WORLD RUBBER MARKET STRUCTURE AND STABILISATION:

AN ECONOMETRIC STUDY

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DECLARATION

Except where otherwise indicated, this thesis is my own work.

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ABSTRACT

This study examines some problems in the market for natural rubber, one of the ten core commodities proposed for stabilisation by a Common Fund to be established under the Integrated Programme for Commodities.

The first part of this study is concerned with the specification, estimation and validation of an econometric model of the world natural and synthetic rubbers market. The highly disaggregated annual model for 1956-1978 consists of two submodels, one for each rubber and reflecting their different industrial organisations. Other salient features of the model are the long lagged structures and the interaction between the submodels through relative rubber prices in the demand equations. The model validation shows that the secular decline in natural rubber price up to 1973 was due primarily to the substitution of natural rubber by the cheaper synthetic rubbers and the falling natural rubber share.

The second part of this study concerns the application of the model to forecast natural rubber price and to analyse the implications of natural rubber stabilisation along the lines of the International Natural Rubber Agreement. The impact of national government interventions in world commodity markets was also illustrated by an examination of the impact of changing Malaysian export taxes.

Ex post and *ex ante* simulations of buffer stock stabilisation all showed the importance of the manner in which the buffer stock is operated. The results also show that stabilisation will have different effects for the producing and consuming countries and thus raise the question of funding of the buffer stocks.

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CHAPTER ONE

INTRODUCTION

1.1 Problems of the World Rubber Market

The question of price and export instability of primary commodities has occupied economists for a long time. More recently, the UNCTAD proposal for an Integrated Programme for Commodities has caused renewed interest in this problem and precipitated further empirical and theoretical studies of this issue.

The maintenance of interest in the problem of commodity market instability stems largely from the fact that many developing countries are known to be dependent on the export earnings of one or two commodities only. The problem of price and export instability is therefore particularly crucial for the major suppliers because of their reliance on commodity exports for foreign exchange earnings.

Two types of problems caused by price and export instability may be distinguished. At the micro level, commodity instability affects employment and producers' earnings and investment in the commodity concerned. At the macro level, export earnings from primary commodities often form the main source of foreign exchange funds for imports of investment goods required for development purposes. The export instability therefore causes financial bottlenecks which hinder the implementation of overall development plans. Furthermore, it has also been argued that the micro level problems caused by export instability are in fact greater than those suggested by the direct impact, because of the associated indirect input demand and multiplier effects on the rest of the economy and hence on overall investment.

The problems of export instability are relevant to natural rubber, production of which is concentrated in the South and Southeast Asian countries of Indonesia, Malaysia, Sri Lanka and Thailand. For all of these countries, natural rubber is a major source of export earnings and export tax revenue. Furthermore, as natural rubber production is particularly labour-intensive, the industry is also an important provider of employment.

The problem of natural rubber market instability became more complicated after the sale in 1955 of the US government-owned synthetic rubber production capacities to the private sector. The subsequent dynamic growth of the synthetic rubber industry also led to increased competition between natural and synthetic rubbers. This increased competition between the two types of rubbers from 1956 to the first oil crisis in late 1973 was manifested in the continual decline of the long-run natural rubber price and natural rubber share of consumption.

This study therefore sets out to examine the problems of the natural rubber market with the primary focus on market instability. An econometric model of the world market is estimated from data covering the 1956-1978 period. Such a model facilitates analysis of the market instability as well as the observed long-run decline in natural rubber price and consumption share during the historical period. The model is used to forecast future natural rubber prices under a given oil price scenario; subsequently, price stabilisation schemes under the International Natural Rubber Agreement are evaluated.

The model can also be used for other purposes, viz. the impact of national government market interventions. In this study the case of Malaysian export taxes on natural rubber is chosen. The incorporation of Malaysian export taxes on natural rubber in the model enables evaluation of the effects of variations in export tax rates on Malaysian production of rubber and world rubber price and hence on world production and consumption of rubber and market instability. This evaluation of Malaysian export taxes is an example of the effects on the world market of removing an existing intervention in the market by a national government.

1.2 Background to the World Rubber Market

Natural rubber has been known as an industrial raw material since the last century. However, its importance to the modern industrial economy (via the tyre industry) has occurred only since the worldwide popularisation of road (private and commercial) and air transport, especially in the industrialised countries. A crucial aspect of the postwar transport industry's impressive growth is its interdependence with the rates of growth of natural rubber, oil and synthetic rubber industries. The long production gestation lag and accompanying geographic concentration of natural rubber production encouraged the rapid development of the synthetic rubber industry. Thus a study of the natural rubber market involves a study of the inter-relations between three commodities: natural rubber, oil and the synthetic rubbers.

By the nature of agronomy, technology, location factors, market structures and economic behaviour, any exogenous shock to the natural rubber-oil-synthetic rubber system has tended, in general, to produce both positive and negative consequences for natural rubber due to substitution and income effects. This can be seen, for example, in the short-run effects of a change in oil price, an important variable in the competition between natural rubber and the oil-based synthetic rubbers. Ceteris paribus, higher oil price results on the one hand in increased natural rubber consumption (via substitution of synthetic rubber by natural rubber) while on the other hand higher oil price causes a fall in natural rubber consumption (through a decline in transport demand and hence tyre consumption). Similarly, the offsetting effects of technology on natural rubber consumption is illustrated by the introduction in the early 1960s of radial tyres, which have a higher natural rubber content per tyre than the conventional cross-ply tyres. Production of radial tyres in each period should result in increased natural rubber consumption. But radial tyres are known to be longer lasting than cross-ply tyres.[1]

[1] Although radial tyres have been quoted to be longer-wearing than cross-ply tyres by 30 to 80 percent, this feature is still being tested by the tyre industry for a more precise figure (Billet, 1981).

Under a given demand for tyres and a constant rate of tyre utilisation, the demand for natural rubber over time may decline if existing cross-ply tyres are gradually replaced by the longer-lasting radial tyres. The net effect of radial tyres on natural rubber consumption therefore depends on the trade-off between increased natural rubber consumption and the increased mileage per radial tyre. These examples illustrate the complex relationships influencing the two basic components of natural rubber demand: that of essential demand for natural rubber versus that of competitive demand between natural rubber and synthetic rubbers. The question therefore is whether the observed volatility of natural rubber price can be explained by the interaction of these two demand components with natural and synthetic rubber supply variations.

1.3 Falling Natural Rubber Market Share and Instability

The two components of demand for natural rubber mean that this demand cannot be divorced from (a) the overall demand for elastomers and (b) the demand for synthetic rubbers. An overview of the interaction of the natural and synthetic rubber markets is therefore pertinent to an understanding of the natural rubber market. The salient features of this interaction will now be briefly discussed.

Tables 1.1 and 1.2 show the volumes and distribution of world production and consumption of natural and synthetic rubbers respectively, for the period between 1956 and 1978. From the Tables,

Table 1.1: Production of Natural Rubber and Synthetic Rubbers, 1956-1978 (thousand tonnes)

Year	Natural Rubber	Synthetic Rubbers	Total
1956	1922.8 (60.9)	1230.4 (39.1)	3153.2 (100.0)
1960	2021.8 (51.4)	1910.1 (48.6)	3931.9 (100.0)
1965	2380.0 (43.7)	3060.7 (56.3)	5440.7 (100.0)
1970	3102.5 (34.4)	5892.5 (65.6)	8995.0 (100.0)
1975	3315.0 (32.5)	6855.0 (67.5)	10170.0 (100.0)
1978	3755.0 (29.7)	8850.0 (70.3)	12605.0 (100.0)

Source: Rubber Statistical Bulletin, various issues.

Note: Figures in parentheses denote percentages of the corresponding totals.

Table 1.2: Consumption of Natural Rubber and Synthetic Rubbers, 1956-1978 (thousand tonnes)

Year	Natural Rubber	Synthetic Rubbers	TOTAL
1956	1907.5 (62.3)	1153.2 (37.6)	3060.7 (100.0)
1960	2098.0 (53.4)	1826.3 (46.6)	3924.3 (100.0)
1965	2420.6 (44.4)	3020.1 (55.6)	5440.7 (100.0)
1970	2990.0 (34.6)	5635.0 (65.4)	8625.0 (100.0)
1975	3367.5 (32.3)	7027.5 (67.7)	10395.0 (100.0)
1978	3725.0 (29.8)	8755.0 (70.2)	12480.0 (100.0)

Source: *Rubber Statistical Bulletin*, various issues.

Note: Figures in parentheses denote percentages of the corresponding totals.

two features are seen to predominate:

(i) Based on four- to five-year intervals, the rate of growth in world production and consumption of elastomers was fastest during the sixties, especially during the second half (1965-1970).

(ii) In both production and consumption, the rate of growth for synthetic rubbers in each time interval was twice to five times as high as the corresponding rates for natural rubber. Obviously the dominant position of synthetic rubbers in the elastomer market was established during the sixties. This has also caused a reversal in the consumption shares of natural rubber and synthetic rubbers between 1956 and 1978. During this period, natural rubber's share of total elastomer consumption fell from 62.3 percent in 1956 to 29.8 percent in 1978; in contrast, synthetic rubbers' share rose from 37.6 percent to 70.2 percent. These consumption share figures, which approximate the respective rubber production shares, reinforce the argument that natural rubber demand should be analysed in the context of overall demand for elastomers.

Since natural rubber is an industrial commodity in its end uses, a pertinent question is the extent to which demand are concentrated within the industrialised countries. Table 1.3 shows the distribution of natural rubber consumption between the main industrial countries (of France, West Germany, Italy, Japan, UK and USA) and the rest-of-the-world. Although consumption in these countries dominate world natural rubber consumption, their shares have been declining,

Table 1.3: Distribution of Natural Rubber Consumption, 1956-1978 (thousand tonnes)

Year	Major Industrialised Countries	Rest-of-the-World	TOTAL
1956	1190.3 (62.4)	717.0 (37.6)	1907.5 (100.0)
1960	1222.5 (58.2)	875.5 (41.8)	2098.0 (100.0)
1965	1278.5 (52.8)	1142.1 (47.2)	2420.6 (100.0)
1970	1518.4 (50.7)	1471.6 (49.3)	2990.0 (100.0)
1975	1593.0 (47.3)	1774.5 (52.7)	3367.5 (100.0)
1978	1716.7 (46.0)	2008.3 (54.0)	3725.0 (100.0)

Source: Rubber Statistical Bulletin, various issues.

Note: Figures in parentheses denote percentages of corresponding totals.

albeit gradually, from 58.2 percent in 1960 to 46.0 percent in 1978.[2] A sectoral breakdown of natural rubber consumed in the major industrial countries is presented in Table 1.4 and shows that natural rubber demand is concentrated largely in the transport sector whose share of consumption has grown from 58.8 percent in 1960 to 72.3 percent in 1978. Clearly this growth in transport sector demand is due to the growth of the road transport industry in the postwar period. Tables 1.3 and 1.4 thus emphasise the influence of industrial activity -- especially that of transport -- of the industrialised countries on the natural rubber market.

The interaction between natural and synthetic rubbers and the influence of industrial (especially transport sector) activity on the elastomer market can be seen from the behaviour of elastomer prices. Figure 1.1 illustrate the time paths of natural and synthetic rubber prices during 1956 to 1978; these prices refer to c.i.f. New York price for RSS1-grade natural rubber and the unit export value for styrene-butadiene, the most widely used synthetic rubber. Figure 1.1 reveals three features:

(a) the similarity in the price trends;

(b) the well-defined falling trend in prices during 1960-1972 which has been shown to contain the period of fastest growth in elastomer production and consumption;

2 As 1956 sectoral figures for Japan are not available, the figures here relate to the situation from 1960 onwards.

Table 1.4: Natural Rubber Consumption by Sector in Major Industrialised Countries, 1956-1978 (thousand tonnes)

Year	Transport	Non-Transport	TOTAL
1956	-	-	1190.3 (100.0)
1960	720.0 (58.8)	502.5 (41.2)	1222.5 (100.0)
1965	757.4 (59.2)	521.1 (40.8)	1278.5 (100.0)
1970	928.5 (61.1)	590.0 (38.9)	1518.4 (100.0)
1975	1082.4 (67.9)	510.5 (32.1)	1593.0 (100.0)
1978	1241.9 (72.3)	474.8 (27.7)	1716.7 (100.0)

Source: Rubber Statistical Bulletin, various issues.

Note: Figures in parentheses denote percentages of corresponding totals.

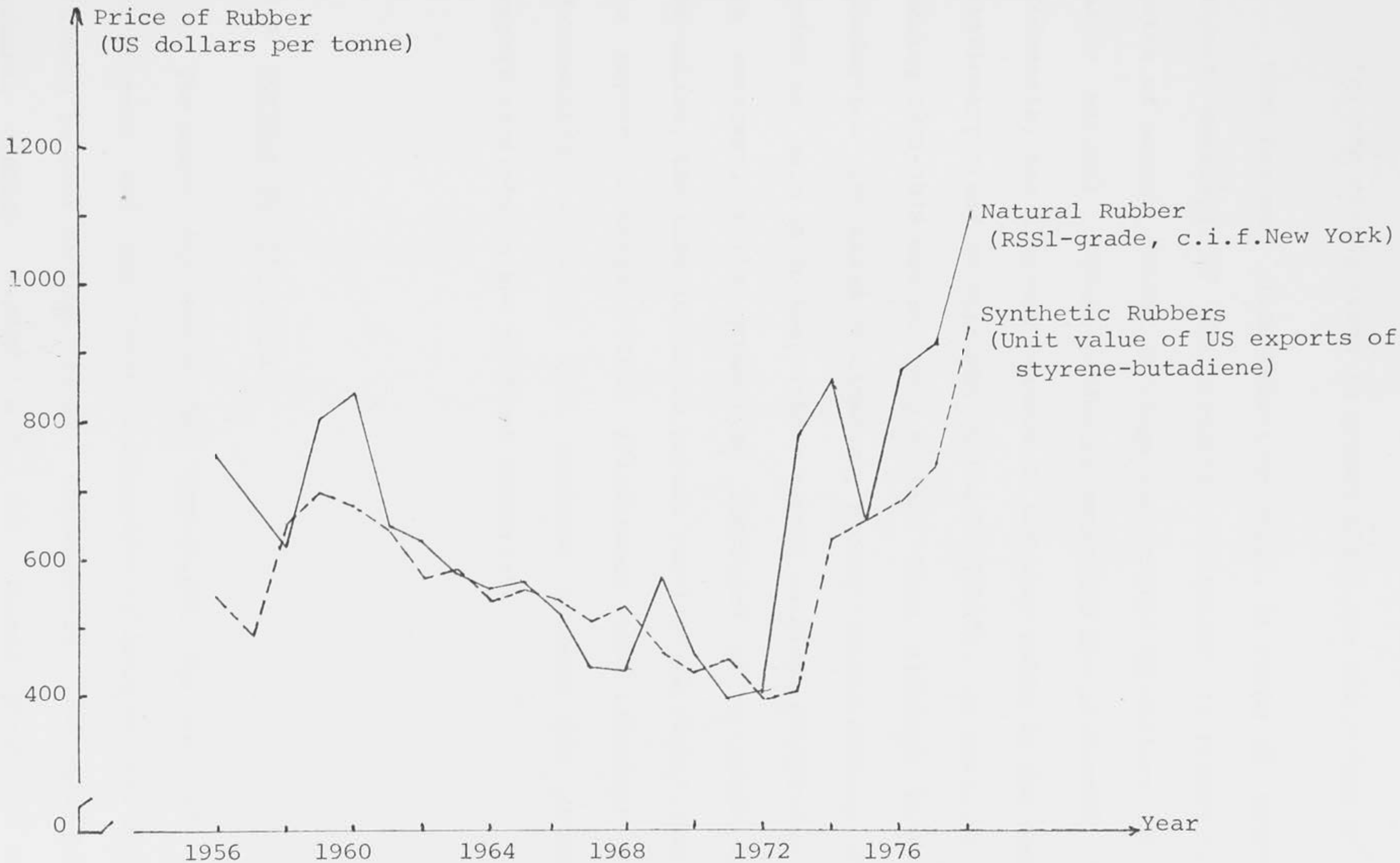


Figure 1.1: Natural Rubber and Synthetic Rubber Prices, 1956-1978

(c) the rising trend in prices after the oil crisis of late 1973.

What has such price behaviour meant, in terms of natural rubber export earnings of the producing countries? In Figure 1.2 the time paths of natural rubber earnings (in current US Dollars) of the four major natural rubber producing countries are presented. Except for Indonesia, the distinct feature of the time paths is the approximately stationary trend in earnings during 1956-1972. In contrast, the trend during 1972-1978 was markedly rising. Thus although natural rubber production increased continuously throughout the sixties, the fall in price was such as to keep rubber export earnings relatively constant. In contrast, while production increased at a lower rate in the seventies, the rise in rubber prices resulted in significant increases in export earnings. This illustrates the importance of price in determining nominal and real producer incomes and natural rubber export receipts in the producer countries.

1.4 Purpose of this Study

The above discussion has emphasised the derived demand for elastomers and the joint consumption of both natural and synthetic rubbers in this derived demand. Consequently, a balanced study of the natural rubber market and its future prospects entails an understanding of the synthetic rubber industry.

Figure 1.2: Total Natural Rubber Export Earnings of Major Producing Countries, 1956-1978.

The proximate aim of this study is the estimation of an econometric model of the world natural and synthetic rubbers market to explain natural rubber price and consumption share over time. Such a model should reflect the lagged price effects on supply and demand. After the model has been validated it can then be used in various applications. In this study, the primary application of the model is to evaluate buffer stock price stabilisation by the International Natural Rubber Agreement; the basis for this evaluation is the forecast of future rubber prices under a given oil price scenario. Since non-stochastic simulations are used, the sensitivity of stabilisation effects to stochastic and non-stochastic simulations will be evaluated by examining the effects of hypothetical price stabilisation during 1970-1980. In all these simulations, the evaluation of stabilisation effects on individual countries are facilitated by the highly disaggregated model. With the highly disaggregated model, the impact of any national policy change on the rubber supply and demand of individual countries can also be examined. Since many of the natural rubber producing countries impose taxes on their natural rubber exports, the impact of Malaysian export tax variations on the rest of the world will also be assessed to illustrate the interrelations between variables within the system. All these simulations also provide information on the long-run behaviour of the natural rubber share of consumption.

This thesis can be divided into two parts, the first of which concerns the various aspects of the market and the model specifications and estimations. The second part of the thesis concerns the application of the model to analyse the natural rubber price stabilisation and the effects of national government market interventions.

In the first part, Chapter Two analyses the joint consumption of natural rubber and synthetic rubbers and emphasises the "habit persistence" aspect of the demand for elastomers. Chapter Three treats the question of supply of elastomers; the emphasis is to contrast the markedly different gestation periods and industrial organisation in the production of the two types of rubbers. Since primary producing countries typically tax their primary exports, Chapter Four examines the impact of export taxation on natural rubber supply response in Malaysia. Because of the derived nature of demand, and the geographical concentration of natural rubber production away from the main industrial consuming countries, Chapter Five examines the role of stocks and highlights the influence of stock location on price formation. These various components are synthesised in Chapter Six which shows that the world market for elastomers can be represented by a model consisting of two submodels: a natural rubber submodel featuring perfect competition and a synthetic rubber submodel featuring imperfection competition. The nexus between the natural rubber and synthetic rubbers submodels is provided by the consumption equations through which the natural rubber and synthetic rubber price effects are modelled. The validation of the model provides an understanding of the interaction between the long-term rubber market behaviour and the natural rubber market instability around the trend.

The second half of this study begins with Chapter Seven which examines alternative oil price scenarios for 1980-1995. These scenarios provide the basis for projecting values of the exogenous variables in the model so that the model can be used to forecast natural rubber price under alternative scenarios. Chapter Eight begins with a discussion of the theoretical underpinnings of price stabilisation. It then goes on to discuss the clauses of the International Natural Rubber Agreement and to examine the conditions for a viable buffer stock price stabilisation policy. A 5-year buffer stock stabilisation scheme for 1982-1986 under a low oil price scenario is then examined. Chapter Nine examines whether the distribution of gains is affected by (a) the period of a stabilisation agreement and (b) the use of equidistant or non-equidistant price bands. Forecasts of prices, production and consumption of rubbers under the high oil price scenario are also presented and the respective rubber consumption shares evaluated. Chapter Ten analyses the sensitivity of price forecasts, production and consumption of rubber to variations in Malaysian export tax rates; such export tax variations illustrate the effects of a market intervention by a national government and serve to verify the high degree of interdependence between variables in the rubber market. The simulations in Chapters Eight to Ten also emphasise the influence of lagged price effects and the issues which warrant consideration in any price stabilisation attempt. Finally, Chapter Eleven presents the main findings for the rubber market and summarises the problems of natural rubber stabilisation; further work along the lines of optimal stockpiling programmes is then suggested.

CHAPTER TWO

DEMAND FOR RUBBERS

2.1 Introduction

In Chapter One it was explained why evaluation of stabilisation measures for the natural rubber market rests on the study of the interaction between the consumption and production of natural rubber and synthetic rubbers, and the price of oil. The three aspects of this interaction are (1) the substitutability, and hence competition, between natural and synthetic rubbers in the derived demand for elastomers; (2) the impact of oil price on synthetic rubber production costs and (3) the impact of oil price on general economic activity and hence on the demand for elastomers. The competition between natural rubber and the synthetic rubbers in the demand for rubber will be analysed in this chapter. The role of oil price (aspects (2) and (3)) will be discussed in subsequent chapters.

