 HAS BEEN PREPARED AS ABOVE
C         INCLUDIN PREPARING FOR MATRIX SBD
        DO 2035 J=1,140
           DO 2036 I= 1,140
              W140SQ(I,J)= ANI88(I,J)
2036       CONTINUE
2035    CONTINUE
        IFAIL=0
        CALL F01CKF(W340SQ,W140SQ,W240SQ,140,140,140,Z,1,1,IFAIL)
        IFAIL=0
        CALL F01CAF(A8891,143,143,IFAIL)
C        A8891(110,141) = -0.4976
C        A8891(111,142) = -0.5315
C        A8891(113,143) = -0.1606
        CALL F01CMF(W340SQ,140,A8891,143,140,140)
        IFAIL=0
        CALL F01CKF(B34014,W140SQ,B14014,140,12,140,Z,1,1,IFAIL)

C        NOW PREPARE MATRIX A8487
        DO 2045 J=1,140
           DO 2046 I=1,140
              W140SQ(I,J)= ANI84(I,J)
2046       CONTINUE
2045    CONTINUE
        IFAIL =0
        CALL F01CKF(W340SQ,W140SQ,W240SQ,140,140,140,Z,1,1,IFAIL)
        IFAIL=0
        CALL F01CAF(A8487,143,143,IFAIL)
C        A8487(110,141) = -0.4976
C        A8487(111,142) = -0.5315
C        A8487(113,143) = -0.1606
        CALL F01CMF(W340SQ,140,A8487,143,140,140)
        IFAIL=0
        CALL F01CKF(B44014,W140SQ,B14014,140,12,140,Z,1,1,IFAIL)
        IFAIL=0
        CALL F01CAF(SBD,143,12,IFAIL)
        CALL F01CMF(B24014,140,SBD,143,140,12)
        CALL F01CMF(B34014,140,SBD,143,140,8)
        CALL F01CMF(B44014,140,SBD,143,140,4)
C        DO 8347 I=1,143
C         WRITE(NOUT,8348) (SBD(I,J),J=1,12)
C8347    CONTINUE
C8348    FORMAT(1H ,8D13.5)
C       MATRIX SBD IS NOW READY
C       MATRIX A8487 HAS NOW BEEN PREPARED
C
C       VALUES OF SBD ARE FOUND AS ABOVE
        CALL F01CMF(A9295,143,A7,143,143,143)
C        VALUES OF A7 ARE ENTERED AS ABOVE
```

```
             DO 19 J=1,143
                DO 20 I=1,3
                   C7TT(I,J) = C9295(J,I)
      20        CONTINUE
      19     CONTINUE

             CALL F01CMF(C9295,143,C7,143,143,3)
      C      VALUES FOR C7 PREPARED AS ABOVE
             DO 2075 J=1,143
                DO 2076 I=1,143
                   A7TT(I,J) = A9295(J,I)
      2076      CONTINUE
      2075   CONTINUE

      C        VALUES FOR SPSAD TO BE GENERATED HERE
             DO 2100 K=1,12
                DO 2101 J=1,133
                   SAD(J,K) = SPSAD(J,K)
      2101      CONTINUE
                DO 2103 J=134,140
                   SAD(J,K) = 0.0
      2103      CONTINUE
      2100   CONTINUE
      C       AAAA
             DO 5957 K=1,12
      C       SAD(109,K)=0.97*SAD(109,K)
      C       SAD(106,K)=1.03*SAD(106,K)
      C       SAD(51,K) =0.95*SAD(51,K)
             SAD(109,K)=1.2*SAD(109,K)
             SAD(106,K)=1.03*SAD(106,K)
             SAD(51,K) =1.3*SAD(51,K)
      C       SAD(109,K)=1.4*SAD(109,K)
      C       SAD(106,K)=1.1*SAD(106,K)
      C       SAD(51,K) =1.5*SAD(51,K)
      C       SAD(107,K) =0.5*SAD(107,K)
      5957   CONTINUE
             DO 6788 I=1,143
             WRITE (NOUT,6789)(SAD(I,J),J=1,12)
      6788   CONTINUE
      6789   FORMAT(1H ,8D13.5)

             DO 40 I=1,143
                SB(I,1) = SBD(I,12)
                SA(I,1) = SAD(I,12)
      40     CONTINUE
      C      LOAD IN MATRIX QK AS NULL MATRIX USING NAG
             IFAIL =0
             CALL F01CAF(QK,143,143,IFAIL)
      C      SET RELEVANT VALUES OF QK TO 1.0
      C        DO 7321 I=1,133
      C        QK(I,I) = 0.1*(1.0/SAD(I,12))**2
              QK(109,109) = 1.0*(1.0/SAD(109,12))**2
              QK(106,106) = 1.0*(1.0/SAD(106,12))**2
              QK(51,51) = 1.0*(1.0/SAD(51,12))**2
      C        QK(I,I) = (SAD(109,12)/SAD(I,12))**2
      C7321     CONTINUE
              DO 7322 I=141,143
```

```
C        QK(I,I) = (SAD(109,12)/SAD(I,12))**2
         QK(I,I) = 1.0*(1.0/SAD(I,12))**2
 7322    CONTINUF

C        QK(51,51) =2.1
C        QK(106,106) = 3.8
C        QK(109,109) = 1.0
C           C 1784.5,1755.1,584.0/

C        QK(141,141) = 1.0
C        QK(142,142) = 1.0
C        QK(143,143)= 1.0
C       EQUATE H TO QK
        CALL F01CMF(QK,143,H,143,143,143)
        IFAIL=0
        CALL F01CKF(SH,QK,SA,143,1,143,Z,1,1,IFAIL)
        WRITE (NOUT,6744) (SH(I,1),I=1,143)
 6744   FORMAT(1H ,5D13.5)
C       START THE MAIN LOOP USING KY AS YEAR COUNTER
        DO 30 KY= 12,1,-1
C       ..........................