The demand for rubber is derived from the demand for final goods; about 65 percent derives from the transport sector (mainly in the production of tyres and tubes) and the remaining 35 percent from the non-transport sector (from the production of producer goods such as conveyor belts to consumer goods such as footwear and gloves). The two types of rubber jointly consumed in this derived demand are natural rubber and the synthetic rubbers. Figure 2.1 gives a flowchart of the various final goods demand, their translation into

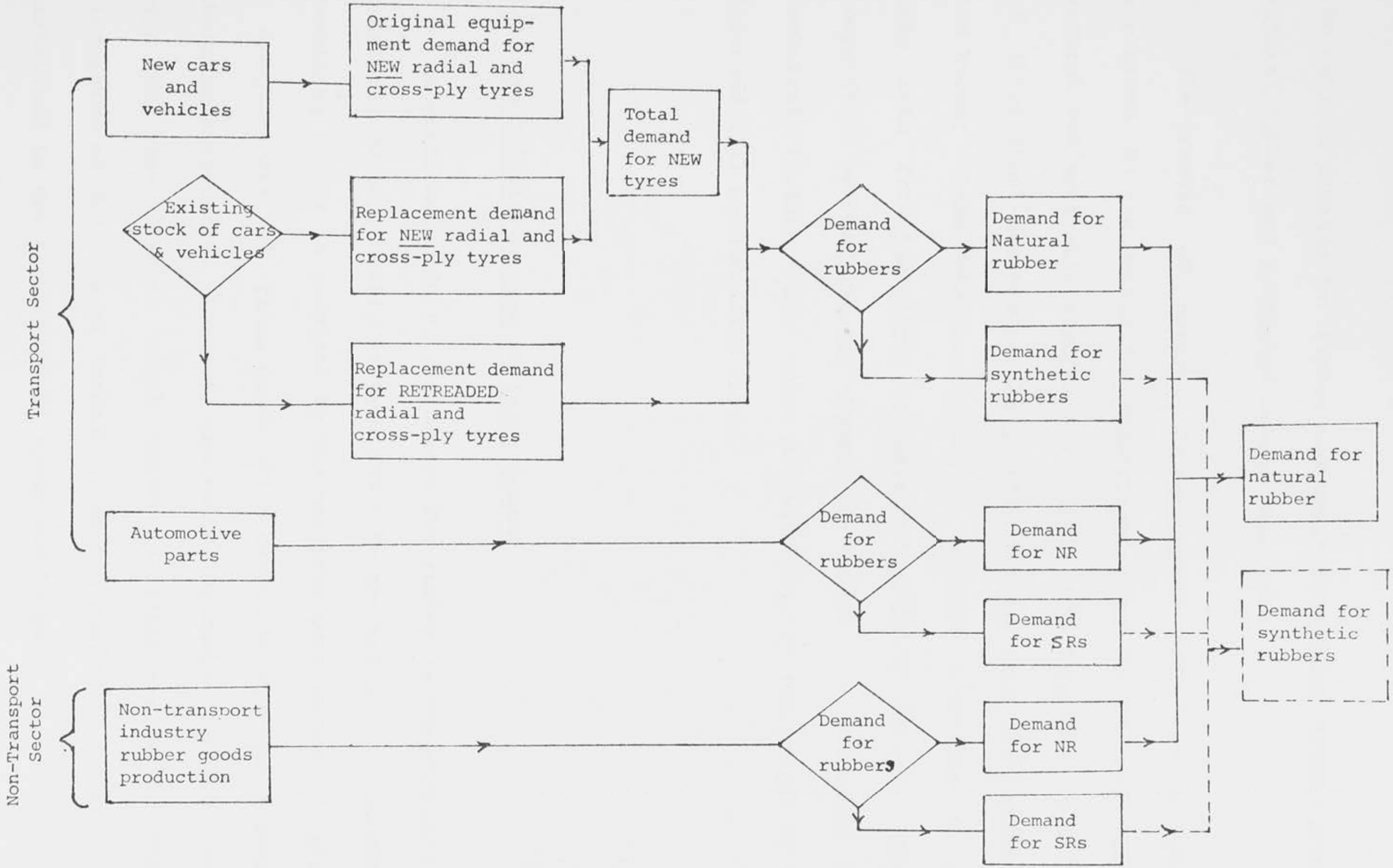


Figure 2.1: Demand for Natural and Synthetic Rubbers by Sector for each Country.

the derived demands for rubber and their subsequent decomposition into natural rubber and synthetic rubber demands.

The process of natural rubber price formation is partially explained by the demand for rubbers and hence for natural rubber. As natural and synthetic rubbers are jointly consumed, the specification of these input demands can be jointly derived once their determinants are known; these determinants can be grouped according to whether they stem from technical, economic and political factors. Since the competition between the two types of rubber is dominated by the technical factors, the role of technology in the choice of rubbers demanded will be discussed first.

2.2 Technical Features of Input Demand

As mentioned before, the demand for rubber is concentrated in the transport sector, mainly in tyre and tube production. In contrast the remaining rubber is consumed by the non-transport sector in producing a conglomerate of final goods which cannot be aggregated because of their heterogeneity. However, the volume of rubber consumed by each type of non-transport final goods is relatively small. Thus this discussion of the role of technology in the choice of rubber will be restricted to the production of tyres and tubes.

Basically, the substitutability between natural and synthetic rubbers in tyre and tube manufacturing stems from the development of "general-purpose" synthetic rubbers[1] having, in varying degrees, the properties of natural rubber. In joint use, these properties may be viewed as competing with and/or complementary to those of natural rubber. Apart from natural rubber, the general-purpose synthetic rubbers are styrene-butadiene(SBR) and the stereo-regular polybutadiene(BR) and polyisoprene(IR), the latter being known as "synthetic natural rubber" because its properties are very similar to those of natural rubber.

Since the competition among the general-purpose synthetic rubbers is critical to the overall competition between natural and synthetic rubbers in tyre manufacturing, the nature of competition amongst the general-purpose rubbers within the tyre sector will now be discussed. The basic requirements of a tyre are its tyre strength, high speed and endurance; under these criteria, tyres can be made entirely from natural rubber as in some instances in the less-developed natural rubber producing countries. However technological progress in synthetic rubbers and tyre manufacturing has yielded tyres with improved properties, viz. tyre wear resistance (treadwear), road adhesion (weather resistance), groove and sidewall cracking (resilience), heat durability and cold flexibility. To distinguish these two sets of criteria, Allen(1972) has termed the former as

1 In addition there are special-purpose rubbers designed for specific end uses; these are polychloroprene, butyl, ethylene-propylene, co- and ter-polymers and the expensive specialty rubbers such as silicones, acrylics, et cetera. Usages of the special-purpose rubbers have not been extensive for reasons of price or of inadequacy in physical properties.

"product specifications" and the latter as "service performance". Strictly speaking, "product specifications" are essential requirements; "service performance" properties, though preferred are not essential. However, from Table 2.1 which compares natural and synthetic rubbers' properties, it can be seen that it is on their ability to meet these "service performance" criteria that synthetic rubbers have made their inroads into the tyre industry. The development of blending technologies, especially for blending styrene-butadiene with polybutadiene has been instrumental in making these inroads. Because of the close substitutability between the various general-purpose rubbers, including natural rubber, the pattern of input-mix and volume of natural rubber consumption finally observed reflects a process of rubber input selection based on technical, economic and political considerations.

In discussing the technical factors, a brief resume of the role of technological progress in the rubber industry is warranted. The effects of technological progress on rubber demand are two-faceted: qualitative effects which refer to physical properties versus quantitative effects which impact on production costs. The qualitative effects concern the physical properties attainable in individual or compounded rubber and new products, such qualitative technological progress having for example occurred in the mid-1950s with new processing techniques for styrene-butadiene and the development of polybutadiene and polyisoprene (which became commercially important by 1959). Subsequent displacement of natural rubber by synthetic rubbers was accelerated by the development of the blending technologies referred to above. Since the mid-1960s this

Table 2.1: Comparison of the Properties of the General-Purpose Rubbers

Property	Natural Rubber	Polyisoprene	Styrene-Butadiene	Polybutadiene
Treadwear	100	100	115	150
Resilience	100	100	75	95
Heat durability	100	100	150	150
Cold flexibility	100	100	90	120
Weather resistance	100	100	115	100

Source: D'Ianni, (1969).

trend has been counteracted by the development of the radial tyre which has a higher natural rubber content than the conventional cross-ply tyre. The quantitative effects of technological progress concern increased productivity and lower unit costs in synthetic rubber production[2] and the increased natural rubber content per tyre required by the radial tyres.

The technical considerations in the choice of rubber inputs are therefore based on the availability of different rubber inputs, of blending technologies and of new products wrought through technological progress. Technically, the choice of natural or synthetic rubber inputs is dictated by the requirement that end-products meet the users' specifications. The development of blending technologies means that careful compounding of natural rubber with synthetic rubbers can yield almost any rubber with a predetermined set of properties. Conversely, for products requiring the general-purpose rubbers, there is a range of technical possibilities. This leads to the question of costs of mixing rubbers and of mix changes; the influences of economic and also of political factors will be discussed below.

2 An example of this is the cold-stream polymerisation of styrene-butadiene in the mid-1950s resulting in lower-cost production. For details of other cost-reducing technological change, see Allen(1972) and Allen, Thomas and Sekhar(1974).

2.3 Minimum Input Requirement of Tyre Production

Having briefly described the role of technological progress in rubber and rubber goods production, it is essential to discuss a technical constraint on the choice of rubber inputs observed in the tyre industry. The main inputs under consideration are natural rubber, styrene-butadiene, polybutadiene and polyisoprene. Three categories of output from the tyre industry may be distinguished; namely, tyres for passenger cars (hereafter referred to as cars), for commercial vehicles (hereafter referred to as trucks) and off-the-road tyres such as aeroplane tyres, tractor tyres and tyres for earthmovers. Since off-the-road tyres consume only a relatively small share of the total rubber consumed in the tyre industry, this discussion will concentrate on car and truck tyres.

Basically the rubber input mix for car and truck tyres differs because of their difference in size, product specifications and service performance. For each category (new or retreaded) of tyre, the availability of different types of tyres (crossply and radial), leads to further variations in input mix. The total demand for natural rubber for each category and type of tyre is the product of the total number of tyres produced and the natural rubber content-per-tyre, the latter being determined by the input mix applied. Tables 2.2, 2.3 and 2.4 present input mixes used in the various components of cross-ply and radial car tyres and cross-ply tyres for large trucks respectively. The Tables show that for each type of tyre, several input mixes are feasible for each of their tyre components. Thus different input mixes are feasible for the tyre as a

Table 2.2: Input Mix for Cross-ply Car Tyre

Components	Percentage of Total Rubber	Input Mix
Tread	35	75 SBR : 25 BR*
Carcass	37	60 NR : 40 SBR
Side Wall-(a) Black	14	75 SBR : 25 BR* or Blend of NR/SBR/BR
-(b) White		Blends of NR/SBR/BR with higher NR-content than (a) but not exceeding 50 per cent
Liner	14	Chlorobutyl and IR
Inner Tubes		Mainly butyl

* Usually made from same input material (Sin, 1979).

Source: Anderson(1977) and Grosch(1969)

Table 2.3: Input Mix for Radial Car Tyre

Components	Percentage of Total Rubber	Input Mix
Tread	33	75 SBR : 25 BR
Carcass	21	70 NR : {30 SBR; 30 BR; 30 SBR/BR blend}
Side Wall	18	55 NR : 25 SBR : 15 BR
Liner	14	{NR $\leq$ 30 per cent; Chlorobutyl $\geq$ 70 percent}
Breaker	14	70 NR : {30 SBR; 30 BR; 30 SBR/BR blend}
All parts	100	40 NR : 60 SBR/BR blend

Source: As for Table 2.2;

Table 2.4: Input Mix for Cross-ply Large Truck Tyre (Composition very diversified)

Component	Percentage of Total Rubber	Input Mix
Tread	30	75 NR : 25 BR 60 NR : 40 BR 40 NR : 10 SBR : 50 BR
Subtread	10	100 NR 50 NR : 50 BR
Shoulder Wedge	5	100 NR 80 NR : 20 BR 45 NR : 55 BR
Side Wall	8.5	80 SBR: 20 BR 55 NR : 45 BR 30 NR : 20 SBR : 50 BR 40 NR : 60 BR
Carcass	46.5	100 NR 45 NR : 25 SBR : 30 BR 65 NR : 35 BR 80 NR : 10 SBR : 10 BR

Source: Sin (1979).

whole from which it may be inferred that there exist minimum requirements of the various rubber inputs for each tyre component. This is substantiated in Figure 2.2 which presents histograms of natural rubber, styrene-butadiene and polybutadiene usage in car tyre treads; however, it should be emphasised that these histograms are based on analysis of tyre tread compounds used in over 200 car tyres produced in Europe and USA between 1964 and 1967 and are likely to be outdated by subsequent trends in tyre technology. An example of later trends is the widespread replacement of commercial vehicles by "mini-buses" in congested cities, as in Japan, so that the tyres required are smaller and can therefore use more synthetic rubbers than is permissible in tyres for heavy-duty commercial vehicles. Then the overall minimum requirement per type of input per tyre is the sum of minimum input requirements of the various tyre components. In order to examine the interaction between natural rubber and the various synthetic rubbers, the demand for the various elastomers per type of tyre should therefore be analysed together.

Under a given technology, the substitutability between natural rubber and the various synthetic rubbers per tyre should, strictly speaking, refer only to the range of feasible inputs net of their minimum requirements. Hence while the minimum natural and synthetic rubber inputs per tyre are determined by the available technology and the service performance criterion, the substitutable shares of these inputs are determined by their relative prices. However, limits to substitution exist. These are imposed by the costs of technical adjustment and of the reallocation of labour input and/or of the alternative division of labour within the plant. The influence of

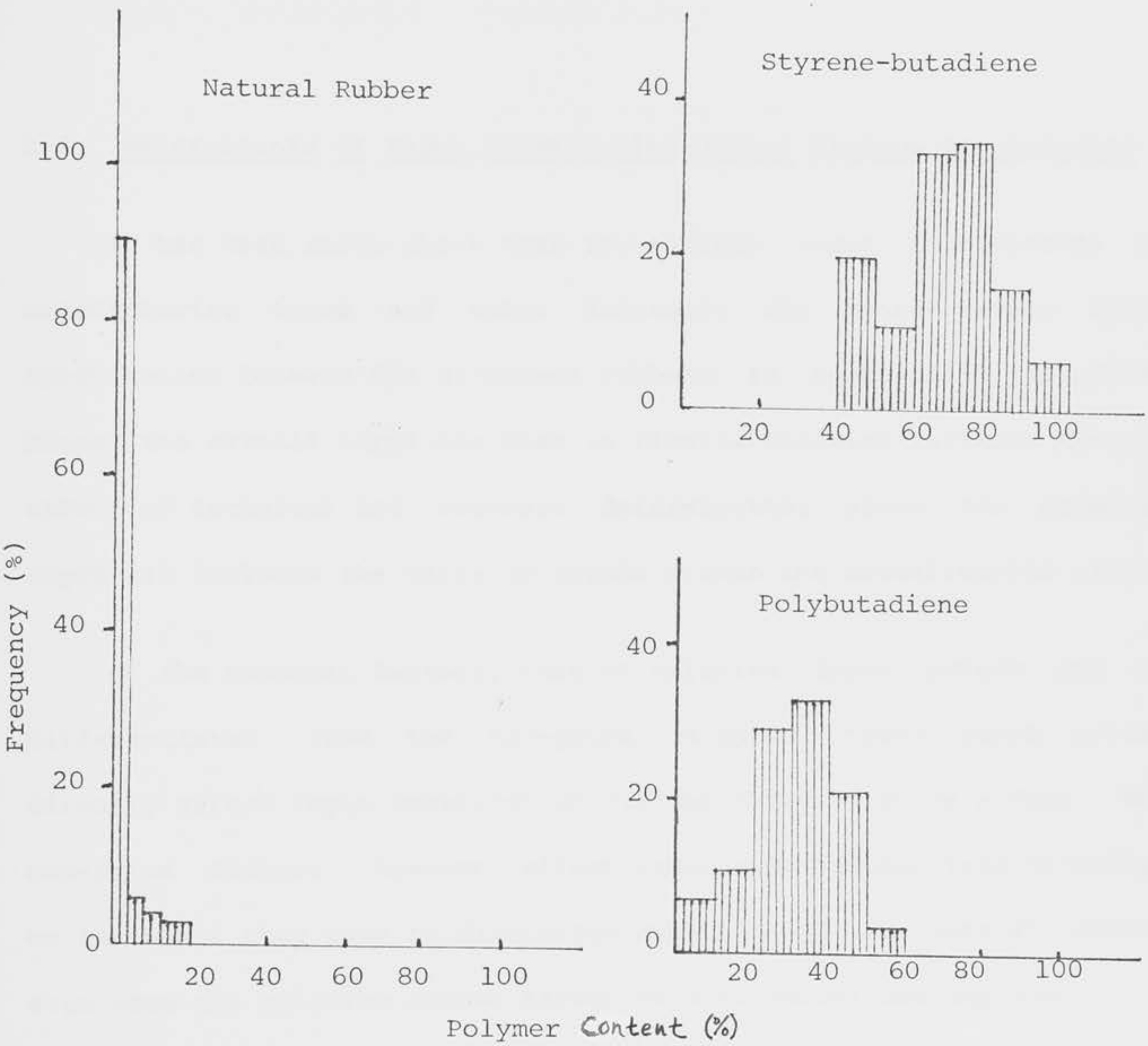


Figure 2.2: Rubber Compositions of Car Tyre Treads

Source: Grosch(1969).

relative prices, adjustment costs and other factors on the substitution between natural and synthetic rubbers will now be discussed.

2.4 Determinants of Input Substitution Beyond Minimum Requirements

It has been shown above that the minimum input requirements in manufacturing tyres and tubes delineate the range within which substitution between the different rubbers is technically feasible. Hence the overall input mix that is finally observed reflects the net effect of technical and economic determinants, since the observed input mix includes the share of inputs within the substitutable range.

Of the economic factors, that of relative input prices may be differentiated from the non-price factors. These input prices directly affect input substitution via the relative price effect. The non-price factors, however, affect input substitution less directly; on the whole they tend to discourage substitution by natural rubber even when the relative prices favour natural rubber consumption.

The main determinants of competition within the general-purpose rubbers (especially between natural rubber and styrene-butadiene) are price and price stability. Price stability is important not only because manufacturing facilities cannot easily adapt to different blends of rubbers when relative prices change (because of technical adjustment costs) but also because the competitive situation of rubber goods manufacturing in the Western World (outside the centrally-planned economies) does not on the whole yield high returns so that the industry is especially sensitive to raw material costs (Allen, 1972:164). The nature of the markets for rubber products also precludes frequent sharp changes in their selling prices.[3] Furthermore, price instability also affects stock valuations.

The nature of natural rubber price instability versus synthetic rubbers price stability will be discussed at length in Chapter Five on the price formation process in the two markets. For the present it suffices to mention that while natural rubber is traded internationally under perfect competition and openly in the world's major commodity exchanges, the same cannot be said of synthetic rubbers. Synthetic rubbers are neither traded openly nor on commodity exchanges; instead they are traded under list prices that are announced periodically so that price increases occur "in a predictable and orderly fashion" (Grilli, 1980); however, actual sales of synthetic rubbers are understood to be at discounts from the published prices (Allen, 1972), so that synthetic rubber prices actually do vary. If this is compared with the long-term contractual arrangement for the bulk of natural rubber consumed to be discussed at length in Chapters Four and Five, then the apparent contrast in price stability/instability may be overemphasised. In reality the prices actually paid by consumers for natural(synthetic) rubber(rubbers) may not be as unstable(stable) as their spot(list) price(prices) would suggest.

3 For details on the workings of the international tyre industry, see Stanton(1979).

The location of rubber supply presents another factor in input choice and substitution. The consequence of the geographical concentration of natural rubber production in South and Southeast Asia is the long supply route to buyers which adds to transportation costs and causes buyer insecurity because of his vulnerability to possible shipping delays. Thus the consumer has to buy further forward which complicates his inventory policy. The sale of natural rubber is traditionally based on payments against documents; this means that the buyer must part with his money earlier than if he were to buy synthetic rubbers from sources closer to home. With speculative trading complicating the price behaviour of natural rubber as will be seen in Chapter Five, more trading acumen is therefore required of the buyer in natural rubber than in synthetic rubbers purchasing. Since synthetic rubbers are mainly produced in the industrial countries, the supply line from producer to manufacturer is shorter than that for natural rubber. Inventories can thus be kept at a lower level and quality complaints can also be dealt with more directly and quickly. The only problem with synthetic rubbers purchasing is their greater variety (both types and grades) and periodic shortages (due to occasional feedstock shortages and synthetic rubber supply adjustments) which the buyer has to consider for purchasing and stocking. This is important since the function of a buyer is to anticipate changes in input mixes that may be necessary in view of <u>expected</u> long-term relative price movements. One description of the role of a buyer is that by Anderson:

> "As an individual, the commercial buyer of natural rubber for a medium to large rubber manufacturer does not play a significant part in making his company's choice between natural and synthetic rubber. He is a specialist engaged in daily

contact with the market and primarily concerned with the movement of prices and differentials of the many grades he has to buy and with the control of inventory, forward commitments, deliveries and claims.

Even though he may also be involved in the purchase of equivalent synthetic rubbers he is not normally aware of the equivalent cost of synthetic rubbers in his company's products compared with natural rubber, where substitution is technically possible.

The rubber buyer is responsible for supplying information on the prices ruling for natural rubber grades and for the synthetic rubbers to his technical colleagues. It is they who are responsible for compounding to meet the product performance specifications from the materials available at minimum overall costs, on which the choice of polymers depends. The buyer's role is then limited to obtaining supplies of the materials specified at minimum cost, and, of course, of keeping his company informed of the likely future price movements and changes in availability, particularly if these should call for development work leading to the use of more readily available or cheaper alternatives."[4]

Another factor influencing substitution between the two commodities is the processability of natural and synthetic rubbers. Figure 2.3 which compares the processing of natural rubber with synthetic rubbers shows that the latter can be used immediately it is received. In contrast, several preparatory steps are required of natural rubber before it is amenable for use in the Banbury Mixer where blending takes place before vulcanisation (or curing). The preparatory stages for natural rubber are:

(a) Cleaning of the bales surfaces. This is because traditionally natural rubber arrives 'bare back'. Hence the bale surfaces must be cleaned of all extraneous dirt and foreign material which they have picked up en route to the factory.