C           BLOCK ONE: TO DETERMINE GT
C       ..........................
C          MULT C7TT WITH H TO GIVE WM1
        IFAIL = 0
        CALL F01CKF(W3B143,C7TT,H,3,143,143,Z,1,1,IFAIL)
C          MULT W3B143 WITH C7 TO GIVE W1SQ3
        IFAIL = 0
        CALL F01CKF(W1SQ3,W3B143,C7,3,3,143,Z,1,1,IFAIL)
C .        FORM INVERSE OF W1SQ3 AND PUT IN W2SQ3
         WRITE(NOUT,9113)
         WRITE(NOUT,9112) ((W1SQ3(I,J),I=1,3),J=1,3)
        N=3
        IA=3
        IUNIT =3
        IFAIL =0
        CALL F01AAF(W1SQ3,IA,N,W2SQ3,IUNIT,WKSPCE,IFAIL)
C         MULT W2SQ3 WITH W3B143 TO FORM W3B243
        IFAIL =0
        WRITE(NOUT,9114)
        WRITE(NOUT,9111) ((W2SQ3(I,J),I=1,3),J=1,3)
        CALL F01CKF(W3B243,W2SQ3,W3B143,3,143,3,Z,1,1,IFAIL)
C         MULT W3B243 WITH A7 TO GIVE W3B143
        IFAIL=0
        CALL F01CKF(W3B143,W3B243,A7,3,143,143,Z,1,1,IFAIL)
        DO 22 I=1,3
           DO 23 J=1,143
              G(I,J,KY) = -1.0*W3B143(I,J)
 23        CONTINUE
 22     CONTINUE
C       .....................
C          BLOCK TWO: TO DET SGT
C       .........................
C       EQN:- SG83 = -(C9295'H83 C9295)" C9295'(H83 SB83- SH83)
C         MULT H WITH SB TO FORM W143B1
        IFAIL=0
        CALL F01CKF(W143B1,H,SB,143,1,143,Z,1,1,IFAIL)
```

```
              IFAIL=0
      C        SUBTRACT SH FROM W14381 FO FORM W24381
              CALL F01CEF(W24381,W14381,SH,143,1,IFAIL)
              IFAIL=0
              CALL F01CKF(W381,C7TT,W24381,3,1,143,Z,1,1,FAIL)
              IFAIL=0
              CALL F01CKF(W3881,W2SQ3,W381,3,1,3,Z,1,1,IFAIL)
              DO 46 I=1,3
                 W38881(I,1) = -1.0*(W3881(I,1))
                 SG(I,KY) = W38881(I,1)
      46      CONTINUE
      C       .....................
      C        BLOCK THREE: TO DET SHT-1
      C       .....................
      C        EQN:- SH82 = K SA82 - A9295'H83(SB83+ C9295 SG83)+ A9295'SF83
      C        MULT C7 WITH SG IE.W38881 TO GIVE W14381
              IF(KY.EQ.1) GO TO 3099
              IFAIL=0
              CALL F01CKF(W14381,C7,W38881,143,1,3,Z,1,1,FAIL)
      C        ADD SB TO W14381 TO GIVE W24381
              IFAIL=0
              CALL F01CDF(W24381,SB,W14381,143,1,IFAIL)
      C       MULT A7 WITH H TO GIVE W143SQ
              IFAIL=0
              CALL F01CKF(W143SQ,A7TT,H,143,143,143,Z,1,1,IFAIL)
      C        MULT W143SQ WITH W24381 TO GIVE W14381
              IFAIL=0
              CALL F01CKF(W14381,W143SQ,W24381,143,1,143,Z,1,1,IFAIL)
      C       BRING IN SA
              DO 53 I=1,143
                 SA(I,1)= SAD(I,KY-1)
      53      CONTINUE
      C       MULT K WITH SA(T-1) TO GIVE W24381
      C       BUT CHANGE K TO K-1
      C         DO 6321 I=1,133
      C          QK(I,I)= (SAD(109,KY-1)/SAD(I,KY-1))**2
      C          QK(I,I) = 0.1*(1.0/SAD(I,KY-1))**2
               QK(109,109) = 1.0*(1.0/SAD(109,KY-1))**2
               QK(106,106) = 1.0*(1.0/SAD(106,KY-1))**2
               QK(51,51) = 1.0*(1.0/SAD(51,KY-1))**2
      C6321    CONTINUE
               DO 6322 I=141,143
      C         QK(I,I)= (SAD(109,KY-1)/SAD(I,KY-1))**2
               QK(I,I) = 1.0*(1.0/SAD(I,KY-1))**2
      6322    CONTINUE

              IFAIL=0
              CALL F01CKF(W24381,QK,SA,143,1,143,Z,1,1,IFAIL)
      C       SUBTRACT W14381 FROM W24381 TO GIVE W34381
              IFAIL=0
              CALL F01CEF(W34381,W24381,W14381,143,1,IFAIL)
      C
              IFAIL=0
              CALL F01CKF(W14381,A7TT,SH,143,1,143,Z,1,1,IFAIL)
              IFAIL=0
              CALL F01CDF(W24381,W34381,W14381,143,1,IFAIL)
              DO 60 I= 1,143
```

```
            SH(I,1) = W24381(I,1)
   60    CONTINUE
   C     ..............................
   C     BLOCK 4: TO DET HT-1
   C     ..............................
         DO 68 J=1,143
            DO 69 I=1,3
               W38143(I,J) = G(I,J,KY)
   69       CONTINUE
   68    CONTINUE
         IFAIL =0
         CALL F01CKF(W143SQ,C7,W38143,143,143,3,Z,1,1,IFAIL)
         IFAIL =0
         CALL F01CDF(W243SQ,A7,W143SQ,143,143,IFAIL)
         IFAIL=0
         CALL F01CKF(W143SQ,A7TT,H,143,143,143,Z,1,1,IFAIL)
         IFAIL=0
         CALL F01CKF(W343SQ,W143SQ,W243SQ,143,143,143,Z,1,1,IFAIL)
         IFAIL =0
         CALL F01CDF(H,QK,W343SQ,143,143,IFAIL)
   C     THE VALUE OF HT-1 IS DET BY THE LAST CALL
   C     ........................
   C     UPDATE THE INPUT VECTORS FOR NEXT ITERATION
   C     ........................
   C
         DO 400 I=1,143
         SB(I,1) = SBD(I,KY-1)
   400   CONTINUE
   C     UPDATE THE COEFFS A7 AND C7 ETC
         IF (KY-9) 411,412,413
   412   CALL F01CMF(A8891,143,A7,143,143,143)
         DO 420 J=1,143
            DO 421 I=1,143
                     A7TT(I,J) = A8891(J,I)
   421            CONTINUE
   420      CONTINUE
         CALL F01CMF(C8891,143,C7,143,143,3)
         DO 425 J=1,143
            DO 426 I=1,3
               C7TT(I,J) = C8891(J,I)
   426      CONTINUE
   425   CONTINUE
         GO TO 413
   411   IF(KY-5) 413,416,413
   416   CALL F01CMF(A8487,143,A7,143,143,143)
         DO 430 J=1,143
            DO 431 I=1,143
                     A7TT(I,J) = A8487(J,I)
   431            CONTINUE
   430      CONTINUE
         CALL F01CMF(C8487,143,C7,143,143,3)
         DO 435 J=1,143
            DO 436 I=1,3
               C7TT(I,J) = C8487(J,I)
   436      CONTINUE
   435   CONTINUE
```

```
 413   CONTINUE

 30    CONTINUE
 C     ====================
 C     START SECOND LOOP TO DET XT AND YT
 3099     DO 600 KY=1,12
            DO 605 J=1,143
              DO 606 I=1,3
                 W38143(I,J) = G(I,J,KY)
 606          CONTINUE
 605        CONTINUE
       DO 608 I=1,143
          W14381(I,1) = Y(I,KY)
 608   CONTINUE
       IFAIL=0
       CALL F01CKF(W381,W38143,W14381,3,1,143,Z,1,1,IFAIL)
       DO 609 I=1,3
          W3BB1(I,1) = SG(I,KY)
 609   CONTINUE
       IFAIL=0
       CALL F01CDF(W38BB1,W381,W3BB1,3,1,IFAIL)
       DO 610 I=1,3
          X(I,KY) = W38BB1(I,1)
 C      WRITE (NOUT,56789) X(I,KY)
 610   CONTINUE
 C56789  FORMAT(1H ,3D13.5)
 C     ...........
 C     TO DET YT
 C     ...........