4 Anderson(1977); emphasis mine.

(b) Raw natural rubber is also susceptible to crystallisation at low ambient temperatures. Several days' conditioning at elevated temperatures are generally required prior to plastication.

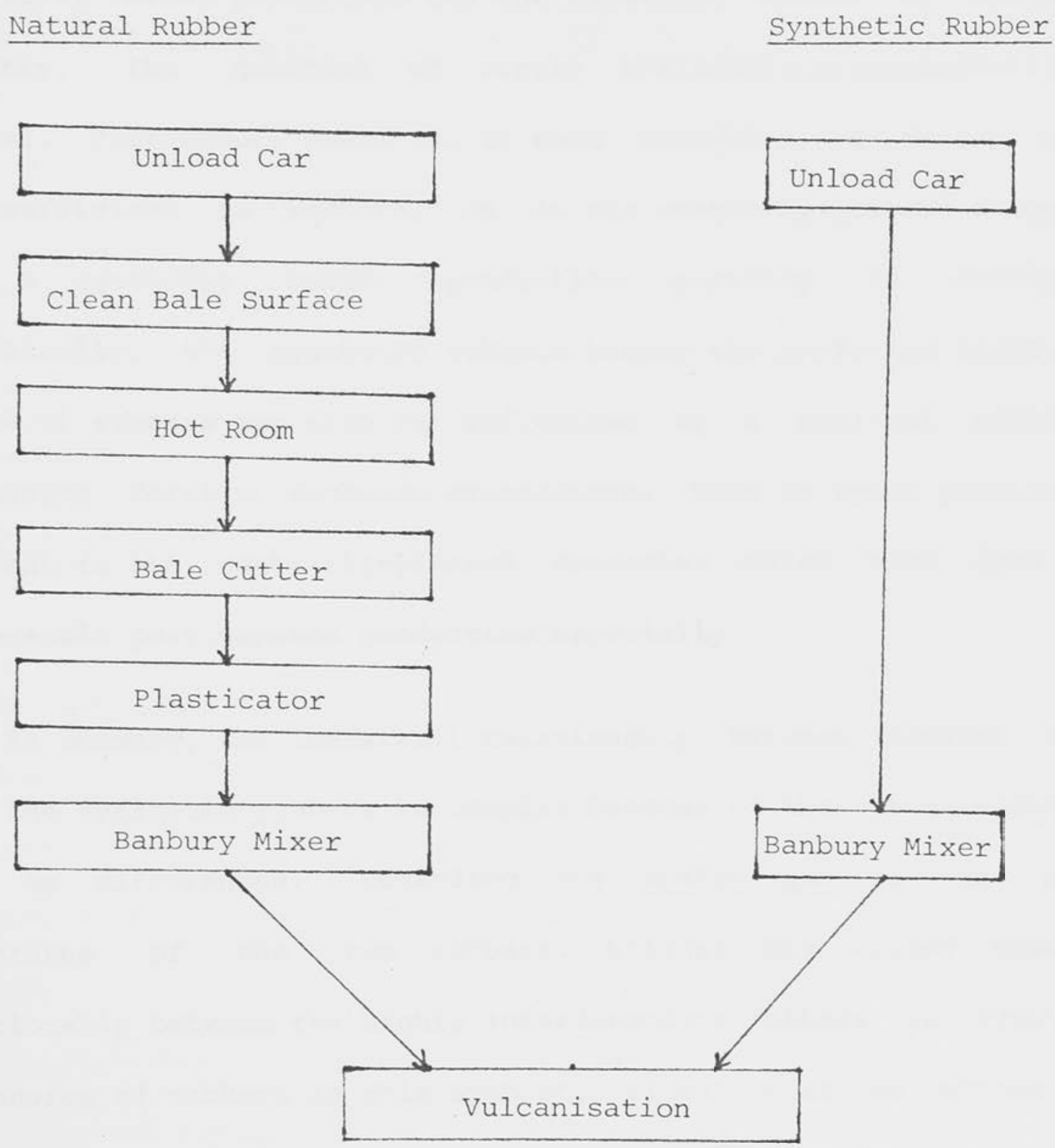
(c) The large bales of natural rubber must be cut into smaller pieces for efficient handling.

(d) The Mooney viscosity of natural rubber must be reduced by multiple passes through the plasticator for mastication so as to attain optimum processibility before the natural rubber is delivered to the Banbury for mixing.

Attempts to save some of these processing costs led to the production and export of crumb rubber, generally known as Standard Malaysian Rubber(SMR) and Constant Viscosity(CV) rubber in the mid-1960s. Crumb rubber has the advantage of low dirt content (which permits better processing, lower scrap and improved quality) and better scorch resistance while constant viscosity rubber eliminates much of the mastication required and its attendant degradation of physical properties. However, the tendency of raw natural rubber to crystallise at low ambient temperatures has yet to be overcome.

From Figure 2.3 it can be seen that the various stages of processing relevant to the major part of the time period under study are not continuous, so that the intermediate output has to be stockpiled between each operation and transported onto the next; hence the operation is one of "batches". There is now a trend towards use of continuous processes where feasible, such as in mixing. Because of the various preparatory stages required in natural rubber

Figure 2.3: Comparison of Natural and Synthetic Rubber Processing



Source: Bekema (1969).

processing, more factory area and more inventory stations are required than in synthetic rubber processing, thus further increasing the cost of using natural rubber.

Another factor influencing the choice of rubber is the question of accessibility to supply. Because of the geographical concentration of natural rubber production and the strategic nature of rubber in industry, the question of supply availability/accessibility is crucial. Furthermore there is, in some countries, a desire to be self-sufficient in rubbers, as in the centrally-planned economies. Once a synthetic rubber production capacity is established domestically, the synthetic rubbers become the preferred input. The choice of rubbers may also be influenced by a national policy of minimising foreign exchange expenditure. This is again particularly relevant to the centrally-planned economies which have gone into large-scale polyisoprene production especially.

In summary, the industrial relationship between natural rubber and the synthetic rubbers is complex because of their similarities as well as differences. Regarding the status quo in the market structures of the two rubbers, D'Ianni has argued that the relationship between the highly interdependent rubbers is symbiotic. The choice of rubbers in this symbiotic situation is the outcome of an optimising process requiring constant revaluation of the cost and quality factors so that a "dynamic equilibrium is maintained with a balancing of costs, properties and performance as the critical criteria" since the cases "where blends are superior to either component alone outnumber those where only one is indicated" (D'Ianni, 1969:217). Any guideline for natural rubber supply management by a stabilisation agency thus hinges on an understanding of the interaction between the two rubber markets through their joint demand.

2.5 Specification of Input Demand Functions

The competition between natural and synthetic rubbers has been shown to stem from technical, economic and autarkic considerations. In specifying the input demand functions, the original intention was to build upon the findings by Behrman(1971). In analysing the competition between the two types of rubbers, Behrman first explained total rubber demand in terms of overall industrial activity and transport demand indices. The ratio of natural to synthetic rubber demand was then explained by total rubber demand and the relative price of natural to synthetic rubbers. Technical change in the synthetic rubber industry was represented by four technological indices which separately account for (1) the cold processing of styrene-butadiene, (2) the oil-extension of styrene-butadiene production, (3) the introduction of stereo-regular polybutadiene and polyisoprene and (4) the introduction of special-purpose rubbers. For the 1950-1966 period Behrman obtained significant estimates when these four indices were incorporated in the relative rubber demand equation to account for input substitution due to the effects of relative prices and physical properties of the rubbers. Thus up to the mid-1960s, the elasticity of substitution may be decomposed into the technical (qualitative) and the price (quantitative) components.

By the mid-1960s the impact of the qualitative technical change in the form of new stereo-regular synthetic rubbers and their blending with styrene-butadiene to give synthetic rubbers of improved properties was well-established. Technical change in the ensuing period focussed on the specialty synthetic rubbers and on improving the tyre quality, the latter feature tending to lower the minimum inputs requirements of natural rubber. This trend may be attributed to the growth of the oil industry and the low stable oil prices, both of which facilitated the easy expansion of synthetic rubber production capacities. Thus it would have been interesting to examine the price elasticity of substitution net of these minimum inputs. However, since only European synthetic rubber list price data from mid-1960s on are available, it was decided to concentrate on the influence of minimum input requirements and relative input prices on rubber demand.

Other factors relevant to input substitution and hence overall input demand, viz. the relative lengths of supply routes, the differences in processability, the strategic issue of natural rubber supply availability and the constraints on foreign exchange outflow is regrettably not incorporated into the present simplified study. These unincorporated factors are nevertheless pertinent to input demand choice and should be borne in mind since they are implicit in the determination of the final observed volumes of natural and synthetic rubbers consumed. Furthermore unless new and significant supplies of natural rubber emerge (such as from Brazil and Mexico), relevance of these factors are likely to persist into the foreseeable future. Consequently in any complete evaluation of the market prospects for natural rubber, appropriate weights should be given to those factors that have not been incorporated in the empirical estimation.

Four assumptions about the rubber market are used in the specification of input demand functions. These assumptions concern the natural rubber and synthetic rubber markets, the nature of the two types of rubbers and the nature of production in the rubber goods industry.

As indicated natural rubber is traded internationally as well as openly on commodity exchanges. In Chapter Three the atomistic nature of natural rubber supply will be discussed at length. It suffices here to mention that natural rubber is produced by estates and smallholders, the latter being the dominant producer group. The natural rubber market operates on conditions approximating the traditional model of profit-maximisation under perfect competition.

In contrast to natural rubber, the synthetic rubber industry is vertically-integrated: backwards with the oil and petrochemical industry and forwards with the rubber goods industry. Since the oil and petrochemical industry and rubber goods industry are dominated by multinational corporations, the synthetic rubber industry is therefore related to these corporations. For reasons elaborated in Chapter Three (where the approach to modelling synthetic rubber supply is discussed) the assumption of profit-maximisation under monopolistic conditions for the synthetic rubber market will be adopted.

On the whole natural rubber and synthetic rubbers are jointly consumed in rubber goods manufacturing. As with the transport-sector (the major demand sector) demand for general-purpose rubbers, it is also assumed that the two types of rubbers are imperfect substitute inputs in rubber goods production.

Arising from the highly competitive nature of the rubber goods industry the last assumption is that rubber goods are produced under cost-minimisation in a perfectly competitive market.

A heuristic model of aggregate input demand in a one world economy and under the four assumptions can then be derived as follows. Let the production function for an aggregate group of rubber goods Q be

(2.1) $$Q = f_o (N, S, F, T)$$

where N is the natural rubber input in Q-production;

S is the synthetic rubber input in Q-production;

F is the fixed input in Q-production;[5]

T is the technology used in Q-production.

Under cost-minimisation the input demand functions are then given by

(2.2) $$CN = f_1 (PN/PS , Q , T)$$

(2.3) $$CS = f_2 (PN/PS , Q , T)$$

where CN and CS are the consumption of natural rubber and synthetic

5 The inclusion of labour input as part of fixed input is not unrealistic in rubber goods manufacturing in view of the adjustment costs associated with labour input re-allocation that is discussed in section 2.3 above.

rubbers respectively. Since CN and CS are jointly consumed, these may be written as

$$(2.4) \qquad CN = (CN/TR).(TR/Q).Q$$

and

$$(2.5) \qquad CS = (CS/TR).(TR/Q).Q$$

where TR = CN + CS

Then f_1 and f_2 gives

$$(2.6) \qquad CN = \left[\frac{f_1(PN/PS,\ Q,\ T)}{f_1(PN/PS,\ Q,\ T) + f_2(PN/PS,\ Q,\ T)} \right] . \frac{TR}{Q} . Q$$

$$= f_3(PN/PS,\ Q,\ T) \ . \ \gamma Q$$

On the assumption of minimum requirements, technology effect enters through CN^* which is the minimum requirement level and the price effect enters only through CN^{**}, so that

$$(2.7) \qquad CN = (CN/TR)^* + (CN/TR)^{**} \ . \ \gamma Q$$

$$= f_4(T) + f_5(PN/PS) \ . \ \gamma Q$$

where $(CN/TR)^*$ is the minimum requirement and T is the trend variable to proxy the technology which defines the minimum input requirement. Therefore

$$(2.8) \qquad CN = \{\alpha_0 + \alpha_1(T) + f_5(PN/PS)\}.\ \gamma Q$$

Similarly assumption of minimum input requirement $(CS/TR)^*$ leads to

$$(2.9) \qquad CS = \{\beta_0 + \beta_1(T) + f_6(PN/PS)\}.\ \gamma Q$$

Joint consumption of natural and synthetic rubbers is reflected by the following constraint across equations (2.8) and (2.9)

$$(2.10) \qquad \alpha_0 + \alpha_1(T) + f_5(PN/PS) = 1 - \{\beta_0 + \beta_1(T) + f_6(PN/PS)\}$$

Disaggregating the one world economy into individual countries, a set of input demand functions (2.8) and (2.9) would then apply to each country. Since different types of tyres have different minimum input requirements, a set of input demand functions (2.8) and (2.9) should be estimated for each type of tyre. However, data limitations prevent the estimation of these input demand functions, since data on rubber consumption in the major tyre producing countries viz. France, Italy and Japan, are differentiated only by transport and non-transport sector. While data for car, truck and off-the-road tyre production are separately available for the UK and the USA, these could not be used because data for their corresponding natural and synthetic rubber consumptions are not available. Available data for the remaining industrial countries are even less detailed. A highly aggregated approach is thus adopted in estimating the input demands, concentrating only on the impact of lagged relative prices on the individual rubber demands. The consequence of this simplification is that the minimum input requirements cannot be substantiated empirically.

2.6 Estimation of Input Demand Functions

The approach adopted in estimating the input demand functions was dictated by the data availability. Since the Rubber Statistical Bulletin (henceforth referred to as the Bulletin), a monthly publication of the London-based International Rubber Study Group(IRSG), provides the most comprehensive coverage of data pertaining to the world rubber market the basic data in this study are extracted from this source.

The Bulletin provides separate data on natural and synthetic rubber consumption differentiated by transport and non-transport sectors, for the major tyre producing countries only. For the remaining countries no sectoral breakdown of natural and synthetic rubber consumption is available. Although the Bulletin also provides data on the production of various types of tyres in the USA and UK, the corresponding data on natural and synthetic rubbers consumed by each type of tyre are again unavailable.

The consuming countries are grouped according to their data position into:

(1) those countries for which sectoral rubber consumption data are available, viz. France, Italy, Japan, UK, USA and West Germany whose natural rubber consumption averages about half of the world's total natural rubber consumption; and

(2) those countries for which sectoral rubber consumption data are not available, viz. Australia, Brazil, Canada, China, COMECON, India and The Netherlands. To account for the balance rubber consumption a Rest-of-the-World consumption was introduced.

For each consuming country the basic input demand equations are given by equation (2.2) and (2.3). For the transport sector demand function, the rubber goods refer to the number of tyres and tubes produced for each type of transport vehicle; for West Germany quantity indices were used instead. For the non-transport sector demand the index of industrial production is used to reflect the level of activity in rubber goods manufacturing.

As mentioned earlier, the degree of input substitutability (beyond their minimum requirements) in any period is constrained by technical considerations. Savings made on the input costs through substitution between inputs may be offset by adjustment costs to machinery and equipment and to the management. Substitution is also restrained by the known volatility of natural rubber price. Consequently in the short run natural rubber consumption does not respond to the full extent warranted by relative price changes per se.

To incorporate this "habit persistence" effect, lagged relative prices are introduced so that the relative price (PN/PS) takes the form of $\sum_{i=1}^{4} (PN/PS)_{t-i}$, The natural rubber demand equation to be estimated is then some form of

$$(2.11) \quad CNR = f_7 \left(\sum_{i=1}^{4} (PN/PS)_{t-i}, Q, T \right)$$

Correspondingly the synthetic rubber demand equation is then some form of

$$(2.12) \quad CSR = f_8 \left(\sum_{i=1}^{4} (PN/PS)_{t-i}, Q, T \right)$$

Before estimating the input demand equations, the question of which rubber prices to use had to be decided upon. The criterion of using the natural rubber prices quoted in the market closest to the consuming country being dealt with was applied; for example, New York prices were used for USA and Canadian demand while London prices were used for West European demand. For synthetic rubber prices, the domestic list prices for styrene-butadiene (grades 1500 and 1712) and polybutadiene for the country concerned were used, such prices being available for the UK, France and Italy.[6] Polyisoprene price is not used because of the data paucity. For consuming countries not having their own domestic list price quotations, the average European list prices were used instead. For the centrally-planned economies, lagged consumption were used instead of relative prices. In the Chinese case this is because apart from some domestic production of natural rubber

6 Although list prices are available for West Germany they were not used because the series for polybutadiene is incomplete.

they also obtain natural rubber from Sri Lanka under a Rice-Rubber (barter) exchange pact. In the Eastern European case this is because of the increasing domestic production and thus consumption of synthetic rubbers, particularly polyisoprene, at prices that are not publicly known. For want of an appropriate activity variable for the rest-of-the-world consumption, a trend variable was used instead.

The use of list prices for synthetic rubbers departs from the use of unit export/import values in some existing empirical studies of the rubber market.[7] The reasons for using unit export/import values in previous studies and the preference in this study for list prices, as seen from the perspective of modelling synthetic rubber supply, will be discussed in Chapter Five.

It will be recalled that an _a priori_ reason favouring synthetic rubber consumption is its list price stability. However, the stability of prices actually paid for synthetic rubbers needs to be qualified. Prior to the 1973 oil crisis, the effective period for published list prices extended up to periods of eighteen months. The regularly published list prices with notification of its effective period therefore served as indicators of ceiling prices. Although

7 Studies using list prices are, for example, that by Behrman(1971) and by Man and Blandford(1980) whose study of the natural rubber market became available during this writing. In estimating the natural rubber demand functions, Man and Blandford used the New York spot price for RSS1 natural rubber and the New York Wholesale price for styrene-butadiene to form the relative price variable.

price discounts are given, they are known only to the trading participants. The discounted prices therefore serve as indicators of floor prices to the synthetic rubber buyers. Thus given the list price for any synthetic rubber, the range within which the actual traded price will fall is known only to the buyers. It is in this sense that list prices incorporates a stability aspect. Actual traded prices of synthetic rubbers do fluctuate; however, in contrast to natural rubber price fluctuations, synthetic rubber price fluctuations lie within a relatively well-defined price band. The use of these list prices in the input demand functions is also an attempt to incorporate consumers' preference for synthetic rubber because of this stability and the predictable and orderly price increases relative to that of the market determined and less predictable natural rubber price. The use of list prices is an attempt to see if they will provide further insights about the competition between the two types of rubbers. This is relevant since in the event of continued escalation of oil price, the stability of list price would also be questioned.

The demand equations were estimated in log-linear form using Almon polynomial lags (typically of second order) for the lagged relative prices. As data on synthetic rubber list prices are available only from 1963 the sample period begins from 1963 and ends at 1977 or 1978 depending on the individual countries' data position at the time of our data collection.

The estimation results selected for subsequent simulation experiments are presented in Tables 2.5 and 2.6 with Table 2.7 providing a summary of the composition of relative prices referred to in the two aforementioned tables. As Tables 2.5 and 2.6 reveal the "habit persistence" effect was significant and, in general extends up to a period of three to four years.

The trend variable used to proxy technological change was dropped from all equations for the transport sector; this is because inclusion of the trend variable generally gave poor, if not perverse estimates, possibly because technological change during the estimation period was relatively insignificant or was not time-related. A probable reason is the multicollinearity between the trend and Almon variables. Furthermore, because of the growth in rubber fabricating activities during the period, which is reflected either in the activity index or the volume of tyres and tubes produced, inclusion of trend term also causes multicollinearity. As discussed in Section 2.5 above, the key technological progress in the synthetic rubbers industry had occurred in the mid-1950s. By the mid-1960s, the industrial position of these general-purpose synthetic rubbers was firmly established. More recent technological progress focusses on the specialty synthetic rubbers; though this is important to automotive parts production, they are nevertheless only a small proportion of total synthetic rubber consumption by this sector. Likewise the technological progress manifested in the radial tyre occurred in the early sixties. By the late sixties the shift towards radial tyres was largely accomplished, especially in the European countries.

Table 2.5 Estimates of Natural Rubber Demand Equations

Explanatory Variables / Dependent Variables	Constant	QTY	QTU	QTYC	QTYV	QTYT	IPI	T	CNR_{-1}	CNR_{-2}	CNR_{-3}	$\left(\frac{PN}{PS}\right)$	$\left(\frac{PN}{PS}\right)_{-1}$	$\left(\frac{PN}{PS}\right)_{-2}$	$\left(\frac{PN}{PS}\right)_{-3}$	$\left(\frac{PN}{PS}\right)_{-4}$	$\sum_{i=1}^{4} \lvert\beta_i\rvert$	R^2	F	DW
Italy																				
CNRT	0.7787 (0.9)	0.2861 (1.5)	0.6054 (4.2)									-0.0638 (-1.2)	-0.1218 (-1.7)	-0.1518 (-1.9)	-0.1539 (-2.1)	-0.1281 (-2.3)	0.6193 (0.3)	0.9382	15.1689	1.8432
CNRNT	-2.7438 (-2.4)						1.0185 (3.2)		0.1733 (0.8)	1.1963 (2.5)	-0.8865 (-2.4)							0.8630	9.4527	2.2426
France																				
CNRT	-4.1970 (-7.4)			0.5046 (8.2)	0.4369 (8.6)							-0.0435 (0.6)	-0.0694 (-0.8)	-0.0794 (-0.8)	-0.0733 (-0.9)	-0.0511 (-1.0)	0.3167 (0.4)	0.9928	166.1636	2.2703
CNRNT	1.8859 (0.8)						0.4982 (1.7)	-0.0456 (-2.7)	0.0997 (0.4)									0.9090	56.5946	1.7279
West Germany																				
CNRT	2.3373 (6)				0.5293 (7.6)							-0.0102 (-0.1)	-0.1542 (-1.2)	-0.2179 (-1.6)	-0.2012 (-1.6)	-0.1041 (0.9)	0.6876 (0.6)	0.9218	20.6251	2.6667
CNRNT	2.8947 (1.8)						0.4019 (1.1)					-0.3445 (-1.2)	-0.6727 (-2.0)	-0.8537 (-2.3)	-0.8875 (-2.7)	-0.7740 (-2.8)	3.5324 (1.4)	0.5435	2.0831	1.6574
United Kingdom																				
CNRT	-5.9084 (-2.2)			0.3697 (2.0)	0.8223 (2.4)							-0.1109 (-1.8)	-0.0977 (-1.2)	-0.0815 (-0.9)	-0.0624 (-0.8)	-0.0403 (-0.6)	0.3928 (0.3)	0.7735	4.0980	1.8181
CNRNT	-3.3547 -0.8)						1.9255 (1.9)	-0.0650 (-4.3)				-0.0155 (-0.1)	-0.0770 (-0.6)	-0.0068 (-0.1)				0.8583	9.6933	1.3969
United States																				
CNRT	3.3214 (4.7)				0.7878 (4.7)	0.1493 (1.3)						-0.0730 (-0.5)	-0.0946 (-0.5)	-0.1105 (-0.6)	-0.1208 (-0.6)		0.3990 (0.7)	0.9161	13.1017	1.1988
CNRNT	6.1754 (3.5)						0.9131 (3.8)		-0.6963 (-2.4)	-0.0555 (-0.2)	-0.2800 (-1.1)							0.7122	3.7122	1.9957
Japan																				
CNRT	1.6603 (3.7)	0.8177 (7.8)										-0.0223 (-0.1)	-0.1492 (-0.6)	-0.2105 (-0.8)	-0.2061 (-0.9)	-0.1361 (-0.8)	0.7243 (1.0)	0.9498	33.0845	1.9291
CNRNT	2.6197 (3.1)						0.6879 (3.2)	-0.0955 (-5.1)				-0.2330 (-1.9)	-0.3017 (-2.1)	-0.2486 (-1.7)	-0.0737 (-0.5)		0.8568 (0.5)	0.9178	13.4074	1.3895
Canada																				
CNR	0.0258 (0.1)						0.9966 (3.7)					-0.4370 (-3.5)	-0.4850 (-2.9)	-0.4411 (-2.2)	-0.3055 (-1.6)	-0.0781 (-0.5)	1.7467 (0.8)	0.9437	29.3347	1.5571
The Netherlands																				
CNR	1.2805 (0.9)						0.3011 (1.7)					0.0926 (0.5)	0.1055 (0.3)	0.0883 (0.2)	0.0413 (0.1)	-0.0358 (-0.1)	0.3635 (1.7)	0.7107	3.6848	1.5164
Brazil																				
CNR	0.0886 (0.1)						0.6640 (7.0)					-0.2426 (-1.8)	-0.2733 (-1.8)	-0.2719 (-1.7)	-0.2381 (-1.4)		1.0258 (0.6)	0.9575	33.7948	1.5837
India																				
CNR	3.5007 (2.4)						0.3688 (1.3)					-0.2664 (-2.2)	-0.7037 (-3.7)	-0.8889 (-4.1)	-0.8218 (-4.1)	-0.5025 (-3.4)	3.1833 (0.8)	0.9716	59.9244	1.6549
Australia																				
CNR	-4.2938 (-3.6)		0.9786 (6.9)									-0.1679 (-2.1)	-0.2956 (-1.9)	-0.3175 (-4.2)	-0.2237 (-3.3)	-0.0438 (-0.5)	1.0585 (0.3)	0.9054	16.7563	2.4105
COMECON																				
CNR	0.6358 (0.4)						-0.1105 (-1.1)		0.8927 (2.2)	0.1286 (0.2)								0.8031	10.8745	1.9755
China																				
CNR	1.9316						0.3062 (1.7)		1.1493 (0.4)	-0.8520 (-2.3)								0.9543	55.7853	1.9936
Rest-of-the- World																				
CNR	4.4170 (5.1)							0.0550 (5.8)	0.1520 (0.8)	0.0188 (0.1)								0.9859	233.6997	1.9565

Table 2.6 Estimates of Synthetic Rubber Demand Equations

Dependent Variable \ Explanatory Variables	Constant	QTY	QTU	QTYC	QTYV	QTYT	IPI	T	CSR_{-1}	CSR_{-2}	CSR_{-3}	PN/PS	PN/PS_{-1}	PN/PS_{-2}	PN/PS_{-3}	PN/PS_{-4}	$\sum_{i=1}^{4} \lvert\beta_i\rvert$	R^2	F	DW
Italy																				
CSRT	-0.9760 (-1.3)	0.6830 (3.6)	0.5273 (4.2)										-0.0672 (-1.4)	0.0910 (2.2)	-0.01661 (-1.7)			0.9743	37.8640	1.5801
CSRNT	-2.9226 (-3.3)						1.1456 (4.0)		0.3115 (1.7)	0.1925 (1.1)								0.9846	235.0102	1.5666
France																				
CSRT	-5.6673 (-4.2)			0.7445 (5.1)	0.3357 (2.8)							0.0607 (0.4)	0.1131 (0.5)	0.1399 (0.6)	0.1411 (0.7)	0.1167 (1.0)	0.5716 (0.9)	0.9755	47.6904	1.0841
CSRNT	-3.6847 (-2.5)						1.1637 (2.9)	-0.0531 (-3.1)	0.8341 (11.1)									0.9830	328.3311	2.1288
West Germany																				
CSRT	0.4306 (0.5)			0.7578 (3.1)	0.2577 (2.8)							-0.0563 (-0.5)	0.1109 (1.0)					0.8456	12.3183	1.5169
CSRNT	-4.5592 (-6.5)						2.0924 (13.0)					0.3319 (2.6)	0.4107 (2.7)	0.4104 (2.5)	0.3308 (2.3)	0.1721 (1.4)	1.6559 (0.6)	0.9814	92.4299	2.5031
United Kingdom																				
CSRT	-6.0039 (-5.8)			0.7741 (9.4)	0.3653 (2.4)							0.0540 (1.3)	0.0228 (0.7)	0.0333 (0.7)				0.9588	37.2498	2.6831
CSRNT	-5.8441 (-2.4)						2.1954 (3.9)	0.0392 (3.9)				0.1196 (1.1)						0.9757	160.2768	1.7824
United States																				
CSRT	1.7084 (3.2)			0.7651 (6.5)	0.4125 (5.3)							0.1315 (2.4)	0.1196 (1.8)	0.1248 (1.6)	0.1470 (1.9)		0.5229 (0.3)	0.9769	57.7637	2.0597
CSRNT	0.6061 (0.7)						0.9571 (1.6)		0.0783 (0.2)	-0.2687 (-0.6)	0.4253 (1.1)							0.9224	17.8248	2.1190
Japan																				
CSRT	-0.5716 (-0.9)	1.2512 (14.5)	0.2074 (1.0)									0.1426 (1.2)	0.2640 (1.4)	0.3013 (1.4)	0.2544 (1.4)	0.1233 (0.9)	1.0857 (0.8)	0.9877	96.6440	2.3636
CSRNT	0.3558 (0.3)						0.6913 (1.4)		0.4708 (1.3)	-0.1163 (-0.3)	-0.1027 (-0.3)							0.8595	10.7018	1.6181
Canada																				
CSR	-3.8275 (-4.5)						1.8289 (11.6)						0.1540 (1.5)	0.3161 (2.8)	0.3540 (3.0)	0.2683 (2.3)	1.0925 (0.4)	0.9722	61.2938	2.3904
The Netherlands																				
CSR	-10.4465 (-2.6)						2.2500 (4.5)					0.4634 (0.9)	1.0843 (1.1)	1.3503 (1.1)	1.2613 (1.1)	0.8174 (0.9)	4.9767 (4.8)	0.9131	15.7592	1.7194
Brazil																				
CSR	-1.5290 (-1.8)						0.8641 (4.7)	0.0471 (2.4)										0.9952	1243.8501	1.6275
India																				
CSR	-6.7448 (-2.1)						1.9585 (3.2)					0.0575 (0.2)	0.9473 (2.3)	1.4384 (2.9)	1.5309 (3.3)	1.2249 (3.3)	5.1990 (1.9)	0.7766	5.2145	2.7679
Australia																				
CSR	-8.1189 (-2.2)	1.3507 (2.8)							0.0001 (0.1)	-0.2912 (-1.1)	0.3024 (1.4)							0.7371	4.9084	1.6452
COMECON																				
CSR	-1.5442 (-4.2)						1.0515 (4.5)		0.6711 (2.0)	-0.0922 (-0.2)	-0.3525 (-1.4)							0.9989	1532.6874	1.8992
Rest-of-the-World	3.0615 (1.6)							0.0472 (1.2)	0.2276 (0.7)	0.2006 (0.6)								0.9480	60.7309	2.1577

Table 2.7: Summary of Relative Prices Used in Demand Equations.

Country/Demand		$PN/PSBR^{1712}$	PN/PSBR	PN/PSR	PN/PSR1
Australia	/ CNR	✓			
Australia	/ CSR	✓			
Brazil	/ CNR	✓			
Brazil	/ CSR	✓			
Canada	/ CNR	✓			
Canada	/ CSR	✓			
West Germany	/ CNRT	✓			
West Germany	/ CSRT	✓			
India	/ CNR	✓			
India	/ CSR	✓			
Italy	/ CNRT	✓			
Italy	/ CSRT	✓			
Netherlands	/ CNR	✓			
Netherlands	/ CSR	✓			
UK	/ CNRT	✓			
UK	/ CSRT	✓			
USA	/ CNRT		✓		
USA	/ CSRT		✓		
Japan	/ CNRT			✓	
Japan	/ CSRT			✓	
Japan	/ CNRNT			✓	
France	/ CNRT				✓
France	/ CSRT				✓
West Germany	/ CNRNT				✓*
West Germany	/ CSRNT				✓*
UK	/ CNRNT				✓
UK	/ CSRNT				✓

Notes: (1) PN represent the price of RSS3-grade natural rubber, except in the case of West German rubber consumption in the non-transport sector (marked with *) where the average of RSS1-and RSS3-prices were used.

(2) $PSBR^{1712}$ represents the price of styrene-butadiene(SBR) grade 1712 (used mainly in tyre treads).

(3) PSBR represents the simple average price of SBR grades 1500 and 1712.

(4) PSR represents the simple average price of SBR grades 1500 and 1712 and polybutadiene(BR).

(5) PSR1 represents the simple average price of SBR grade 1712 and BR.

However, the impact of technological progress persisted in the non-transport sector where specialty synthetic rubbers are more important. The negative impact of this technological progress on natural rubber consumption in the non-transport sector was found for France, UK and Japan, but the corresponding expected positive impact of technological change on synthetic rubber consumption was substantiated for UK and Brazil only. For France and Japan the trend estimates had incorrect signs, possibly because the general-purpose synthetic rubber list prices were poor proxies for the prices of specialty synthetic rubbers used in these countries. In the Japanese case, the equation without the trend variable was selected. For France, the trend estimate was retained despite its incorrect sign since its omission severely affected the remaining estimates.

Table 2.8 presents the short- and long-run estimates of elasticities of demand with respect to the respective relative prices used in the demand equations. The calculated estimates (synthetic rubber consumption in the Italian transport sector notwithstanding) generally substantiated the a priori arguments for low price elasticity of input demand, especially in the short-run.

Tables 2.2, 2.3 and 2.4 revealed the range of input combinations that are used in the tyre industry. Since a breakdown of the aggregate synthetic rubber consumption data for the transport sector is not available, the precise synthetic rubbers input combination used is not known. Thus the use of the simple average list price of the major types of synthetic rubbers may not correspond precisely to the synthetic rubber input combinations used. The non-availability of

Table 2.8: Estimates of Short (Long) Run Demand Elasticities With Respect to Relative Price of Natural Rubber to Synthetic Rubbers

Country	Natural Rubber		Synthetic Rubbers	
	Transport Sector	Non-Transport Sector	Transport Sector	Non-Transport Sector
Italy	-0.0638 (-0.6193)	n.a. (n.a.)	0.0000 (-0.0423)	n.a. (n.a.)
France	-0.0435 (-0.3467)	n.a. (n.a.)	0.0607 (0.5715)	n.a. (n.a.)
West Germany	-0.0102 (-0.6876)	-0.3445 (-3.5324)	0.0000 (0.0546)	0.3319 (1.6559)
United Kingdom	-0.1109 (-0.3928)	-0.0155 (-0.0993)	0.0540 (0.1101)	0.1196 (n.a.)
United States	-0.0730 (-0.3990)	n.a. (n.a.)	0.1315 (0.5229)	n.a. (n.a.)
Japan	-0.0223 (-0.7243)	-0.2330 (-0.8568)	0.1426 (1.0857)	n.a. (n.a.)
Canada	-0.4370 (-1.7467)		0.0000 (1.0925)	
Netherlands	Estimates of wrong sign and insignificant		0.4634 (4.9767)	
Brazil	-0.2426 (-1.0258)		n.a. (n.a.)	
India	-0.2664 (-3.1833)		0.0575 (1.5990)	
Australia	-0.1679 (-1.0585)		n.a. (n.a.)	
COMECON	n.a. (n.a.)		n.a. (n.a.)	
China	n.a. (n.a.)		-	
Rest-of-the-World	n.a. (n.a.)		n.a. (n.a.)	

prices for specialty synthetic rubbers used also lends bias to the price data used. Hence any intersectoral comparison of demand elasticities should be made cautiously since these elasticities should be interpreted as being indicative only of orders of magnitude.[8] As list prices are regularly published in advance, the elasticities may however be interpreted as reflecting consumption behaviour that is influenced by the certainty of price bands within which the synthetic rubber prices will fluctuate and the uncertainty regarding the price band within which natural rubber prices will fluctuate. This feature, together with those factors causing "habit persistence" then makes the low demand elasticities inevitable.

8 A _priori_ the presence of a positive bias (over-estimation since elasticities is negative) and negative bias (under-estimation since elasticities is positive in value) in the natural and synthetic rubbers estimates respectively may be expected.

CHAPTER THREE

THE SUPPLY OF RUBBERS

3.1 Introduction

This chapter discusses the supply of rubbers, both natural and synthetic.

For each type of rubber a supply function is specified on the basis of their production characteristics; estimates of the supply functions are then presented. At risk of imbalance in treatment of the two types of rubbers, the lengthier discussion of natural rubber reflects the relative data abundance in the available literature on natural vis-a-vis synthetic rubbers. Whereas demand data limitations are manifest in the use of list prices instead of traded prices, the supply data limitations are manifest in the assumptions concerning synthetic rubber supply.

3.2 Five Features of Natural Rubber Supply

Natural rubber is a perennial tree crop; amongst perennials, natural rubber has the atypical feature of broadly non-seasonal production and therefore of an indistinct harvesting period. To understand the determinants of natural rubber supply, the features characterising its cultivation and production will be discussed first.

The supply of natural rubber is characterised by five main features. These are (1) the long gestation period, (2) a long productive lifespan, (3) a yield profile resembling a flattened F-distribution curve, (4) non-seasonal production except for inclement weather and wintering effects which vary across locations and therefore have little aggregate influence and (5) a lengthy period before the impact of any agronomic technological progress can be felt.

The gestation period refers to the period between initial input and first output; this period can range from five to twelve years depending on the type of clones and the quality of seedlings used, and the maintenance of the tree and its environs. This is then followed by a long productive lifespan - an extended period of output flowing from the initial production. For natural rubber, the productive lifespan ranges from 15 to 35 years, again depending on the types of clones and quality of seedlings used and the maintenance of the tree and environs during its productive lifespan. The resulting yield profile (depicting the yield of a rubber tree over its lifespan) generally tends to increase rapidly in the first few years after production commences; it then levels off for about 10 to 15 years before markedly diminishing yield sets in. Figure 3.1 presents some yield profiles for the period before markedly diminishing yield begins; profiles A, B and C are based on Malaysian data and profile D is based on Indonesian data. Profiles A and B, obtained from Allen(1972) refer to estate performance; profile A is for a group of modern high-yielding clones while B is for earlier high-yielders. The

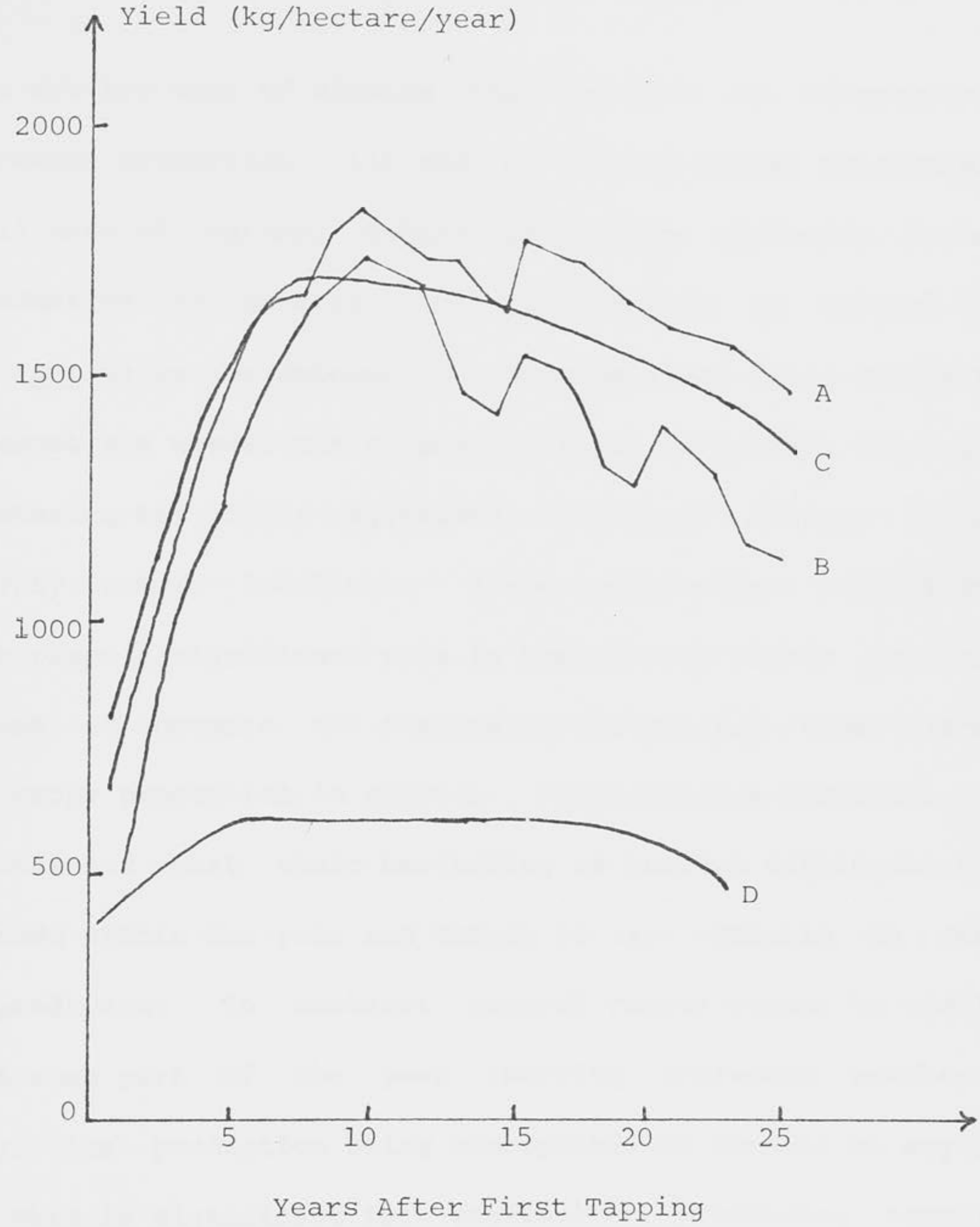


Figure 3.1: Variation of Yield with the Number of Years After First Tapping.

difference in rubber smallholder performance in Malaysia and Indonesia is seen by comparing profile C for Malaysia which was estimated by Smit (1978) and profile D for Indonesia (for largely unselected material) which was estimated by Barlow and Muharminto (1981).

There are two ways of viewing the question of seasonality in natural rubber production: (i) that of natural rubber production *per se* and (ii) that of natural rubber production vis-a-vis perennial crops production in general. The seasonality of natural rubber production *per se* is the outcome of wintering (leaf fall) during which period (about six weeks) the tapping of trees is halted. On a global level, wintering has little aggregate influence because wintering periods vary across locations. Since smallholder natural rubber production plays a significant role in the natural rubber market, it is relevant to compare the seasonality of natural rubber vis-a-vis perennial crops production in general. Fruit-bearing perennial crops are seasonal in that their harvesting is bunched within one or two short periods within the year and output is less amenable to control by the producers. In contrast natural rubber output is available throughout most part of the year (barring inclement weather and wintering), its production being susceptible to control at any point in time. This is significant for smallholder producers, especially those using only family labour, since the problem of peak labour demand such as during the harvesting of fruit-bearing perennials therefore does not arise. In the very short-run, the decision to produce rubber depends on the decision to tap the tree or not. If the tree is to be tapped, the output flow can then be controlled by the tapping frequency and intensity and the use of chemical stimulants (not fertilisers since fertiliser effects are only felt with a one- to three-year lag). The ability to halt production instantaneously (by not tapping) but inability to increase output instantaneously beyond the trees' potential output introduces an asymmetry into the short run production elasticity of natural rubber; viz. producers can only respond to price rises only if the tapping rate is below the maximum feasible rate. This asymmetry is reinforced by the fact that more than 50 percent of the world's natural rubber production is in the hands of smallholder producers, many of whom use family labour in rubber tapping.[1] The reactions of smallholder producers to price declines are known to vary in accordance with the degree of price fall. Under a relatively small price decline, the smallholders would tend to increase production so as to maintain their earnings from rubber. However, when the drop in price persists the smallholders are then inclined to abandon their rubber trees (temporarily at least) to turn to other more remunerative activities. Where the land value is relatively low, as in land-abundant Indonesia and Thailand, the smallholders would generally turn to alternative (cash or subsistence) crop cultivation. In less land-abundant situations as in Malaysia and Sri Lanka, the smallholders may increase production to maintain their income levels or else seek alternative employment to which they may be

1 About two-thirds of the global 2.5 million people cultivating natural rubber are subsistence farmers and smallholders with less than 4 acres of natural rubber land (Anon., 1980a:1).

accessible.[2] The problem of natural rubber price instability therefore carries wider economic implications.[3]

In contrast to technological change in manufacturing, the effects of technological progress in the natural rubber industry are felt relatively slowly. This is because experimentation in biological engineering and the subsequent diffusion and adoption of the new technologies takes place over a very long period.[4]

3.3 General Determinants of Natural Rubber Supply

The supply of perennials hinges on their long gestation and productive lifespan, which features are fundamental to understanding investment and production behaviour in the industry. This is because the time horizon for natural rubber producers must, pari passu with the lifespan of rubber trees, be longer than that for producers of

2 This is especially relevant to the situation in Peninsular Malaysia in recent years because of the good transport facilities and the availability of industrial employment.