 C
       DO 650 I=1,143
          W14381(I,1) = Y(I,KY)
 650   CONTINUE
       IFAIL=0
       CALL F01CKF(W24381,A7,W14381,143,1,143,Z,1,1,IFAIL)
       IFAIL=0
       CALL F01CKF(W14381,C7,W38BB1,143,1,3,Z,1,1,IFAIL)
       IFAIL=0
       CALL F01CDF(W34381,W24381,W14381,143,1,IFAIL)
       DO 655 I=1,143
          W14381(I,1) = SBD(I,KY)
 655   CONTINUE
       IFAIL=0
       CALL F01CDF(W24381,W34381,W14381,143,1,IFAIL)
       DO 670 I=1,143
          Y(I,KY+1)= W24381(I,1)
 670   CONTINUE
        DO 7923 I=1,133
        SUM=SUM+0.1/SAD(I,KY)*(Y(I,KY+1)-SAD(I,KY))**2
 7923   CONTINUE
        DO 7924 I=141,143
        SUM= SUM+10.0/SAD(I,KY)*(Y(I,KY+1)-SAD(I,KY))**2
 7924   CONTINUE
 C     NOW UPDATE A7,AND C7
       IF(KY-4) 711,712,713
 712   CALL F01CMF(A8891,143,A7,143,143,143)
       CALL F01CMF(C8891,143,C7,143,143,3)
```

```
                GO TO 711
        713       IF(KY-8) 711,716,711
        716     CALL F01CMF(A9295,143,A7,143,143,143)
                CALL F01CMF(C9295,143,C7,143,143,3)
                  GO TO 711
        711     CONTINUE
        600     CONTINUE
        C       .................................
        C       END OF LOOP TWO
        C       .................................
        C
                WRITE (NOUT,9200) SUM
                   DO 801 I=1,3
                        WRITE(NOUT,1111) (X(I,KY),KY=1,12)
        801           CONTINUE
                WRITE (NOUT,9202)
                   DO 804 I=1,143
                       WRITE(NOUT,1112) (Y(I,KY),KY=1,13)
        804        CONTINUE
                DO 810 KY=1,12
                WRITE (NOUT,9204) KY
                      DO 812 J=1,3
                         WRITE (NOUT,1113) (G(J,I,KY),I=1,143)
        812           CONTINUE
        810     CONTINUE
        9200    FORMAT(1H ,'SUM = ',D13.5//'MATRIX X'/1X)
        C9200    FORMAT(9HOMATRIX X/1X)
        9202    FORMAT(9HOMATRIX Y/1X)
        9204    FORMAT(9HOMATRIX G,I2/1X)
        9113    FORMAT(9HOMATRIX A/1X)
        9114    FORMAT(10HOMATRIX AI/1X)
        9112    FORMAT(1H ,3D13.5)
        9111    FORMAT(1H ,3D13.5)
        1111    FORMAT(1H ,5D13.5)
        1112    FORMAT(1H ,8D13.5)
        1113    FORMAT(1H ,8D13.5)
                END
```

	GDPC(-1)	PPRIMIR(-1)	YAC(-1)	MSQ(-1)	FPDIC(-1)	GFDDEBC(-1)	WGRIR(-1)	WGRIR(-2)
1988	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1989	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1990	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1991	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1992	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1993	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1994	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000
1995	72000.00000	105.00000	27500.00000	45000.00000	6000.00000	33000.00000	0.02000	0.02000

	VAGDPNA(-1)	WGRR(-1)	LABNAGR(-1)	PXRUB1(-1)	PXRUBS(-1)	PXPALM(-1)	PXSLUG(-1)	PXSTIM(-1)
1984	23982.00000	0.34494	3500.29980	2472.00000	2384.89990	1129.80005	149.00000	390.70001
1985	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1986	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1987	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1988	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1989	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1990	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1991	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1992	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1993	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1994	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000
1995	25000.00000	0.40000	3600.00000	2200.00000	2100.00000	1000.00000	165.00000	360.00000

	[illegible](-1)	WGRI(-1)	PXMFGI(-1)	PXSERI(-1)	PCI(-1)	PCOPRI(-1)	PIMI(-1)	IMTXDF(-1)
1984	[illegible]	4.13925	325.68298	216.72539	216.10001	[illegible]	276.29999	187.03810
1985	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1986	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1987	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1988	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1989	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1990	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1991	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1992	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1993	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1994	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000