3 For details see Bauer (1948), MacBean (1966) and Radhakrishnan (1974).

4 For details on the R and D process in natural rubber cultivation see Ng and Pee (1977).

annual crops. Upon planting the tree becomes a capital asset for the planter/producer. Consequently, decision-making in planting and/or replanting perennials becomes a problem in capital theory where the objective is to maximise the present value of the discounted future stream of net returns from the rubber investment. In the case of smallholder rubber, this is complicated by the simultaneous presence of cash and subsistence "intercrops" cultivation from which substantial values are derived. Indeed in the more land-abundant rubber producing countries, rubber planting alone may not be justified on present value grounds. However, given the data constraints, the theoretical developments of perennial crop response have in the main taken into consideration alternative competitive crops rather than such complementary intercropping.

Theoretically, the relevant time horizon should also determine the time periods corresponding to the short- and long-runs. At the producer level the short-run, by the Marshallian-Cournot definition, is that time period during which the productive capacity of a producer is fixed. This means that short-run supply variations are restricted only to variations in the use of the variable factors in combination with the fixed productive capacity. At the industry level, the short-run is restricted by the condition of no new producers entering the market.

For perennial crops, the productive capacity at any time period is represented by the existing stock of mature trees. Barring very short time periods, distinction between short- and long-runs for perennial crops is hazardous because of the continuously changing stock of mature trees, especially because smallholders in land-abundant countries may switch between cultivation of natural rubber and other crops. This in turn stems from the fact that the rubber producer, unlike the typical manufacturer (or at least the version in theory) has <u>many</u> units of capital (namely trees). The problem is further aggravated in the case of natural rubber since there is no distinct harvesting period. To illustrate the difficulty of distinguishing short- and long-run supply responsiveness consider rubber production at any time period t. For any such period, the supply function for rubber is

$$(3.1) \qquad Q = g_1(PN, PC, PI, A(m), T, W, \ldots)$$

where Q is output;

PN is the price of natural rubber;

PC is the price index of products competing for inputs used in natural rubber production;

PI is the vector of prices of factor inputs;

A(m) is the mature acreage;

T is the state of technology;

W is the weather/rainfall variable (this affects the yield of trees as well as stock of trees via damaging trees).

It is more helpful to write output Q_t from any given mature acreage $A(m)_t$ in any given period as

(3.2) $$Q_t = A^T_t . Y_t \qquad A^T_t \leq A(m)_t$$

where A^T_t is the mature acreage that is being tapped (that is, the number of trees tapped) and Y_t is the actual average yield per tapped acre.

For any time period t, the mature acreage $A(m)_t$ may be considered to proxy the existing stock (number) of mature trees and hence the productive capacity. By the Marshallian-Cournot criterion, the short-run is the period during which $A(m)_t$ is fixed. This raises the problem of distinguishing the short- from long-runs, since $A(m)_t$ may be constantly changing as new mature acreages (from new planting and/or replanting) come into production whilst old mature acreages (removed and/or abandoned) go out of production. It was mentioned that the gestation period is determined by the types of clones and quality of seedlings used. Abstracting from the qualitative difference in clones and seedlings used, $A(m)_t$ at any time period t may be expressed as

(3.3) $$A(m)_t = A(m)_{t-1} + \sum_{i=5}^{n} N_{t-i} + \sum_{i=5}^{n} R_{t-i} - L_t$$

$$\text{for} \quad 5 \leq n \leq 12$$

where n is the gestation period of natural rubbers;

$\sum_{i=5}^{n} N_{t-i}$ is the sum of surviving new plantings undertaken during the period (t-5, t-n) that has come into production in the current period;

$\sum_{i=5}^{n} R_{t-i}$ is the sum of surviving replantings undertaken during the period (t-5,t-n) that has come into production in the current period, and

L_t is the loss of mature trees in period t due to disease or age;

It should be mentioned that the terms N_{t-i} and R_{t-i} allow for the situation where a stand of trees though of the same age may differ in maturity and therefore enter the production phase at different points in time. This difference in growth rates which leads to time difference in production initiation of the trees of the same age is particularly important in Indonesian and Thai rubber production.[5]

The change in mature acreage between any two periods is then given by

$$(3.4) \qquad \Delta A(m)_t \equiv A(m)_t - A(m)_{t-1}$$

$$= \sum_{i=5}^{n} N_{t-i} + \sum_{i=5}^{n} R_{t-i} - L_t$$

Given the non-seasonality of rubber versus seasonality of other fruit-bearing perennial crop production, mature trees would therefore be constantly coming into production in accordance with the prior planting and replanting schedules. Thus, except for very short time periods, $A(m)_t$ would be changing continuously; hence annual production reflects the sum of both short- and long-run supply responsiveness since production in any period t is the result of

5 I am grateful to Dr. Barlow for this point.

(a) short-run response to price changes and

(b) long-run response to planting decisions taken (t-i) periods ago for i=5, 6, ..., 12;

In summary, short-run supply response relates to actual output while long-run supply response relates to potential output.

Even supposing that the time period was specified such that $A(m)_t$ is constant, the data requirement for determining movements in $A(m)_t$ accurately is enormous as it entails knowledge of the number of trees planted and removed at each point of time within the gestation period.

Assuming a sufficiently short time period to warrant fixed productive capacity $A(m)_t$ in each t, the short-run supply response can then be effected by varying the yield. The short-run determinants of variations in yield are:

(a) the tapping frequency F. In general the selected frequency is used throughout the productive lifespan of a tree, thus defining a long-run tapping "system" applicable to each tree. For short-run responsiveness, the producer must be able and willing to vary the tapping frequency in response to natural rubber price fluctuations.

(b) the tapping intensity I. This refers to the length of the tapping cut. In general, the tapping frequency and intensity are jointly determined.[6]

(c) the number of trees tapped per acre N(1). This reflects the density of planting and the 'reserve' of untapped trees.

(d) the number of trees tapped per worker N(2). The argument for the inclusion of this variable is that early morning tapping is important in extracting maximal latex from the tree. Thus savings in labour costs by a bigger tapping task per tapper may be offset by lower overall unit yield; that is, the unit yield is negatively related to the task size. However the significance of tapping task has not been empirically substantiated.

(e) the application of chemical stimulants M. In the short-run, yield can be raised by use of stimulants. The disadvantage of this is that continuous usage over a longer period causes residual effects on subsequent yields.[7] However, M is more important as a long-run substitute for labour through reduction of the tapping frequency F.

Hence the yield function may be written as

$$(3.5) \qquad Y = g_2(F, I, N(1), N(2), V, G, S, M, H, ...)$$

where (apart from the variables defined above):

6 For details of tapping systems, see Barlow (1978:135-140) and Pee and Arope (1976:81-83).

7 See Barlow (1978:140-148) and Pee and Arope (1976:83-85).

V is the varietal composition of the stand of trees (this is correlated with weather (W) since biological engineering has led to the development of different clones to suit areas having different weather conditions);

G is the age composition of the stand of trees;

S is the quality of the soil and elevation;

H is the condition of the trees (dependent on overall maintenance of the trees and their environs and the application of chemical fertilisers).

3.4 Previous Econometric Studies of Perennial Crop Supply Response

Up to the early 1970s, attempts at estimating supply response for perennial crops have been guided by the long gestation period and productive lifespan features of perennials and recognition of the critical role of expectational variables in perennial crop production. The essence of these attempts concentrated on specifying systems of functional relationships that would explain (a) potential output and (b) actual output.

The relationship used for potential output essentially accounts for the longer-run planting behaviour and is generally a <u>Planting-Price</u> relationship that translates the desired stock to actual stock of trees. For actual output, the relationship used essentially accounts for the shorter-run production behaviour and is generally a Price-Output (Harvesting) relationship. In general the Nerlovian framework of partial adjustment and adaptive expectations was applied to translate the desired and expected variables to observable (measurable) variables.[8] Thus while recognising the existing stock of trees as a source of capital, these attempts failed to integrate the planting process with capital accumulation, and the harvesting process with (optimal) capacity utilisation.

As the major models developed up to the early 1970s have been surveyed by Lim (1975), it suffices here to relate the essence of these models to the issues and problems of investment in perennial crops.

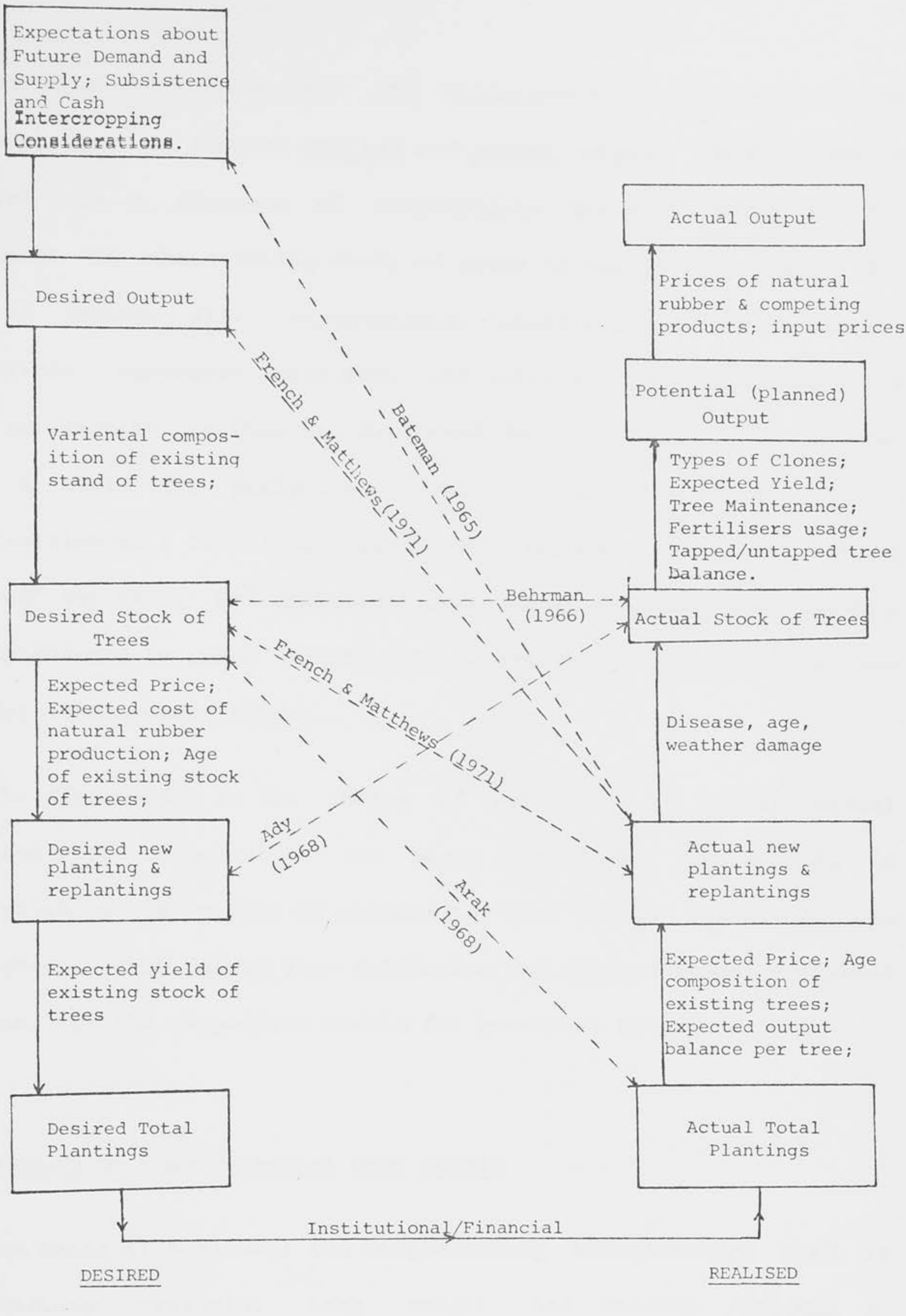
The stages from planning investment to actual production of perennial crops are summarised in Figure 3.2 by the Desired and Realised panels. The intermediate stages are in general essential to all perennial crop cultivation. Two key points in the analysis are the start and close of the stages illustrated which concern

(a) the forces that motivate a producer to plant;

(b) the relationship between area planted and actual output attained.

8 See Nerlove (1956, 1958).

Figure 3.2: Investment Planning and Production of Perennial Crops



Key

______ Sequence of intermediate stages between planning investment in natural rubber and production of natural rubber and their corresponding determinants.

- - - - - Functional relationships forming the essence of various models of perennial crop supply.

The flow chart shows that the cornerstone in perennial crops analysis lies in linking desired and actual output. This linkage is realised via a sequence of intermediate stages leading to the adjustment of the existing stock of trees to the desired stock. The range of factors viz. expectations, institutional and financial constraints, agronomic practices and metereological conditions, and their interaction can then be identified from the sequential stages. Thus a basis for analysing perennial crop cultivation is the specification of a functional relationship between an "actual" and a "desired" variable. For analytical consistency the basic relationship is complemented by other functional relationships representing the relevant intermediate stages.

The flexibility in the choice of any pair of desired-actual variables for focussing the basic functional relationship is illustrated by the variety of pairing (by the dotted lines) in the flow chart. Each dotted line delineates the desired-actual variables pair basic to the respective models for perennial crops.

Summary of Some Perennial Crop Models

The basic (functional) and complementary relationships used in the various perennial crop models are briefly reviewed in chronological order below.

In Bateman's (1965) model the basic relationship used is that between actual planting (planted area) and producer's price expectations (based on expectations about future demand and supply).

Nerlove's adaptive expectations scheme was used to transform the expected price into determinants of planting. Actual planting is then related to observed prices and actual output becomes a function of actual planting, price and natural factors (viz. rain, humidity).

Behrman's (1968) model is based on a planting equation relating actual to the desired stock of trees. As the flow chart indicates, this is complemented by an equation relating the desired stock of trees to the expected prices.

Ady's (1968) model is essentially a capital stock model based on the assumption that the existing (surviving) stock of trees is an important determinant of further planting. That is, the actual tree stock influences desired new plantings. This basic relationship is complemented by equations relating actual to potential output and hence potential output to existing tree stock.

Arak (1968) focussed her interest on the determination of changes in the tree stock. It is basically a stock-adjustment model, relating the actual new plantings to the desired stock of trees. The remaining equations in the model completing the adjustment mechanism are:

(a) an equation relating the rate of new planting and replanting to the proportion of old to young trees and expectations about the labour cost (due to the near-monopsonistic market for labour in the Sao Paulo coffee sector which she was studying);

(b) an equation accounting for the cost of tree removals and

(c) an equation accounting for tree abandonment.

The model by French and Matthews (1971) is the most detailed of this group of models. The two basic relationships concern the adequacy of the existing tree stock in producing the desired output and the adjustment of new plantings towards the desired stock of trees. The remaining equations in the model then caters for

(a)the acreage removed each year;

(b)the transformation of unobservable expectations variables to observable variables and

(c)variations in yield.

The above discussion shows that in examining the responsiveness of perennial crops it is necessary to distinguish between:

(a) the level of production in each period (reflecting the harvesting decision) and

(b) the number of trees planted in each period (reflecting the investment decision).

The short- and long-run supply responsiveness may then be defined by (a) and (b) respectively since (a) reflects the influence of price on supply under fixed productive capacity, while (b) represents the stock adjustment process towards the desired productive capacity.

The perennial crop supply models mentioned so far have assumed that the investment and harvesting decisions are mainly determined by expected prices. The supply function is derived from three basic equations involving desired output (q_t^*) and expected prices (P_t^e)

$$(3.6) \qquad q_t^* = \alpha + \beta p_t^e$$

$$(3.7) \qquad q_t - q_{t-1} = \lambda(q_t^* - q_{t-1}) \qquad 0 < \lambda \leq 1$$

$$(3.8) \qquad P_t^e - P_{t-1}^e = \theta(P_{t-1} - P_{t-1}^e) \qquad 0 < \theta \leq 1$$

which is Nerlove's supply response model, where * denotes long-run equilibrium or desired output and e denotes expected value.

Solving equations (3.6) - (3.8) gives the supply function as

$$(3.9) \qquad q_t = \alpha\theta\lambda + \beta\theta\lambda(P_{t-1}) + [(1-\theta) + (1-\lambda)]q_{t-1} - [(1-\theta)(1-\lambda)]q_{t-2}$$

As Wickens and Greenfield (1973) indicated in their study of the world coffee market, the above approach suffers from the disadvantages of (a) having the model based on ad hoc behavioural relationships with (b) the equations representing behavioural relationships failing to distinguish between the investment and harvesting decisions.

Consequently, the derived supply function does not adequately capture the lagged response of the perennial crop supply to past investment.

3.5 Wickens and Greenfield's Model of Supply Response

In estimating the supply response equations for natural rubber, the Wickens and Greenfield model for perennial crop production was applied. The model is an improvement over earlier models in its explicit treatment of the tree stock as capital and in constraining the harvesting decision by the existing productive capacity. The supply function is derived from a formal optimising model similar to the investment model developed by Jorgenson (1965). The model also has the attractive features of (a) incorporating the yield profile of the crop in question and (b) distinguishing the short-term from the long-term impacts of price on supply.[9]

The model consists of three basic structural relationships reflecting the supply behaviour in both the short- and long-run. The supply response function to be estimated is derived as the reduced form solution of the three-equation system. Consequently both the short- and long-run supply response (adjustment) coefficients are embedded in the nonlinear coefficients of the reduced form equation.

9 The abortive attempt at a similar line of analysis by Cheong (1971) in his Ph.D. thesis ought to be mentioned.

The three structural relationships are: (1) the Vintage Production Function which reflects the constraint of potential output on supply; (2) the Investment Function which reflects the long gestation lag in perennial crop potential supply; (3) the Harvesting Function which reflects the short-run harvesting decision (to tap the rubber tree or not and the rate of extraction). Since in this analysis of world natural rubber supply, the Wickens and Greenfield model is adopted without modification (except for the minor disregard of the biennial cycle for coffee production that was incorporated in their harvesting equation), only the three basic structural equations are discussed in brief.[10]

The Vintage Production Function

The Vintage Production Function gives the potential production

$$(3.10) \qquad q_t^p = \sum_{i=0}^{n} \delta(i, t) I_{t-i}$$

$$= \sum_{i=0}^{n} \delta_i I_{t-i} \qquad\qquad \delta(i, t) \equiv \delta_i$$

where q_t^p is the production potential (of maximal output);

10 An application of the model to natural rubber has been made by Dowling(1977), but only to natural rubber production in Thailand.

I_{t-i} is the number of trees planted i years ago which have survived to year t and

$\delta(i, t)$ is the average yield of the I_{t-i} trees.

In terms of Figure 3.1 the Vintage Production function relates potential output to actual total planting in the previous periods. Since the production function only refers to yield and plantings, several assumptions regarding land and labour inputs are implicit. Taking the number of trees to be capital, the land and labour are assumed to be the other essential but non-substitutable inputs which are used in fixed proportions with capital. Hence the planting densities (capital/land ratio) and tapping task per labourer (capital/labour ratio) are assumed fixed. Where cash and subsistence intercropping are widespread, this assumption would not hold since the capital/labour ratio then tends to vary with the price of output. Land and labour are also assumed to be in unlimited supply so that there are no constraints on attaining the desired investment or fully utilising the capital thereafter.

The Investment Function

Since rubber trees are characterised by long gestation periods and productive lifespan, the decision to plant (invest in) rubber trees is based on the expected discounted income stream from the investment. As cash and subsistence intercropping are disregarded in the Wickens and Greenfield model, the investment function is derived from a formal optimising model assuming no such intercropping exist. Let

V be the expected discounted net revenue;

r be the rate of discount;

p_t^e be the expected unit price for natural rubber;

s_t^e be the expected unit cost of harvesting natural rubber when all potential output q_t^p is harvested;

F_t be the fixed cost in year t;

$f_1(I_t)$ be the planting costs, with $f_1'(I_t) > 0$, $f_1''(I_t) > 0$

I_t be the number of trees in year t.