1995	24000.00000	5.00000	360.00000	220.00000	210.00000	205.00000	260.00000	200.00000

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	URUBSS	MARUBSH	TIME	DUM7588	ETRFRBS	MARUBES	ETRFRB1	MAPALM
1984	60.90650	958.76506	25.00000	1.00000	0.00000	381.39536	0.00000	1105867.37500
1985	60.77880	959.93762	26.00000	1.00000	0.00000	373.37755	0.00000	1189190.75000
1986	60.65110	959.05774	27.00000	0.00000	0.00000	364.06406	0.00000	1273564.87500
1987	60.52340	959.17273	28.00000	0.00000	0.00000	354.86432	0.00000	1358793.75000
1988	60.39570	961.31616	29.00000	1.00000	0.00000	345.71573	0.00000	1444801.37500
1989	60.26800	966.19958	30.00000	1.00000	0.00000	336.88333	0.00000	1531492.37500

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	ORUBSS	MARUBSH	TIME	DUM7388	ETRFRB3	MARUBES	ETRFRB1	MAPALM
1990	60.14030	973.15430	31.00000	1.00000	0.00000	328.36310	0.00000	1618788.25000
1991	60.01260	980.95367	32.00000	1.00000	0.00000	320.02383	0.00000	1706617.50000
1992	59.88490	986.25031	33.00000	1.00000	0.00000	311.86334	0.00000	1794917.87500
1993	59.75720	993.95087	34.00000	1.00000	0.00000	303.87534	0.00000	1883633.75000
1994	59.62950	997.61682	35.00000	1.00000	0.00000	296.06433	0.00000	1972716.25000
1995	59.50180	999.41376	36.00000	1.00000	0.00000	288.43369	0.00000	2062122.50000

	DUM82	DUM7883	ETRFPO	DUM83	ETRFSTC	DUM7475	DUM7780	ETRFSLC
1984	0.00000	0.00000	0.00000	1.00000	0.03000	0.00000	0.00000	0.00100
1985	0.00000	0.00000	0.00000	1.00000	0.03000	0.00000	0.00000	0.00100
1986	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00100
1987	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1988	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1989	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1990	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1991	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1992	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1993	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1994	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000
1995	0.00000	0.00000	0.00000	0.00000	0.03000	0.00000	0.00000	0.00000

	POPMSIA	DUMDR78	DUMSD81	PXRICEP	[illegible]	[illegible]	GPETQ	ETRFTIN
1984	15260.00000	0.00000	1.00000	46.29000	40.00000	35.00000	129322.26563	0.04000
1985	15626.00000	0.00000	1.00000	46.29000	28.00000	32.00000	137993.21875	0.04000
1986	15966.00000	0.00000	1.00000	46.29000	13.00000	25.00000	146664.18750	0.04000
1987	16338.00000	0.00000	1.00000	52.00000	[illegible]	20.00000	155335.14063	0.04000
1988	16681.00000	0.00000	1.00000	52.00000	20.00000	20.00000	164006.10938	0.04000
1989	17014.00000	0.00000	1.00000	52.00000	20.00000	25.00000	172677.06250	0.04000
1990	17338.00000	0.00000	1.00000	55.00000	20.00000	30.00000	181348.03125	0.04000
1991	17650.00000	0.00000	1.00000	55.00000	20.00000	35.00000	190018.98438	0.04000
1992	17950.00000	0.00000	1.00000	62.00000	20.00000	40.00000	198689.93750	0.04000
1993	18237.00000	0.00000	1.00000	62.00000	20.00000	40.00000	207360.90625	0.04000
1994	18570.00000	0.00000	1.00000	65.00000	20.00000	40.00000	216031.85938	0.04000
1995	18786.00000	0.00000	1.00000	65.00000	20.00000	45.00000	224702.82813	0.04000

	DUM7683	DUM7683(-1)	DUM7576	DUM7576(-1)	VAIBSR	INRA	GFIRC	CUTAREA
1984	0.00000	1.00000	0.00000	0.00000	633.49542	12.49680	4228.33057	0.00000
1985	0.00000	0.00000	0.00000	0.00000	675.73279	12.86340	4564.06006	0.00000
1986	0.00000	0.00000	0.00000	0.00000	717.97021	13.23000	4899.79004	0.00000
1987	0.00000	0.00000	0.00000	0.00000	760.20758	13.59660	5235.51953	0.00000
1988	0.00000	0.00000	0.00000	0.00000	802.44501	13.96320	5571.24951	0.00000
1989	0.00000	0.00000	0.00000	0.00000	844.68237	14.32980	5906.97900	0.00000
1990	0.00000	0.00000	0.00000	0.00000	886.91980	14.69640	6242.70898	0.00000
1991	0.00000	0.00000	0.00000	0.00000	929.15723	15.06300	6578.43848	0.00000

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	DUM7683	DUM7683(-1)	DUM7576	DUM7576(-1)	VAIBBR	INRA	GFTRC	CUTAREA
1992	0.00000	0.00000	0.00000	0.00000	971.39459	15.42960	6914.16797	0.00000
1993	0.00000	0.00000	0.00000	0.00000	1013.63202	15.79620	7249.89795	0.00000
1994	0.00000	0.00000	0.00000	0.00000	1055.86938	16.16280	7585.62744	0.00000
1995	0.00000	0.00000	0.00000	0.00000	1098.10681	16.52940	7921.35742	0.00000

	CUTAREA(-1)	CUTAREA(-2)	MLONBKC	FPNETR	DUM8083	DUM6070	DUM7175	IMPPETQ
1984	0.00000	0.00000	25688.54688	-1358.79211	1.00000	0.00000	0.00000	3670.21631
1985	0.00000	0.00000	27699.38672	-1439.92627	1.00000	0.00000	0.00000	3741.58032
1986	0.00000	0.00000	29710.22461	-1521.06030	0.00000	0.00000	0.00000	3812.94434
1987	0.00000	0.00000	31721.06250	-1602.19446	0.00000	0.00000	0.00000	3884.30835
1988	0.00000	0.00000	33731.90234	-1683.32849	0.00000	0.00000	0.00000	3955.67236
1989	0.00000	0.00000	35742.74219	-1764.46265	0.00000	0.00000	0.00000	4027.03638
1990	0.00000	0.00000	37753.57813	-1845.59668	0.00000	0.00000	0.00000	4098.40039
1991	0.00000	0.00000	39764.41797	-1926.73083	0.00000	0.00000	0.00000	4169.76465
1992	0.00000	0.00000	41775.25781	-2007.86499	0.00000	0.00000	0.00000	4241.12842
1993	0.00000	0.00000	43786.09375	-2088.99902	0.00000	0.00000	0.00000	4312.49219
1994	0.00000	0.00000	45796.93359	-2170.13306	0.00000	0.00000	0.00000	4383.85645
1995	0.00000	0.00000	47807.77344	-2251.26733	0.00000	0.00000	0.00000	4455.22021

	OPETQ(-1)	DUM6070(-1)	DUM7175(-1)	IMPPETQ(-1)	GDPUSC	INRBOND(-1)	DUM7483	DUM8283
1984	120450.00000	0.00000	0.00000	3600.00000	3191.00000	11.67000	1.00000	1.00000
1985	129322.26563	0.00000	0.00000	3670.21631	3288.00000	10.00000	1.00000	1.00000
1986	137993.21875	0.00000	0.00000	3741.58032	3386.00000	10.00000	0.00000	0.00000
1987	146664.18750	0.00000	0.00000	3812.94434	3468.00000	10.00000	0.00000	0.00000
1988	155332.14063	0.00000	0.00000	3884.30835	3592.00000	10.00000	0.00000	0.00000
1989	164002.10938	0.00000	0.00000	3955.67236	3700.00000	10.00000	0.00000	0.00000
1990	172677.06250	0.00000	0.00000	4027.03638	3811.00000	10.00000	0.00000	0.00000
1991	181348.03125	0.00000	0.00000	4098.40039	3926.00000	10.00000	0.00000	0.00000
1992	190018.98438	0.00000	0.00000	4169.76465	4043.00000	10.00000	0.00000	0.00000
1993	198689.93750	0.00000	0.00000	4241.12842	4165.00000	10.00000	0.00000	0.00000
1994	207360.90625	0.00000	0.00000	4312.49219	4290.00000	10.00000	0.00000	0.00000
1995	216031.85938	0.00000	0.00000	4383.85645	4420.00000	10.00000	0.00000	0.00000

	INRBOND(-2)	DUM7483(-1)	DUM8283(-1)	EXPENGC	EXPOTC	EXPTINQ	EXPRESC	MTRFF
1984	10.54780	1.00000	1.00000	1000.00000	5870.29443	46.00000	5917.01904	0.08000
1985	11.67000	1.00000	1.00000	1100.00000	6305.71094	34.00000	6357.70361	0.08000
1986	10.00000	1.00000	1.00000	1200.00000	6741.12744	19.00000	6798.38818	0.08000
1987	10.00000	0.00000	0.00000	1300.00000	7176.54395	23.00000	7239.07275	0.09000
1988	10.00000	0.00000	0.00000	1400.00000	7611.96045	24.00000	7679.75732	0.09000
1989	10.00000	0.00000	0.00000	1400.00000	8047.37695	24.00000	8120.44189	0.10000
1990	10.00000	0.00000	0.00000	1400.00000	8482.79395	24.00000	8561.12598	0.10000
1991	10.00000	0.00000	0.00000	1500.00000	8918.20996	24.00000	9001.81152	0.10000
1992	10.00000	0.00000	0.00000	1500.00000	9353.62695	24.00000	9442.49609	0.10000
1993	10.00000	0.00000	0.00000	1500.00000	9789.04297	24.00000	9883.18066	0.10000
1994	10.00000	0.00000	0.00000	1500.00000	10224.45996	24.00000	10323.86523	0.10000
1995	10.00000	0.00000	0.00000	1500.00000	10659.87598	24.00000	10764.54980	0.10000

	DUM75	DUM6972	MTRFF(-1)	DUM6972(-1)	DUM8083(-1)	IMPREB	IMPFREX	PLANTAR
1984	0.00000	0.00000	0.08434	0.00000	1.00000	-205.91943	406.52710	10685.51660
1985	0.00000	0.00000	0.08000	0.00000	1.00000	-250.25243	421.21170	11396.94727
1986	0.00000	0.00000	0.08000	0.00000	1.00000	-294.58542	435.89630	12108.37793
1987	0.00000	0.00000	0.08000	0.00000	0.00000	-338.91843	450.58090	12819.80957
1988	0.00000	0.00000	0.09000	0.00000	0.00000	-383.25143	465.26550	13531.24023
1989	0.00000	0.00000	0.09000	0.00000	0.00000	-427.58444	479.95010	14242.67090
1990	0.00000	0.00000	0.10000	0.00000	0.00000	-471.91742	494.63470	14954.10156
1991	0.00000	0.00000	0.10000	0.00000	0.00000	-516.25043	509.31931	15665.53223
1992	0.00000	0.00000	0.10000	0.00000	0.00000	-560.58344	524.00391	16376.96289
1993	0.00000	0.00000	0.10000	0.00000	0.00000	-604.91644	538.68848	17088.39453