Then

$$(3.11) \qquad V = \sum_{t=0}^{\infty}(1+r)^{-t}[(p_t^e - s_t^e)q_t^p - F_t - f_1(I_t)]$$

V is maximised by choosing suitable time paths for q_t^p and I_t The Lagrangean is

$$(3.12) \qquad L = V + \lambda_t(q_t^p - \sum_{i=0}^{\infty} \delta_i I_{t-i})$$

$$= \sum_{i=0}^{\infty} (1+r)^{-t}\{(q_t^p - s_t^e)q_t^p - F_t - f_1(I_t)\}$$

$$+ \lambda_t(q_t^p - \sum_{i=0}^{\infty} \delta_i I_{t-i})$$

from which the necessary (first-order) conditions for a maximum are

(3.13.i) $$\delta L/\delta q_t^p = (1+r)^{-t} . (p_t^e - S_t^e) + \lambda_t = 0$$

(3.13.ii) $$\delta L/\delta I_t = -(1+r)^{-t} . \delta f_1/\delta I_t - \sum_{i=0}^{\infty} \lambda\delta_i = 0$$

(3.13.iii) $$\delta L/\delta\lambda_t = q_t^p - \sum_{i=0}^{\infty} \delta_i I_{t-i} = 0$$

The rate of investment obtained from (3.13.ii) is

(3.14) $$\delta f_1/\delta I_t = \sum_{i=0}^{\infty} (1+r)^{-i} . (p_{t+i}^e - S_{t+i}^e)\delta_i$$

that is, investment is undertaken up to the point where the marginal cost of investing in one or more tree equals the expected discounted net revenue to be obtained from the future production of that tree. The assumption that $f_1(I_t)$ is convex is used to determine the rate of investment; that is, the rate of planting to attain the desired number of trees.

If $f_1(I_t)$ is a quadratic function of I_t, then the Investment Function derived from $\delta F/\delta I_t$ is

(3.15.i) $$I_t = \beta_0 + \beta_1 R_t^e$$

where

(3.15.ii) $$R_t^e = \sum_{i=0}^{\infty} (1+r)^{-i} . \delta_i (p_{t+i}^e - S_{t+i}^e)$$

To find proxies for the investment function variables, note that R_t^e which is a function of expected prices can instead be represented by a distributed lag of past rubber prices. Assuming a Koyck scheme for the distributed price lags, the investment function becomes

(3.16) $$I_t^a = \beta_0 + \sum_{i=0}^{n} \omega_i P_{t-i} \qquad \omega_i = \beta\lambda^i, \; 0 < \lambda < 1$$

$$= \beta_0^* + \beta(PN)_t + \lambda I_{t-1}^a$$

where $I_t \equiv I_t^a$ is the actual number of tress planted in period t.

and PN is the price of natural rubber.

Assuming that trees losses due to disease, removal and abandonment are relatively small, and using the change in planted acreage to proxy new plantings, the investment function may be approximated by

(3.17) $$\Delta A_t = \beta_0^* + \beta(PN)_t + \lambda(\Delta A_{t-1})$$

The investment function can be written more generally as

(3.18) $$I_{t-i} = \beta_0^* + \beta(PN)_{t-i} + \lambda I_{t-i-1}$$

$$= \beta_0^*(1 - \lambda D)^{-1} + \beta(1-\lambda D)^{-1}(PN_{t-i})$$

with $D \equiv$ first-differencing operator

and since $I_{t-i} - \lambda I_{t-i-1} = (1-\lambda D)I_{t-i}$

The Harvesting Function

The harvesting decision function is to explain the short-run supply behaviour.

In the short-run the upper limit in production is given by the production capacity, which is the potential output of the existing stock of trees. Whether the potential output is fully exploited in each period depends on the profitability of doing so. It is assumed that this is determined by the recent behaviour of natural rubber prices so that actual production will be some function of the potential output and a short distributed lag of natural rubber prices; that is:

$$(3.19) \qquad q_t = \alpha_0 + \alpha_1 q_t^p + \sum_{i=0}^{m} b_i P_{t-i}$$

The Reduced Form Supply Equation

The reduced form supply equation is then obtained by substituting the potential output equation (3.10) and investment equation (3.18) in the short-run supply equation (3.19). This gives

$$(3.20) \qquad q_t(1-\lambda D) = \alpha_0(1-\lambda D) + \alpha_i \sum_{i=0}^{n} \delta_i(\beta_0^* + \beta P_{t-i}) + (1-\lambda D)\sum_{i=0}^{m} b_i P_{t-i}$$

Expanding (3.20) and collecting terms, equation (3.20) becomes

$$(3.21) \qquad q_t = \text{Constant} + \sum_{i=0}^{n} \tau_i P_{t-i} + \lambda q_{t-1}$$

where

$$\tau_i \begin{cases} = \alpha_1\beta\delta_0 + b_o & i=0 \\ = \alpha_1\beta\delta_i + b_i - \lambda b_{i-1} & i=1, 2, \ldots, m \\ = \alpha_1\beta\delta_i - \lambda b_{i-1} & i=m+1 \\ = \alpha_1\beta\delta_i & i=m+2, \ldots, n. \end{cases}$$

In equation (3.21) the lagged supply term q_{t-1} is related to the dynamics of the investment function whilst the nonlinear price coefficients are related to short-run price response and long-term adjustment to the yield profiles.

It can be noted from the composite term τ_i that:

(i) in the current period, output response is determined by the short-run price coefficient b_o;

(ii) in the medium-term ($i \leq m$) output response is determined by the yield δ_i and price coefficients b_i.

(iii) for $i = m+1$, τ_i is influenced by the yield δ_i and price coefficients b_m;

(iv) for the longer-run, τ_i is proportional to the yield δ_i;

Thus the nonlinear coefficients show the dominance of price in the short- to medium-term supply response and of yield in the longer-term response. In the medium-term, τ_i is influenced by the short- to medium-term adjustment and the relative size of the coefficients δ_i and b_i while in the long-run τ_i is directly proportional to the yield profile.[11]

Since yield of rubber trees levels off after about four to five years after the first tapping (depending on the type of trees, care and maintenance), the reduced form expression can be simplified by first differencing so as to shorten the lag. Then

11 A problem with this approach is that the relationship between 'm' and the gestation period for natural rubber production cannot be directly established.

$$(3.22) \qquad q_t = \sum_{i=0}^{k} \tau_i^* p_{t-i} + (1+\lambda) q_{t-1} - \lambda q_{t-2}$$

where

$$\tau_i^* \begin{cases} = \tau_i = \alpha_1 \beta_0 \delta_0 + b_0 & (i=0) \\ = \tau_i - \tau_{i-1} = \alpha_1 \beta(\delta_i - \delta_{i-1}) + (b_i - b_{i-1}) \\ \qquad -\lambda(b_{i-1} - b_{i-2}) & (i=1,2 \ldots,k) \\ = -\tau_{i-1} & (i=k+1) \end{cases}$$

3.6 Estimation of Supply Response Equations

The supply response equation (3.22) was estimated separately for the chief natural rubber producing countries of Africa, Brazil, Indonesia, Malaysia, Sri Lanka and Thailand.[12] To account for the balance world production (mainly in Burma, China, Indochina, Papua New Guinea and the Philippines), a Rest-of-the-World supply equation was also estimated. The natural rubber market price quotations used in the estimation were chosen so as to reflect the orientation of the producing countries to the rubber trading centres geographically nearest to them. Thus the Singapore f.o.b. price quotations were used in estimating the supply equations for India, Indonesia, Malaysia, Sri Lanka, Thailand and the Rest-of-the-World; for Africa

12 For an empirical evaluation of the acreage function as a proxy for investment function, see Appendix 3.A.

and Brazil the London and New York price quotations were used respectively. To reflect the yield profiles of rubber trees, third and fourth order polynomials were alternatively tried in the Almon scheme specified for the distributed price lags; the flexibility of the Almon scheme provides a means of determining the most appropriate lag lengths for price in each case.

The estimation results presented in Table 3.1 indicate fairly good fits overall with the distributed price lags generally behaving in accordance with the expected pattern. However, in the choice of market price quotations that for Brazil appeared unsatisfactory; although estimation with New York price quotations gave a good fit, the resulting Durbin-Watson statistic was unduly high. Re-estimation with Singapore prices improved the Durbin-Watson statistic; for Brazil, the supply response equation using Singapore prices was selected for inclusion in the model.

The estimates for the distributed price lags generally followed the expected pattern; that is, the price coefficients have positive values over the periods at the tail-ends and are negative in value over the interim lagged periods. This is in accordance with the nonlinear price coefficients composition given in equation (3.19). Since the average tree is tapped in the sixth to seventh year, the nonlinear price coefficients can be expected to resume positive values around the sixth or seventh lag. In general the price estimates conform with this expectation. In cases where positive values are resumed at much later lags, two non-mutually exclusive reasons may be given; either (a) the tapping of trees was initiated at a later stage

Table 3.1: Estimates of Supply Response Functions for Natural Rubber Producing Countries, 1956-1978

	QN_{-1}	QN_{-2}	PN	PN_{-1}	PN_{-2}	PN_{-3}	PN_{-4}	PN_{-5}	PN_{-6}	PN_{-7}	PN_{-8}	PN_{-9}	PN_{-10}	PN_{-11}	PN_{-12}	PN_{-13}	PN_{-14}	$\sum_i \lvert\beta_i\rvert$	R^2	F	DW
(1) Africa	0.2384 (0.7)	-0.0041 (-0.01)	0.1224 (2.0)	0.0819 (1.2)	0.0176 (0.3)	-0.0505 (-1.4)	-0.1068 (-1.7)	-0.1404 (-1.3)	-0.1447 (-1.1)	-0.1178 (-0.9)	-0.0619 (-0.5)	0.0160 (0.2)	0.1047 (3.5)	0.1884 (2.3)	0.2467 (1.8)	0.2549 (1.5)	0.1839 (1.4)	1.8385 (0.2)	0.7308	1.6292	2.2498
(2) Brazil	1.1348 (4.2)	-0.3324 (-1.5)	-0.0042 (-2.1)	-0.0030 (2.9)	0.0042 (3.3)	0.0024 (2.4)	-0.0002 (-0.1)	-0.0022 (-1.2)	-0.0026 (-1.6)	-0.0015 (-1.6)	0.0008 (0.8)	0.0028 (1.7)	0.0027 (2.0)	-0.0022 (-0.8)				0.0288 (0.0)	0.8031	3.3991	2.4386
(3) India	-0.9147 (-3.0)	-0.2570 (-0.8)	-0.0448 (-0.9)	0.0465 (1.8)	0.0924 (2.6)	0.1046 (2.5)	0.0933 (2.1)	0.0679 (1.5)	0.0362 (0.9)	0.0047 (0.1)	-0.0210 (-0.7)	-0.0369 (-1.4)	-0.0400 (-1.3)	-0.0288 (-0.7)	-0.0028 (-0.1)	0.0370 (0.9)	0.0885 (1.8)	0.7454 (0.1)	0.9503	6.3684	2.0888
(4) Indonesia																					
(a) Estates	0.5600 (2.5)	-0.5702 (-2.1)	0.0698 (4.6)	0.0375 (2.6)	0.0079 (0.9)	-0.0158 (-2.4)	-0.0314 (-2.6)	-0.0379 (-2.2)	-0.0352 (- .9)	-0.0243 (-1.5)	-0.0072 (-0.8)	0.0129 (4.3)	0.0319 (2.9)	0.0446 (2.4)	0.0447 (2.2)	0.0249 (1.8)		0.4259 (0.04)	0.9612	8.2677	3.0969
(b) Small-holders	-0.3435 (-1.9)	0.3909 (2.4)	0.1429 (3.2)	0.0260 (0.9)	-0.0239 (-1.5)	-0.0310 (-1.4)	-0.0152 (-0.4)	0.0081 (0.2)	0.0280 (0.5)	0.0379 (0.9)	0.0359 (1.4)	0.0245 (1.8)	0.0105 (0.3)	0.0054 (0.1)	0.0251 (0.5)	0.0897 (3.3)		0.5040 (0.1)	0.9404	5.2634	2.1867
(5) Malaysia																					
(a) Estates	-0.6394 (-3.6)	-0.4430 (-3.6)	0.1089 (2.9)	0.1748 (8.5)	0.1462 (6.8)	0.0666 (2.4)	-0.0287 (-0.9)	-0.1123 (-3.4)	-0.1650 (-5.3)	-0.1756 (-6.7)	-0.1409 (-7.3)	-0.0658 (-3.9)	0.0367 (1.6)	0.1457 (4.9)	0.2321 (7.2)	0.2588 (8.6)	0.1809 (4.0)	2.0387 (0.1)	0.9676	9.9597	2.9826
(b) Small-holders	0.1107 (0.8)	0.9384 (7.4)	0.2119 (8.1)	-0.0440 (-2.4)	-0.1524 (-7.7)	-0.1624 (-8.9)	-0.1153 (-6.0)	-0.0446 (-2.3)	0.0237 (1.5)	0.0714 (5.0)	0.0881 (4.7)	0.0708 (3.8)	0.0247 (1.0)					1.0093 (0.02)	0.9939	162.5128	1.6734
(6) Sri Lanka	-1.2176 (-3.7)	-0.3369 (-1.1)	0.0626 (4.9)	0.0431 (4.6)	0.0197 (2.8)	-0.0024 (-0.4)	-0.0194 (-2.8)	-0.0288 (-3.4)	-0.0295 (-3.4)	-0.0214 (-3.0)	-0.0060 (-1.5)	0.0140 (4.8)	0.0347 (4.6)	0.0509 (4.3)	0.0559 (4.1)	0.0420 (3.9)		0.4304 (0.04)	0.8219	3.6906	1.8589
(7) Thailand	-0.4658 (-3.6)	-0.0564 (-0.6)	0.0987 (12.0)	0.1210 (12.1)	0.0942 (12.1)	0.0413 (10.6)	-0.0188 (-5.1)	-0.0714 (-9.7)	-0.1062 (-10.6)	-0.1170 (-10.9)	-0.1019 (-11.2)	-0.0633 (-11.4)	-0.0076 (-7.3)	0.0543 (10.6)	0.1074 (11.1)	0.1324 (11.2)	0.1059 (11.2)	1.2414 (0.02)	0.9942	172.3124	1.7741
(8) Rest-of- the-World	-0.9450 (-2.3)	-0.5152 (-1.3)	0.0678 (1.6)	0.0889 (3.4)	0.0742 (3.1)	0.0405 (1.4)	0.0012 (0.03)	-0.0332 (-0.8)	-0.0553 (-1.4)	-0.0608 (-1.9)	-0.0484 (-2.4)	-0.0200 (-1.2)	0.0196 (0.7)	0.0623 (1.7)	0.0971 (2.5)	0.1098 (2.3)		0.7791 (0.1)	0.7919	1.9032	1.9653

NOTES:

QN_{-i} is the natural rubber output lagged i periods, i = 1,2;

PN_{-i} is the natural rubber price per tonne lagged i periods , i = 1,2, ..., 14;

$\sum_i \lvert\beta_{-i}\rvert$ is the sum of the absolute values of the Almon lags;

Except for $\sum_i \lvert\beta_i\rvert$, all figures in parentheses are t-statistics for the corresponding estimates.

For $\sum_i \lvert\beta_i\rvert$, the figures in parentheses refer to standard deviations.

or (b) the trees were protected from over-exploitation in the initial tapping years. For the Malaysian estate supply equation where price coefficients resumed positive values only in the tenth lag, (b) would seem to be the relevant reason.

To obtain supply elasticities from the estimates presented in Table 3.1, the price coefficient τ_i in the reduced form equation (3.21) must first be derived from the τ_i^* -estimates in Table 3.1. This is done by using the relationship between τ_i^* and τ_i given in equation (3.22). The supply elasticity η_i^S for each period is then calculated from τ_i and average price $(\overline{P})$ and output$(\overline{Q})$ during the sample period; that is

$$\eta_i^S = \tau_i(\overline{P}/\overline{Q}) \qquad \text{for } i = 0,1,2, \ldots, 14;$$

Once the supply elasticity for each period is known, the supply elasticities over different lengths of time periods is obtained by summing the elasticities of the various periods. The short-run is here defined as covering the current period (i=0); the medium-run covers the current and first three lagged periods (i=0,1,2,3) while the long-run includes current and all lagged periods (i=0,1,2, ... , 14). Table 3.2 presents the estimated short-, medium- and long-run supply elasticities. On the whole the supply elasticities are found to increase as the lagged periods lengthen, except for Africa, Brazil and smallholder production in Malaysia.

For Brazil the short-run elasticity is negative in value and may be a reflection of the unsystematic nature of Brazilian natural rubber

Table 3.2: Short-, Medium- and Long-Run Supply Elasticities

Country	Short-Run	Medium-Run	Long-Run
Africa	0.1809	1.0642	0.2808
Brazil	(-0.2807)	0.2005	1.3969
India	0.1175	2.7915	37.3776
Indonesia			
Estates	0.4945	3.6423	5.6559
Smallholders	0.3586	1.4324	6.6673
Malaysia			
Estates	0.3007	3.6422	8.9245
Smallholders	0.6865	3.0774	11.0407
Sri Lanka	0.6368	4.2386	13.0913
Thailand	0.3952	3.9536	6.7137
Rest-of-the-World	0.4142	4.4404	15.0592

Notes: (1) Short-run elasticities refer to the supply responses in the current period.

(2) Medium-run elasticities refer to the sum of supply responses in the current and first three lagged periods.

(3) Long-run elasticites refer to the sum of supply responses in the current and all lagged periods.

cultivation up to the mid-1970s.[13] During the historical period natural rubber production in Brazil seemed to have behaved more in accord with a backward bending supply curve with increased production when price falls and decreased production when price rises. A possible explanation for the decline in long-run supply elasticities for African and Malaysian smallholder production may be the fall in average yield due to replanting that took place during the historical period. Since the yield is embedded in the composite price coefficients the price coefficients are affected differentially so that the relative size of the (τ_i) coefficient values are similarly affected. In the next chapter the supply response for Malaysian natural rubber producers will be re-estimated under world price net of export tax. It will be found that the smallholder supply response obtained in this chapter under world price, gross of export tax, will be vindicated after export tax have been deducted.

3.7 Oligopoly, Vertical Integration and Synthetic Rubber Supply

The conditions under which synthetic rubbers are produced contrast sharply with those for natural rubber. Unlike natural rubber, synthetic rubbers are produced under imperfect competition and

13 In 1973, the Federal Government of Brazil declared statutory measures to implement systematic cultivation of natural rubber; for details, see Ribeiro(1980).

a high degree of vertical integration;[14] while natural rubber is openly traded on commodity markets and exchanges, no such trading is observed for synthetic rubbers.

Synthetic rubbers are derived from petrochemical feedstocks so that the industry is dependent on the petrochemical industry for its raw material feedstocks. Since the processing of feedstocks into synthetic rubbers only entails marginal extensions of the machinery used in oil refining, the backward integration of synthetic rubber production with the petrochemical industry is thus not surprising. On the other hand, the bulk of synthetic rubbers are consumed by the tyre industry, thus galvanising the forward integration of the synthetic rubber industry with the tyre industry, and providing the synthetic rubber output with a captive market. Such vertical integration facilitates intra-firm transfers and protects the captive sales from market instabilities to some extent. Through this vertical integration the synthetic rubber market also acquires the oligopolistic structure characterising the oil and tyre industries.[15]

14 For example, a study conducted in 1967 found that rubber fabricators in the US own about 44 percent of the synthetic rubber production capacity. See Barlow(1970).

15 The world oil and tyre industries are dominated by seven and nine transnational corporations respectively.

Apart from the capital-intensive feature of synthetic rubber production, its production is also characterised by economies of scale in capital and labour inputs but not in raw material inputs. Consequently production capacity and its rate of utilization are important to synthetic rubber price determination. With the introduction of new processing technologies in the mid-1950s for styrene-butadiene (viz. cold-stream polymerisation and oil extension) and the introduction of the second-generation stereo-regular synthetic rubbers (polybutadiene and polyisoprene), new production capacities were constructed. Hence capacity underutilization was substantial up to the mid-1960s. To keep synthetic rubber prices relatively constant in comparison with natural rubber price and to induce further substitution by these rubbers, producers were believed to have adjusted their inventories and rates of capacity utilization and employed both price and non-price incentives. Thus Behrman argued that a "supply function clearly cannot be defined for such an industry."[16] and until recently studies on the rubber market have

16 See Behrman (1971). Behrman therefore analysed synthetic rubber supply indirectly by concentrating on the technological progress aspect and explaining synthetic rubber price in terms of four technology indices computed for the major types of general-purpose rubbers produced. It should be pointed out that Behrman was dealing with the rubber market in the period up to 1965; that is, before the era of rising oil price. For details see Behrman (1971:17-22).

invariably treated the synthetic rubber sector exogenously.[17]

While recognising the oligopolistic and vertically-integrated features leading to Behrman's caveat on modelling synthetic rubber supply, it was considered useful to specify such supply via the assumption of monopolistic supply and treating world synthetic rubber supply aggregatively. The reasons for doing so are manifold, most important of which is the impact of oil price. While the price of crude oil steadily declined in the 1950s and stabilised in the 1960s, the 1970s initiated the period of rising prices. However, the interest here in analysing the longer-run impact of oil price on synthetic rubbers and hence on natural rubber production and prices explains this attempt to endogenise the synthetic rubber sector. The interaction between natural and synthetic rubbers, which is integral to natural rubber price formation and will be discussed with reference to the post-oil crisis period in Chapter Six, can then be analysed from the two interrelated markets.

Under the assumption of monopolistic supply, synthetic rubber supply (output) and price are jointly determined. Their specifications will therefore be presented simultaneously in Chapter Five where the natural and synthetic rubber price equations are specified.

17 In a recent study by Man and Blandford (1980), the synthetic rubber sector has been partially endogenised through a price equation for styrene-butadiene. For details, see footnote 11 in Chapter Five in this study.