1994	0.00000	0.00000	0.10000	0.00000	0.00000	-649.24945	553.37311	17799.82422
1995	0.00000	0.00000	0.10000	0.00000	0.00000	-693.58246	568.05768	18511.25586

	PLANTAR(-1)	PLANTAR(-2)	TEPFPOS	DUM78	NTAX	OTASBNC	PRFCOPC	DTOTH
1984	8586.00000	8485.00000	1609.35083	0.00000	2419.33472	0.00000	4123.29980	553.34351
1985	10685.51660	8586.00000	1732.45679	0.00000	2600.26709	0.00000	3717.80005	597.83215
1986	11396.94727	10685.51660	1855.56262	0.00000	2781.19946	0.00000	4070.89990	642.32074
1987	12108.37793	11396.94727	1978.66858	0.00000	2962.13159	0.00000	4319.79980	686.80933
1988	12819.80957	12108.37793	2101.77441	0.00000	3143.06396	0.00000	4836.70020	731.29791
1989	13531.24023	12819.80957	2224.88037	0.00000	3323.99634	0.00000	4850.00000	775.78656
1990	14242.67090	13531.24023	2347.98633	0.00000	3504.92847	0.00000	4850.00000	820.27515
1991	14954.10156	14242.67090	2471.09229	0.00000	3685.86084	0.00000	4850.00000	864.76373
1992	15665.53223	14954.10156	2594.19800	0.00000	3866.79321	0.00000	4850.00000	909.25232
1993	16376.96289	15665.53223	2717.30396	0.00000	4047.72534	0.00000	4850.00000	953.74097
1994	17088.39453	16376.96289	2840.40991	0.00000	4228.65771	0.00000	4850.00000	998.22955
1995	17799.82422	17088.39453	2963.51587	0.00000	4409.58984	0.00000	4850.00000	1042.71814

	DUM71BC	TIDOTH	ANARUB(-3)	ANARUB(-4)	ANARUB(-5)	ANARUB(-6)	ANARUB(-7)	ANARUB(-8)
1984	1.00000	1156.38379	41207.00000	39371.00000	34256.00000	43053.00000	29795.00000	23677.00000
1985	1.00000	1231.91589	35735.00000	41207.00000	39371.00000	34256.00000	43053.00000	29795.00000
1986	0.00000	1307.44800	33359.00000	35735.00000	41207.00000	39371.00000	34256.00000	43053.00000
1987	0.00000	1382.98010	0.00000	33359.00000	35735.00000	41207.00000	39371.00000	34256.00000
1988	0.00000	1458.51221	0.00000	0.00000	33359.00000	35735.00000	41207.00000	39371.00000
1989	0.00000	1534.04431	0.00000	0.00000	0.00000	33359.00000	35735.00000	41207.00000
1990	0.00000	1609.57642	0.00000	0.00000	0.00000	0.00000	33359.00000	35735.00000
1991	0.00000	1685.10852	0.00000	0.00000	0.00000	0.00000	0.00000	33359.00000
1992	0.00000	1760.64063	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1993	0.00000	1836.17273	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1994	0.00000	1911.70483	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1995	0.00000	1987.23694	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

	ANARUB(-9)	ANARUB(-10)	ANARUB(-11)	ANARUB(-12)	ANARUB(-13)	CUTAREA(-3)	CUTAREA(-4)	CUTAREA(-5)
1984	41225.00000	34242.00000	54294.00000	48275.00000	37728.00000	0.00000	0.00000	0.00000
1985	23677.00000	41225.00000	34242.00000	54294.00000	48275.00000	0.00000	0.00000	0.00000

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	ANARUB(-9)	ANARUB(-10)	ANARUB(-11)	ANARUB(-12)	ANARUB(-13)	CUTAREA(-3)	CUTAREA(-4)	CUTAREA(-5)
1986	29795.00000	23677.00000	41225.00000	34242.00000	54294.00000	0.00000	0.00000	0.00000
1987	43053.00000	29795.00000	23677.00000	41225.00000	34242.00000	0.00000	0.00000	0.00000
1988	34256.00000	43053.00000	29795.00000	23677.00000	41225.00000	0.00000	0.00000	0.00000
1989	39371.00000	34256.00000	43053.00000	29795.00000	23677.00000	0.00000	0.00000	0.00000
1990	41207.00000	39371.00000	34256.00000	43053.00000	29795.00000	0.00000	0.00000	0.00000
1991	35735.00000	41207.00000	39371.00000	34256.00000	43053.00000	0.00000	0.00000	0.00000
1992	33359.00000	35735.00000	41207.00000	39371.00000	34256.00000	0.00000	0.00000	0.00000
1993	0.00000	33359.00000	35735.00000	41207.00000	39371.00000	0.00000	0.00000	0.00000
1994	0.00000	0.00000	33359.00000	35735.00000	41207.00000	0.00000	0.00000	0.00000
1995	0.00000	0.00000	0.00000	33359.00000	35735.00000	0.00000	0.00000	0.00000

	CUTAREA(-6)	CUTAREA(-7)	CUTAREA(-8)	CUTAREA(-9)	CUTAREA(-10)	CUTAREA(-11)	CUTAREA(-12)	CUTAREA(-13)
1984	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1985	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1986	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1987	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1988	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1989	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1990	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1991	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1992	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1993	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1994	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1995	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