APPENDIX 3.A

ESTIMATES OF ACREAGE FUNCTIONS

Table A3.1 presents the estimates of the investment (acreage) equations for the four major rubber producing countries; for the static case fairly good fits were obtained except for the case of Indonesian estates. The Indonesian case may be explained by the political upheavals in Indonesia in the 1950s and 1960s during which discrimination against foreign-ownership as well as problems associated with the Indonesian foreign exchange rate all contributed towards the decline of the foreign-owned rubber estates.[1] The price estimates in the remaining equations also highlighted a behavioural difference between land-abundant Indonesia and Thailand and less land-abundant Malaysia and Sri Lanka. Although the price estimates for Malaysia and Sri Lanka had the expected positive sign only that for the Malaysian estate equation was significant. It thus appears that price was a significant determinant of area expansion only in the highly-organised estate sector of Malaysia. For Indonesia and Thailand the price coefficients had incorrect negative signs; as for the Malaysian smallholder and Sri Lanka equations, the price estimates were insignificant. The general inference that can be drawn from these estimates is the distinct difference between smallholder attitudes towards rubber cultivation in the land-abundant vis-a-vis

1 For details on this issue see Teken (1971:27-29).

Table A3.1: Estimates of Investment Functions for the Major Natural Rubber Producing Countries, 1956-1978

	Constant	A_{-1}	A_{-2}	ΔA_{-1}	PN	R^2	F	DW
(1) Indonesia								
(a) Estates A	87.9927	0.2619	0.5162		0.0096	0.4720	5.0665	2.2104
	(0.9)	(1.2)	(2.4)		(0.6)			
(a') Estates ΔA								
(b) Smallholders A	154.6163	0.9492	-0.0044		-0.0265	0.9667	164.7365	2.0864
	(1.7)	(4.0)	(-0.02)		(-1.3)			
(b') Smallholders ΔA								
(2) Malaysia								
(a) Estates A	15.6287	0.9579	-0.0329		0.0115	0.9945	1022.5484	1.2371
	(0.2)	(11.5)	(-0.4)		(2.1)			
(a') Estates ΔA	-21.5349			0.4807	0.0094	0.5688	11.8724	1.5937
	(-3.1)			(2.9)	(2.6)			
(b) Smallholders A	69.1785	0.9537	-0.0233		0.0064	0.9892	517.0353	0.9971
(b') Smallholders ΔA	-5.240			0.6604	0.0082	0.4943	8.7969	1.8885
	(-0.4)			(3.9)	(1.0)			
(3) Sri Lanka								
A	26.3213	0.8803	-0.0230		0.0042	0.8195	25.7208	2.0563
	(1.0)	(3.6)	(-0.1)		(0.8)			
ΔA								
(4) Thailand								
A	306.2197	0.8270	0.0671		-0.0965	0.9665	124.9532	2.0935
	(2.0)	(3.1)	(0.3)		(-1.5)			
ΔA	102.8092			-0.0416	-0.0286	0.0241	0.1731	1.9674
	(1.3)			(-0.2)	(-0.6)			

NOTES:

PN represents natural rubber price per tonne.

A represents area under natural rubber

ΔA represents the change in area under natural rubber between two consecutive years.

Figures in parentheses denote the t.statistics of the corresponding estimates.

the less land-abundant situations. In the case of Indonesia and Thailand (where currently about 70 percent and 97 percent of the rubber are respectively produced by smallholders), the rubber smallholders are in the main also cash and/or subsistence crop cultivators. Given the relatively low opportunity cost of land and also of labour (especially in the non-harvesting season for annual crops) in these regions during the historical period studied, rubber planting is a form of creating potential capital assets. In due course when rubber prices are remunerative, the potential of these capital assets could then be exploited (tapped) for additional cash income.[2]

2 The situation may gradually be changing in the face of Government-supported rehabilitation and replanting programmes in these countries. The more systematic approach to rubber cultivation also provides employment for those landless rubber tappers who would previously be tapping on a wage or share-cropping basis.

CHAPTER FOUR

MALAYSIAN NATURAL RUBBER EXPORT TAXATION

4.1 Introduction

The estimates of natural rubber supply response presented in the preceding chapter were obtained by using the world price for natural rubber. In practice however, prices actually received by producers (that is, 'farmgate' prices) are lower than world prices because of the imposition of export taxes in most primary-producing countries and because of the deduction of marketing margins by the middlemen traders. The price differentials between world and 'farmgate' prices are known to vary across countries; for example, Malaysian smallholders on average are estimated to receive about 70 percent, while their Indonesian counterparts are known to receive only about 35 to 40 percent of f.o.b. price (World Bank, 1981:13). Clearly the use of world price leads to over-estimation of supply response, and the relevant price to use is the lower 'farmgate' price. But to derive 'farmgate' price, data on export taxes as well as marketing margins (of which the latter in particular are not easily available) are required.

This chapter attempts to examine the effect of natural rubber export taxation on natural rubber supply response, using Malaysia as an example. The choice is based on consideration that Malaysia is not only the world's largest single rubber producing country but has also devoted concentrated efforts to upgrade its rubber industry. Since the Malaysian natural rubber export tax constitutes a major source of government tax revenue, averaging about 40 percent of total export duties during the period under study,[1] the inclusion of export tax into the model will also permit analysis of rubber export tax revenue profiles under various scenarios.

In the following sections, the natural rubber export tax in Malaysia is first reviewed. The question of export taxation leads to consideration of tax incidence and the extent to which such taxation impacts on supply response and producer returns. The estimates of the acreage and supply response equations using price net of export taxes are then presented. The main finding from these estimates is that export taxation affects estate and smallholder producers differentially. While taxation affected the supply response of both smallholder and estate producers, it is found to influence the decision to invest in natural rubber in the case of the estate sector only.

1 Natural rubber export duty as a share of total export duties ranged from 81 percent in 1959 to only 21 percent in 1972 when prices fell. For details on the distribution of export duties in Peninsular Malaysia during 1947-1974, see Chan(1976:89).

4.2 Tenure of the 4-Component Export Tax

For the 1956-1978 period the export tax, which is levied at the time of shipment, may be described as consisting of the following four[2] components:

(1) Schedule I Tax -- a price-based export duty;

(2a) Schedule II Tax -- a price-based anti-inflation tax (pre-1961);

(2b) Surcharge -- a price-based anti-inflation tax (post-1970);

(3) Schedule III Tax -- a volume-based research cess;[3]

(4) Schedule IV Tax -- a volume-based replanting cess.

2 The number 'four' is arbitrary, primarily depending on a person's attitude towards the Schedule II and Surcharge components. Pee and Arope treated these components individually, therefore stating there are "five types of taxes"; in contrast Lim called it a "three-part tax with surcharge as a levy ....". For details see Pee and Arope (1976:187) and Lim (1976a:6).

3 In general the term "cess" refers to a form of tax which yields revenue that provides a source of "cess funds" from which activities associated with natural rubber investment, such as replanting, can be financed on a grant basis.

The Malaysian export tax on natural rubber is thus a complicated tax,[4] the characteristics of the multiple-component export tax being (a) the use of both price and volume as tax bases and (b) the use of the government gazetted RSS1 price of natural rubber in calculating the price-based tax components. The gazetted price is a moving average of natural rubber prices in previous weeks, the use of which has implications for the export tax paid and will be discussed in detail subsequently in Section 4.3 below.

Despite periodic modifications in tax compositions and/or tax rates, the basic structure of the natural rubber tax has remained unchanged over the last twenty years. The major modification concerns the merging of Schedule II with Schedule I in January 1961; subsequently a Surcharge component was introduced in February 1970. The tenure and details of the different rates applied to each of the four components are shown in Appendix 4.A Tables 4.A.1 to 4.A.3. As a result of the overlap in tax rate changes, the 1956-1978 period is treated as six subperiods delineated by the timing of the introduction, modification and/or cessation of the various tax components. The six subperiods are: 1956-1958, 1959-1960, 1961-1964, 1965-1966, 1967-1969 and 1970-1978.

In the following each of the four tax components will be discussed so as to draw out the implications of the various tax bases and government gazetted price.

4 This tax structure has been described locally as being 'primitive'; see Anon.(1980b:15).

Schedule I Tax

This is the basic export duty[5] component with the gazetted price of M$0.60 per pound RSS1-grade natural rubber serving as demarcation for the application of either a constant *ad valorem* tax or a progressive tax for both estate and smallholder production. Since the quality of smallholder rubber production was largely of lower than RSS1-grade, the use of RSS1 price as the reference price meant that smallholder rubber was effectively being taxed at a higher rate than estate rubber. Details of the different tax rates used during 1956-1978 are presented in Appendix 4.A Tables 4.A.1.

Schedule II Tax

In comparison with the Schedule I basic export duty, Schedule II is the supplementary export duty levied only in times of high prices.

Schedule II was first introduced in 1951 following the impact of the Korean War on rubber prices and was intended as a compulsory replanting cess. In June 1955 it was replaced by an anti-inflationary cess that was operative when price exceeded M$1.00 per pound. The tax *per se* was anti-inflationary because it lowered the domestic price received by the rubber growers; whether it was effectively anti-inflationary would depend however on how the tax revenue raised was used by the government.

5 Hereafter Schedule I will be referred to as the export-duty component and the entire 4-component tax as the export tax.

In January 1961 this Schedule II tax was merged with the Schedule I tax. The rates used during 1956-1961 are given in Appendix 4.A Table 4.A.2(a).

Surcharge

Like the Schedule II tax, the Surcharge is a supplementary export duty which is levied during high price periods. It was introduced in February 1970 as an anti-inflationary cess to be imposed when price exceeded M$0.60 per pound; the rates used since 1970 are given in Appendix 4.A Table 4.A.2(b).

Schedule III Cess

Introduced in 1946 to finance publicity and research, this is a specific tax aimed at extracting part of present income to generate future gains.[6] Using rubber export volume as a tax base, the cess is imposed at all price levels and has been subject to frequent changes in rates. The various rates used are given in Appendix 4.A Table 4.A.3.

6 At present the funds collected under Schedule III are used by the Malaysian Rubber Research and Development Board for production, processing and policy research programmes. The revision of Schedule III rate actually occurred in May 1967. Because annual data is used in this study, the revision will be assumed to have occurred in January 1967. Since the change in tax rate was 0.125 cents per pound of natural rubber, the margin of error resulting from this approximation is negligible.

Schedule IV Cess

This is a replanting cess introduced in May 1952 to induce faster replanting rates. Like Schedule III it is a specific tax using the export volume as the tax base. Of the various tax components, this is the only component where the fixed rate of M$0.045 per pound (when rubber price exceeded $0.60 per pound) was retained throughout the entire 1956-1978 period.

4.3 Implications of Price and Volume Based Taxes

The price-based Schedules I and II and Surcharge components serve to extract part of the producer (treating planters, dealers and exporters aggregatively) gains from price increases due to outward shifts in the demand schedule. When demand is completely elastic, the tax burden falls entirely on the producers.

Since smallholder rubber is traded through intermediary dealers and exporter-traders, it is likely that there is (relatively) more speculative trading with smallholder rubber than with estate rubber. The price-based tax components thus also impinge on the returns to private inventory policies for speculative purposes; given that estates hold stocks largely for supply management purposes, this efficacy in extracting gains is more significant for rubber from the smallholder sector. The impact of the price-based taxes is best understood in conjunction with the meaning and role of the government gazetted price.

The government gazetted price for natural rubber is published weekly. Before October 1977, this gazetted price was a two-week moving average of official prices quoted up to the previous week; from October 1977, it became a four-week moving average.[7] These official prices are based on prices quoted daily on the Malaysian Rubber Exchange and The Rubber Association of Singapore. These prices are in turn based on prices reported to the Exchange and Association by traders operating in the two markets. The official prices may be regarded as an indicator of the market movement; while they need not be the actual price at which natural rubber is traded, they are used as the basis for trading. As in other commodity exchanges where paper trading takes place, there is scope for manoeuvering to place official prices at vantage levels. In the Malaysian case, aside from speculative activities, the rationale for such potential manoeuvering stems from (a) purchases of smallholder rubber being based on official prices and (b) wages in the rubber industry being based on gazetted prices (with bonus payments made in accordance with these gazetted prices).[8] As the price-based tax components are based on gazetted prices, it follows that the export duty and surcharge fluctuate in accordance with the gazetted, and hence the official prices, albeit with a time lag. This known time lag is crucial in providing additional scope for speculation (other than those stemming from world market conditions) since dealers can sell "paper" rubber at prices

7 See Economic Intelligence Unit (1978:88-89) and footnote 17 in this chapter.

8 For details of the wage structure in the rubber industry of Malaysia, see Pee and Arope (1976:141-152).

that go towards forming the gazetted price and hold physical rubber. If higher prices should obtain at the time of shipment, then the value of the exported rubber would become greater because of the lower duty paid. This may be reinforced by the fact that export contracts generally have price clauses geared to shipment dates.[9] Thus the price-based taxes also contain a tool for extracting gains from that speculative stockholding which is motivated by the role of gazetted price in the determination of export duty and surcharge. The differential impact of this on planters and traders is better understood in the context of tax incidence which will be discussed in detail later.

9 For example, it is known that Goodyear's long-term contracts are based on prices during the month previous to the month of shipment; it is possible that such a price clause was aimed at counteracting such gains. The wide variation in the export duty collected weekly (due to the instability of RSS1-price) has also been observed to encourage smuggling of Malaysian rubber to Thailand and the periodic "rushing over" of rubber to Singapore to evade anticipated higher duties. The Malaysian Rubber Producers' Council recently raised the question of modifying the export tax base, arguing that the use of RSS1-price was unfair since it disregards the fact that physical trading generally involves lower-grade rubbers. Moreover, in periods of heavy speculative trading, the paper price of RSS1-grade rubber far exceeds the physical price; the export duty could thus be based on an unrealistic price highly divergent from the price actually received for the physical rubber traded. For details, see Anon.(1980b:2, 13).

In contrast to the price-based Schedules I and II tax components, the Schedules III and IV components are based on export volumes and hence are irrespective of price movements. By considering a situation of increased exports under constant prices, it can be seen that Schedules III and IV are aimed at extracting the gains from increased productivity due to the research output of organisations such as the Rubber Research Institute of Malaysia. Since these taxes are earmarked for research and replanting, the tax extractions may be said to be "returned" to the producers eventually, either indirectly via research findings or directly through the replanting refund covenant. But the size and asset differentials between smallholder and estate producers raise questions about the equity effects.

In general Schedules III and IV benefit the larger more than the smaller estate and smallholder producers. As larger producers own more assets, they are generally able to use more of the services being provided by the Rubber Research Institute and related support organisations. The Schedule IV tax component <u>per se</u> (disregarding the scope within the marketing system for the backward shifting incidence of the export tax to be discussed below) also appears to discriminate against smallholder production during the period under study. This is because the Schedule IV tax is unconditionally refundable to estates on evidence of their production, and hence replanting (since the yield of natural rubber trees declines about twenty years after tapping). Although the smaller rubber holdings are generally not replanted, those that do replant do not receive the entire replanting cess for which they are eligible. Chan(1976) pointed out that not all smallholders who qualify for the subsidy receive the grant to replant the total acreage in their holdings. For example it was only since 1967, when Scheme 4 was introduced, that smallholdings of five or more acres were granted the subsidy equivalent of replanting one-third of their total area (Chan, 1976:165). In comparison with the replanting cess rebate situation for estate production, the Schedule IV tax component has therefore been considered by several writers to be, in effect, an additional tax on the smallholders.[10] In order to put this complicated issue in perspective, it is necessary to indicate that while smallholder producers in general do not pay income taxes because of their low incomes, a person earning the equivalent of their rubber earnings would also be exempt from income taxation under the Malaysian tax regulations. The problem of smallholder tax burden is compounded by the fact that the export taxes on smallholder rubber are paid indirectly by the exporters.

From the above discussion it is seen that the four-component export tax has differential impacts on estate and smallholder rubber. To assess the impact of export tax on natural rubber production supply (in contrast to export supply) response, it is necessary to consider the question of tax incidence. The following discussion on tax incidence and marketing margins draws on the studies by Chan (1976) and by Lim (1976).

10 See Edwards(1970:211-247) where he discusses why the tax burden is effectively higher on smallholders than on estate producers.

4.4 Incidence of Export Tax

From the earlier discussion of the natural rubber export tax structure, it is seen that this export tax is intended for the purposes of (a) acting as a counter-cyclical device to stabilise domestic incomes from rubber production during high price periods and (b) raising government revenue.

The question of incidence of an export tax has two facets: (1) the incidence on the domestic producers/suppliers vis-a-vis the incidence on the foreign consumers and (2) the incidence on domestic exporters/dealers vis-a-vis the incidence on the natural rubber planters. These two facets of the natural rubber export tax incidence will now be discussed in the above order.

Since the export tax is imposed by the Malaysian Government, the question raised is whether this incidence is shifted forwards to the foreign consumers. If the export tax is shifted forwards, the world price at which foreign consumers pay for their natural rubber is higher than would be the case in the absence of the export tax. The ability of Malaysian producers to shift this export tax forwards therefore depends on the elasticity of the world natural rubber demand and the bargaining strength of the Malaysian producers. As the discussion on world natural rubber demand in Chapter Two showed, the determination of the inelastic natural rubber demand is complicated because of (i) the existence of a synthetic substitute, (ii) the property of minimum input requirements in tyre production and (iii) the vertically-integrated feature of the rubber goods manufacturing industry. In contrast natural rubber is traded in an open, perfectly competitive market. Although a main producer of natural rubber, Malaysia nevertheless remains a price taker in the world market. Consequently the export tax paid by the exporter cannot be externally shifted forwards to the foreign consumers, and the tax burden is borne domestically (ignoring the benefits that may flow from government expenditures stemming from the tax revenue collected).

That the export tax is paid by the rubber exporter and the tax burden borne within the rubber producing country -- through a decline in money income -- leads to the question of the export tax incidence on the rubber exporters/dealers vis-a-vis the rubber planters. This in turn hinges on the relative bargaining strengths of the various domestic parties. To determine whether the <u>formal</u> (who formally pays the tax) and the <u>effective</u> (who actually bears the tax burden) incidence coincide, it is necessary to briefly describe the marketing and export of natural rubber in Malaysia. Here again differences exist between the smallholder and estate rubber.

In the marketing and export of smallholder rubber, three levels of trading occur before the rubber is exported. Functioning at the village level, the first-level dealer collects the rubber from the smallholder and sells to the second-level intermediate dealer at the town level. The intermediate dealer then sells to the exporter. At each level a marketing margin[11] is built into the traded price. Since it is the exporter who is exposed to the world market and who must finally dispose of the rubber, the lower level trading prices are therefore functions of the price at which the exporter is prepared to buy. Chan's (1976) survey showed that although the exporter pays the export tax, the tax is fully deducted by the exporter from the f.o.b. world price which approximates the official price; the price offered is therefore the world price net of the export tax and the exporters' marketing (including profit) margin. At subsequent dealer levels, deductions of marketing margins are consistently made. By this process the export tax incidence is thus entirely shifted back to the smallholder producers. This backward shifting incidence of the export tax is enabled by (i) the nature of rubber production which does not permit shifting of resources in and out of natural rubber production easily and (ii) the lack of bargaining strength at the smallholder level.[12] The downward rigidity of profit margins at the various dealer levels is a further manifestation of the two smallholder handicaps described above.[13]

Thus for smallholder rubber the <u>formal</u> and <u>effective</u> incidence of export tax do not coincide. While the formal incidence occurs at the exporter level, the effective incidence is on the smallholders themselves. Moreover, since any wages paid by the smallholders are

[11] The marketing margin at each trading level encompasses the payments for the service of dealers in assembling, smoking, storing, transporting, grading, packing and insuring the rubber. The marketing margin therefore represents the costs incurred by the various levels of dealers in getting the natural rubber ready for export in the desired form at the required time and place plus returns earned by each for their services.

positively related to the gazetted price of natural rubber rather than the actual price received by the smallholders, the smallholders' tax burden (in real terms) is therefore higher than the export tax incidence would suggest.

12 Until recently, smallholders had limited alternative employment opportunities; their general lack of transport facilities also meant total reliance on the first-level dealers to absorb their rubber for export. This constrains their bargaining strength. Chan's survey conducted during May 1973 and January 1974, found that during brief periods of falling prices, the smallholders do not seek alternative employment nor abandon their tapping tasks; instead they attempt to step up production so as to maintain their income. This seemingly "backward" supply may be interpreted as a response to "compensate" for the lack of bargaining strength.

By the later 1970s this situation had changed considerably due to the rural-urban migration arising from the Malaysian government's emphasis on labour-intensive industrialisation programmes. By early 1980 the labour shortage faced by the plantation (including natural rubber) sector had become sufficiently severe to prompt a call for imported contracted labour from the surplus labour areas within ASEAN. For details of the recent labour scene in the Malaysian plantation industry, see Anon.(1980b:5-6) and Smith (1981a, 1981b).

13 Chan examined this by testing for asymmetry in the behaviour of marketing margins under fluctuating prices, and examining the correlation between the first level dealer price, that is, price offered to (received by) smallholders and the world price. For details of Chan's test, see Chan (1976:133-145).

For the estate sector, the incidence of export tax is related to the way in which estate rubber exports are marketed. For most estates the natural rubber produced is exported via three main channels: (i) by direct consignment to selling agents in the consuming countries; (ii) by selling to consumers' buying agents located in Asia and (iii) by selling to dealers and brokers operating in both Malaysia and the consuming countries. In contrast to the marketing of smallholder rubber, the marketing of estate rubber is therefore more direct in that fewer intermediaries are involved. Consequently the total marketing margin that is deducted is also lower.

For the larger estates, production and processing are fully integrated so that the processing services of an intermediate dealer are unnecessary. In addition some large estates either have links with, or are owned by, the consumers; thus some estate rubber may be shipped directly to consumers, thereby requiring lesser involvement of dealers/traders than in the case of smallholder rubber. The upshot of more direct trading is that (a) the marketing margin deducted from world price is smaller than that in the smallholder case and (b) the formal and effective export tax incidence may or may not coincide, depending on whether or not the estates export their output directly. When the estate rubber is exported through dealers/sellers, the export tax incidence is shifted backward to the producers as in the smallholder case. But there is a marked difference here in the attitude towards the treatment of export tax by the two types of producers. In general the smallholders are unfamiliar with the intricacies of the multiple-component tax and the compilation of the gazette price and export tax rates; the same cannot be said of the estate sector. Furthermore, while both the smallholders and estates may receive prices net of their respective marketing margins and export taxes, the estates are able to treat these tax payments as part of their production cost. Chan(1976:186) found that estates treated the export duty, surcharge and research cess as cost components and the recoverable replanting cess as a revenue item in their company tax statements.[14] Thus although the export tax incidence is shifted back to the estates, there is scope for diluting its effects through the company tax returns. Hence the price received by the estates is some function of the world rubber price, the marketing margin of the dealers/exporters and the export taxes. The precise functional relationship depends to a large extent on the relationship between export tax and company tax; however, analysis of this issue is beyond the scope of the present study.