	GFFREC	BSPERUM	BPSDR	BPI[illegible]	DUM73	DUM74	REDLONC	DUM6970
1984	5000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	-50.00000	0.00000
1985	5000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	-50.00000	0.00000
1986	5500.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1987	6000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1988	6000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1989	4000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1990	4000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1991	3000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1992	4000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1993	4000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1994	4000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
1995	4000.00000	300.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

	WRSS1E	WRSS1E(-1)	WRSS3E	WRSS3E(-1)	WPALME	WPALME(-1)	WPSLGE	WPSLGE(-1)
1984	2766.00000	3081.51196	2700.00000	2996.41895	1200.00000	1204.24048	251.00000	241.74182
1985	2395.00000	2766.00000	2300.00000	2700.00000	850.00000	1200.00000	248.00000	251.00000
1986	2563.00000	2395.00000	2490.00000	2300.00000	900.00000	850.00000	262.00000	248.00000
1987	2742.00000	2563.00000	2680.00000	2490.00000	900.00000	900.00000	277.00000	262.00000

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		WRSS1E	WRSS1E(-1)	WRSS3E	WRSS3E(-1)	WPALME	WPALME(-1)	WPSLGE	WPSLGE(-1)
1988	!	2934.00000	2742.00000	2830.00000	2680.00000	950.00000	900.00000	293.00000	277.00000
1989	!	3140.00000	2934.00000	3070.00000	2830.00000	950.00000	950.00000	310.00000	293.00000
1990	!	3359.00000	3140.00000	3260.00000	3070.00000	1000.00000	950.00000	328.00000	310.00000
1991	!	3595.00000	3359.00000	3500.00000	3260.00000	1000.00000	1000.00000	346.00000	328.00000
1992	!	3235.00000	3595.00000	3190.00000	3500.00000	1000.00000	1000.00000	366.00000	346.00000
1993	!	3235.00000	3235.00000	3180.00000	3190.00000	1000.00000	1000.00000	387.00000	366.00000
1994	!	3397.00000	3235.00000	3299.00000	3180.00000	1000.00000	1000.00000	409.00000	387.00000
1995	!	3567.00000	3397.00000	3480.00000	3299.00000	1000.00000	1000.00000	432.00000	409.00000

		WPSTME	WPSTME(-1)	WPTINE	WPTINE(-1)	WEXPIE	WPRIME	WPMFGIE
1984	!	533.00000	512.80481	30279.00000	32315.44336	234.00000	299.00000	371.00000
1985	!	526.00000	533.00000	29189.00000	30279.00000	232.00000	296.00000	369.00000
1986	!	556.00000	526.00000	23351.00000	29189.00000	241.00000	296.00000	381.00000
1987	!	588.00000	556.00000	24518.00000	23351.00000	253.00000	313.00000	400.00000
1988	!	621.00000	588.00000	25745.00000	24518.00000	266.00000	331.00000	420.00000
1989	!	657.00000	621.00000	27032.00000	25745.00000	279.00000	349.00000	441.00000
1990	!	695.00000	657.00000	28383.00000	27032.00000	293.00000	369.00000	463.00000
1991	!	625.00000	695.00000	29802.00000	28383.00000	308.00000	332.00000	487.00000
1992	!	625.00000	625.00000	31293.00000	29802.00000	323.00000	332.00000	570.00000
1993	!	660.00000	625.00000	32857.00000	31293.00000	339.00000	352.00000	536.00000
1994	!	698.00000	660.00000	34500.00000	32857.00000	356.00000	372.00000	563.00000
1995	!	738.00000	698.00000	36915.00000	34500.00000	374.00000	393.00000	591.00000

THE SOLVED VARIABLES WERE STORED WITH A TAG: K

APPENDIX D: LINEARIZATION PROCEDURE FOR NONLINEAR EQUATIONS

For f(x,y), Taylor's series is

$$f(x,y) = f(a,b) + f_x(a,b)(x-a) + f_y(a,b)(y-b) + R_z(x,y)$$

where the term

$$R_z(x,y) = \frac{f_{x,x}(w,m)(x-a)^2}{2} + \frac{f_{y,y}(w,m)(y-b)^2}{2} + f_{x,y}(w,m)(x-a)(y-b)$$

will be ignored.

For $f(x,y) = A\ x\ y^{-1}$, $f_x = A\ y^{-1}$ $f_y = -\ A\ x\ y^{-2}$

$a = x_0$, $b = y_0$

$$\begin{aligned}
f(x,y) &= f(x_0,y_0) + f_x(x_0,y_0)(x-x_0) + f_y(x_0,y_0)(y-y_0) \\
&= Ax_0y_0^{-1} + Ay_0^{-1}(x-x_0) - Ax_0\ y_0^2(y-y_0) \\
&= Ax_0y_0^{-1} + Ay_0^{-1}x - Ax_0y_0^{-1} - Ax_0y_0{-2}y + Ax_0y_0{-1} \\
&= Ax_0y_0^{-1} + Ay_0^{-1}x - Ax_0y_0^{-2}y \\
&= A[(x_0/y_0) + (1/y_0)x - (x_0/y_0^2)y]
\end{aligned}$$