The contrast between prices received by the smallholder and estate producers may be summarised as follows:

$$(4.1) \qquad PN(S)= PN(W,S) - [X + S + R(C) + Rep(C)] - MM(S)$$

$$(4.2) \qquad PN(E)= PN(W,E) - [X + S + R(C)](1-t) - MM(E)$$

where

PN(S) is the price actually received by smallholders;

PN(E) is the price actually received by estates;

14 Ma (1959) had found that for public companies in the rubber industry, export tax and cesses approximate 17 percent of the companies' estate production costs. This treatment of export taxes leads to a further divergence between estate and smallholder producer prices.

PN(W,S) is the world/Singapore price received for smallholder rubber (typically for RSS3- or lower grades);

PN(W,E) is the world/Singapore price received for estate rubber (typically for RSS1- and RSS2-grades);

X is the basic export duty;

S is the supplementary export duty (Schedule II or Surcharge) whenever it applies;

R(C) is the research cess;

Rep(C) is the replanting cess;

MM(S) is the marketing margins of the various level dealers

MM(S) is the marketing margins of the various level dealers/ exporters who handle smallholder rubber;

MM(E) is the marketing margin of the dealers/exporters who handle estate rubber;

t is the proportion of export taxes that can be effectively offset by treating the non-recoverable tax components as part of estate production costs in the estates' company tax statements.

In summary, it can be said that by virtue of the marketing and export tax systems, the onus of rubber price volatility lies relatively more on smallholder than on estate producers. However, because of data limitations, it is assumed in the following empirical analysis that export taxes for estate rubber are shifted backwards fully as in the case of smallholder rubber.

4.5 Empirical Estimates of Malaysian Supply Response Under Export Taxation

This section presents the supply response estimates of Malaysian natural rubber producers under export taxation. It is assumed that export taxes are fully shifted backwards for both estate and smallholder producers so that the price actually received by both types of producer is the world price less the non-recoverable export taxes paid. The basis for calculating the export taxes to be deducted are the tax schedules presented in Tables 1 to 3 of Appendix 4A.

During 1956-1978 the export tax on smallholder rubber was uniformly based on the gazetted RSS1-price, despite the fact that smallholder production were generally of lower than RSS1-grade. The price net of export tax was obtained by deducting the RSS1-based four-component export tax from the f.o.b. Singapore price for RSS3-grade rubber; this price net of tax was then used in re-estimating the smallholder acreage and supply response equations.

The calculation of price net of export tax for the estate sector is similarly based on the f.o.b. Singapore price for RSS1-grade rubber. However, since estates can recover the replanting cess payments, only the three non-replanting (and hence non-recoverable) components, viz. basic export duty (Schedule I), supplementary export duty (Schedule II) or Surcharge and the research cess (Schedule III) were deducted from the f.o.b. price.[15]

15 Thus "t" in equation (4.2) is assumed to equal zero.

It is seen from the above discussion that data non-availability has precluded any consideration of the marketing margins taken by the intermediary dealers. Consequently, the prices net of export taxes used in the estimations are not 'farmgate' prices (which should exclude the marketing margins).

Tables 4.1 and 4.2 present the estimation results for supply and acreage respectively as functions of natural rubber price net of export tax (hereafter referred to simply as net price) for the smallholder and estate sectors. The estimates for the two sectors will be discussed separately, comparing them in each case with their corresponding estimates when gross price (that is, world price which includes export tax) was used.

4.5.1. Impact of Export Tax on Smallholder Supply But Not Acreage

For the smallholder sector, the estimates of supply response under net price revealed smallholder supply to be price responsive as was the case under gross price discussed in Chapter Three. When gross price was used the best fit had a shorter lag structure with price coefficients regaining positive values in the sixth lag (see Table 3.1 of Chapter Three). In contrast the lag structure under net price involved 14 periods with price coefficients regaining positive values in the tenth lag (see Table 4.1). If net price was deflated by the consumer price index, the estimation resulted in equally significant but higher-valued estimates. For the acreage equation, neither gross nor net price was a significant explanatory variable; instead the

Table 4.1: Malaysian Supply Response Equations Under Export Taxation, 1956-1979

Explanatory Variables / Dependent Variable	QN_{-1}	QN_{-2}	X	X_{-1}	X_{-2}	X_{-3}	X_{-4}	X_{-5}	X_{-6}	X_{-7}	X_{-8}	X_{-9}	X_{-10}	X_{-11}	X_{-12}	X_{-13}	X_{-14}	$\sum_{i=1}^{14}\lvert\beta_i\rvert$	R^2	F	DW
Smallholder Sector																					
QN	-0.0180 (-0.2)	0.4828 (5.9)	0.3022 (6.0)	0.1259 (6.7)	-0.0041 (-0.2)	-0.0930 (-2.8)	-0.1457 (-4.1)	-0.1673 (-5.2)	-0.1629 (-6.8)	-0.1374 (-9.7)	-0.0959 (-9.2)	-0.0434 (-2.5)	0.0149 (0.6)	0.0742 (2.8)	0.1293 (5.7)	0.1752 (11.5)	0.2069 (6.9)	1.8782 (0.1)	0.9953	127.2492 ($F_{6,2}$)	2.1829
Estate Sector																					
QN	-0.6681 (-2.5)	-0.3869 (-2.0)	0.0142 (0.3)	0.1578 (4.8)	0.1829 (5.4)	0.1343 (3.7)	0.0491 (1.2)	-0.0423 (-0.9)	-0.1167 (-2.5)	-0.1583 (-3.7)	-0.1580 (-4.5)	-0.1141 (-4.0)	-0.0320 (-1.0)	0.0758 (1.8)	0.1897 (3.8)	0.2830 (5.2)	0.3218 (4.2)	2.0299 (0.1)	0.9194	3.8040 ($F_{6,2}$)	3.0645

Notes: (1) QN represents natural rubber output (tonnes per annum).

(2) X represents natural rubber price net of export tax (dollars per tonne).

(3) $\sum_{i=1}^{14}\lvert\beta_i\rvert$ represents the sum of absolute values of Almon lag coefficients (X_{-i} for i = 0,1,2,...., 13,14).

The corresponding figures in parentheses are the standard deviation of $\sum_{i=1}^{14}\lvert\beta_i\rvert$

All other figures within parentheses denote t-values of the corresponding regression coefficients.

Table 4.2: Malaysian Acreage Equations Under Export Taxation, 1956-1978.

Explanatory Variable / Dependent Variable	Constant	X	A_{-1}	A_{-2}	ΔA_{-1}	R^2	F	DW
Smallholder Sector								
(1) A	43.0931	0.0073	1.4856	-0.5278		0.9933	837.4589	2.0605
	(1.2)	(0.6)	(8.7)	(-3.3)			$(F_{3,17})$	
(2) ΔA	-16.0039	0.0190			0.6213	0.5336	10.2969	2.0401
	(-1.0)	(1.6)			(3.8)		$(F_{2,18})$	
Estate Sector								
(3) A	-5.4178	0.0129	1.5266	-0.5536		0.9967	1693.2528	1.7826
	(-0.4)	(2.8)	(9.4)	(-3.3)			$(F_{3,17})$	
(4) ΔA	-23.6624	0.0119			0.4796	0.5506	11.0247	1.4641
	(-2.9)	(2.4)			(2.8)		$(F_{2,18})$	

Notes: (1) X represents natural rubber price net of export tax (dollars per tonne).

(2) A represents area under natural rubber (acres).

$\Delta A \equiv (A-A_{-1})$ represents the change in planted area between any two consecutive years.

significant explanatory variables were the lagged acreage variables.

The estimates of the supply equations substantiate the negative impact of export tax and multi-level dealer trading on smallholders' supply response. As the lagged gross price coefficients regained positive values after fewer lagged periods, it may be interpreted that smallholder producers would commence tapping sooner had they received the higher gross price for their output. The estimation results therefore indicate that reducing the marketing margins of dealers, viz. by improving smallholders' access to transport facilities, and lowering the export tax burdens of smallholders, is a potential means of increasing their supply. This is substantiated by the estimated supply elasticities presented in Table 4.3 where for each of the short-, medium- and long-runs, supply elasticity is higher under gross price than under net price. However, this benefit of reduced taxation to smallholders should be weighed against the potential use of export tax as a supply management policy instrument for short-run price leverage in the international markets. This is particularly relevant to natural rubber not only because its demand is derived in nature but also because of the competition from synthetic rubbers. In examining the price stabilisation issue, it would therefore be interesting to investigate the interaction between export tax variations and stabilisation activities.

The insignificance of gross as well as net prices in explaining smallholder acreage may be a reflection of the land availability constraint on smallholder rubber cultivation. Furthermore, as employment in the manufacturing sector became increasingly available,

Table 4.3: Malaysian Supply Elasticities Under Gross and Net Prices, 1970-1978

Supply Elasticity	Estate Sector		Smallholder Sector	
	Gross Price	Net Price	Gross Price	Net Price
Short Run (i=0)	0.3007	0.0302*	0.6865	0.4873
Medium Run (i=0,1,...,4)	3.6422	3.3320	3.0774	2.3952
Long Run (i=0,1....,14)	8.9245	8.5422	(-1.0407)	(-0.5321)

Notes: (1) Figures in parentheses denote values countrary to expectations.

(2) * denote that if the insignificant current net price coefficient (of 0.0142) is disregarded, then the short run supply elasticity equals zero.

new investment (planting) in natural rubber may have been dictated not by natural rubber price per se but by a comparison of the discounted return from natural rubber investment with that of wages paid by the manufacturing sector.

4.5.2 Impact of Export Tax on Estate Supply and Acreage

The estimates for the estate supply and acreage equation under price net of export tax contrasts markedly with those for the smallholder sector.

For the estate acreage (which proxies investment) equation, both net price and lagged acreage variables proved to be significant explanatory variables. But the use of net price in the supply response estimation failed to give satisfactory estimates. Despite estimation attempts with alternative lag lengths for net price and polynomials of different orders for the Almon scheme, no estimated equation with significant F-value was obtained under net prices; this was the case for the corresponding equation using gross price. In using the supply equation estimates to calculate supply elasticities, it is found that as for the smallholder sector, supply elasticities are lower under net price than under gross price.

4.6 Generalised Export Tax Functions

In order to simulate the model of the rubber market with Malaysian supply equations estimated from prices net of export taxes, it is necessary to endogenise the different export taxes imposed on estate and smallholder rubber exports respectively. This is so that for each type (estate or smallholder) of rubber supply, the price net of export tax can be obtained by deducting the relevant export tax from the f.o.b. Singapore prices generated as solution values by the model.

Since the Malaysian export tax consist of four components, a simple way of representing the export tax is to specify generalised export tax functions for the estate and smallholder sectors severally. Each generalised export tax function will then be used for calculating the *ad valorem* equivalent tax rate that corresponds to each solution value of the f.o.b. Singapore price generated by the model. In view of the fact that export tax rates were revised in 1980, two sets of generalised export tax functions are therefore required: one for the historical period 1956-1978 and one for the forecast period 1980-1995. The first set of export tax functions (one each for the estate and smallholder sectors) will be used in validating the model for the historical period while the second set will apply when the model is used to simulate alternative scenarios for 1980-1995.

4.6.1 Generalised Export Tax Functions, 1956-1978

The simplest generalisation of the export tax function is to obtain *ad valorem* equivalent tax rates for the various price ranges. Figures 4.1 and 4.2 give scatter diagrams of the export tax rates against unit price for smallholder and estate rubber exports respectively during 1956-1978. From the scatter diagrams the tax rates can be restated in terms of *ad valorem* equivalent tax rates expressed as a function of the world natural rubber price. The tax rates for smallholder rubber exports are then endogenised through the smallholder export tax function (t^S) which is generalised as follows:

$$(4.3) \qquad t^S \begin{cases} = 0.0600 & \text{if } PN \leq \$1400.00 \\ = 0.1240 + 0.1530(PN-1400/1000) & \text{if } PN > \$1400.00 \end{cases}$$

where PN is the f.o.b. Singapore RSS3-price.

Similarly, the *ad valorem* equivalent tax rates for the estate sector can be generalised as:

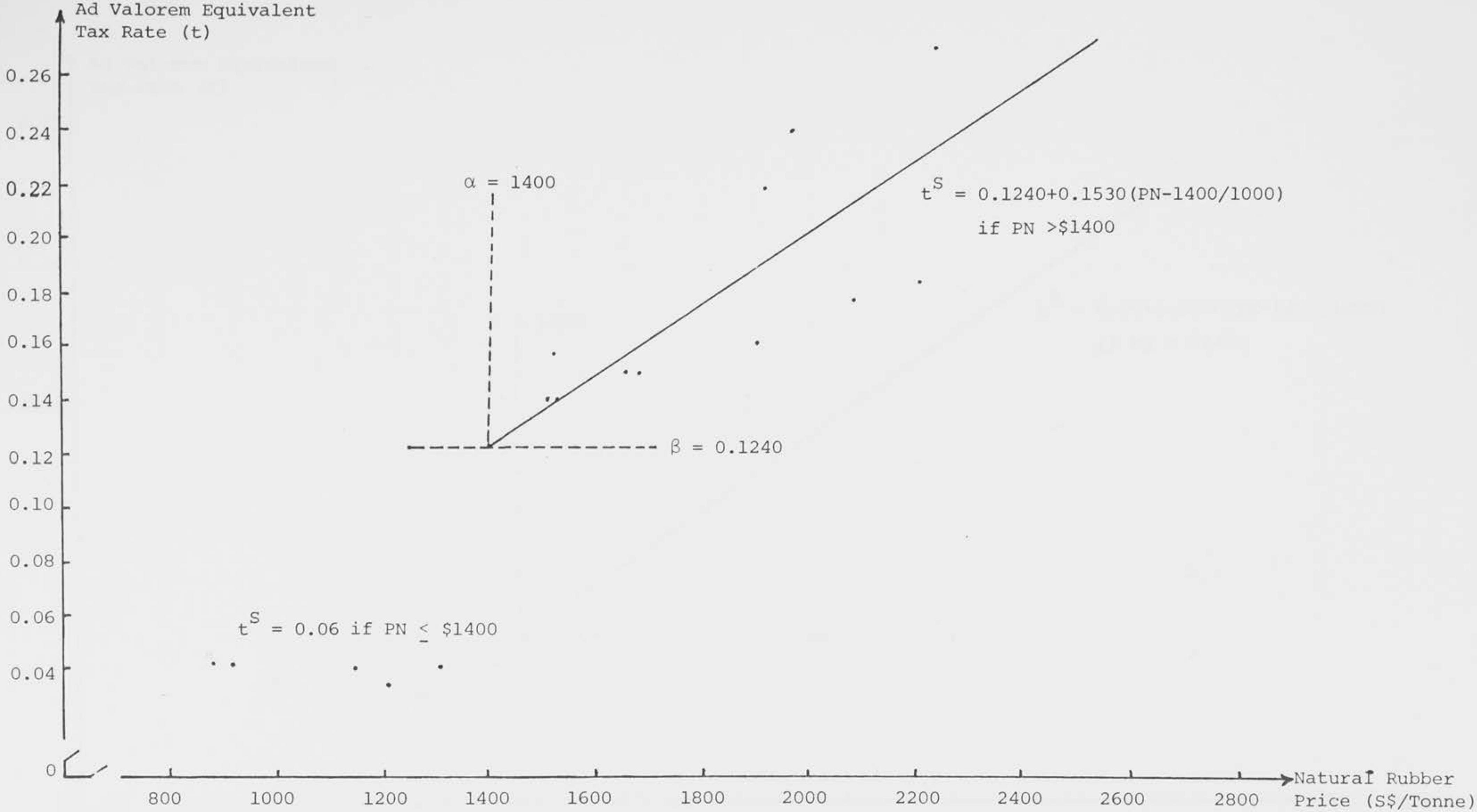
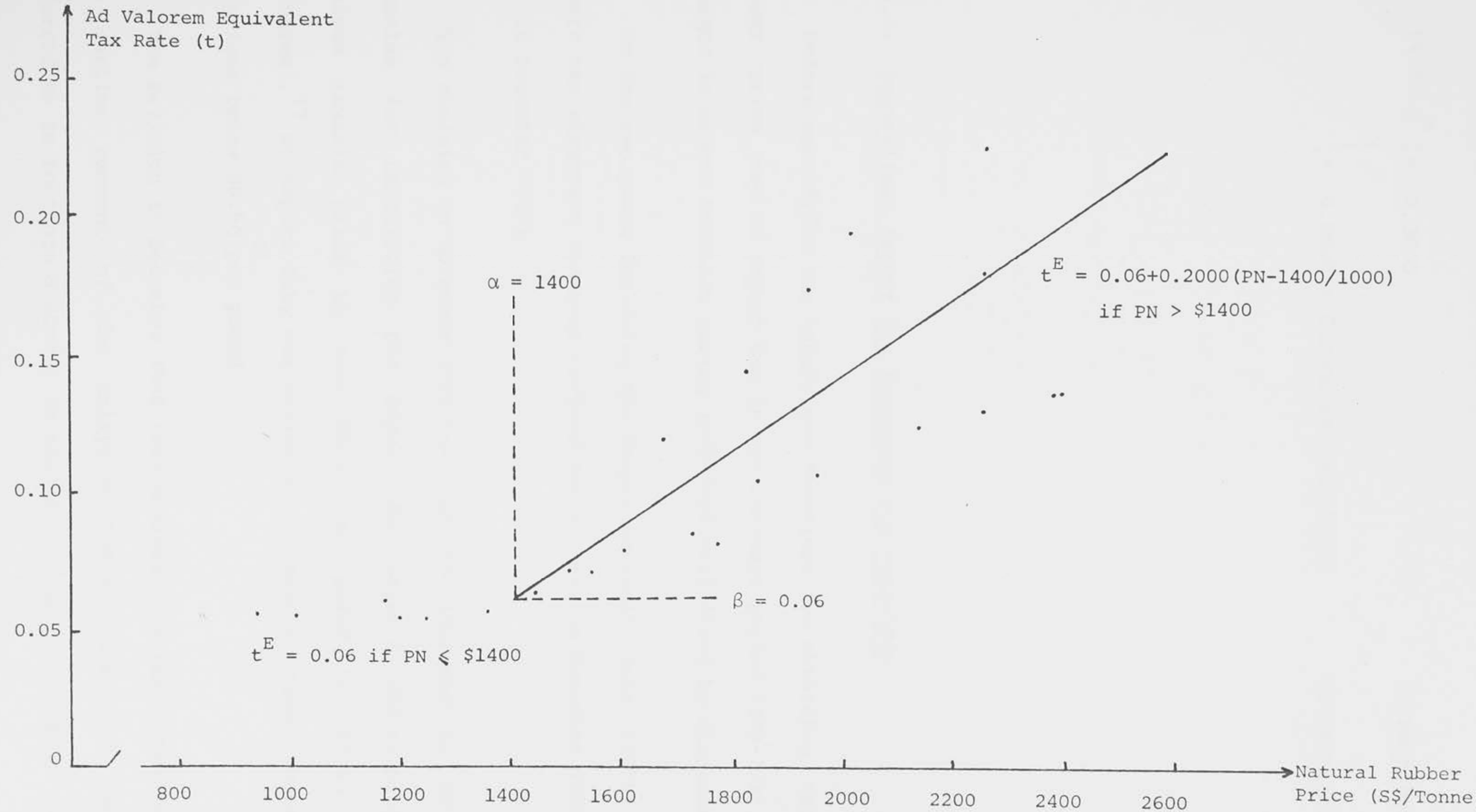


Figure 4.1: Generalised Export Tax Function for Smallholders, 1956-1978.



<u>Figure 4.2</u>: Generalised Export Tax Functions for Estates, 1956-1978.

$$
(4.4)\ t^E \begin{cases} = 0.0600 & \text{if } PN \leq \$1400 \\ = 0.0600 + 0.2000(PN-1400/1000) & \text{if } PN > \$1400 \end{cases}
$$

4.6.2. Generalised Export Tax Functions for 1980-1995

Before specifying the export tax functions for obtaining natural rubber price net of export tax in the forecast period 1980-1995, the changes in export taxation during 1978-1980 will first be discussed.

In the two years following the sample terminal year (1978) the export tax structure has been revised twice: (a) in November 1979 and (b) in December 1980.

The revision in November 1979 involved the introduction of new formulae for calculating the export duty payable, and raising the minimum taxable price to over $0.60 per pound (or $1.33 per kilogram).[17] No export duty was collected for natural rubber exports at prices below $0.60 per pound.

The revision in December 1980 (which might have been prompted by the earlier comment of the Malaysian Rubber Producers' Council referred to in footnote 9 above) is significant in that export duties for RSS1-grade and lower grades natural rubber are now differentiated. Consequently different minimum price levels and different export duty schedules apply to the different natural rubber grades. For RSS1-grade rubber, the minimum price for export duty imposition is M$1430.00 per tonne; for RSS2- and lower-grade rubbers, the minimum price for export duty imposition is M$1540.00 per tonne. Table 4.4 gives the export duty schedules for the two groups of rubber exports.

17 The 4 percent ad valorem export duty when price was below $0.60 per pound was deleted in the October 1977 tax revision. Other changes in this revision involved (a) new formulae for calculating the Schedule I export duty, (b) the incorporation of the Surcharge component into Schedule I accompanied by a 30 percent tax concession for the producers in Sabah and Sarawak since they were previously exempted from the Surcharge payments and (c) the change of the gazetted price basis from a two-week to a four-week moving average of prices in the period immediately preceding the gazette price announcement. This revision has been examined in detail by Lim and Tay(1977) who concluded that:

(1) the downward revision of export duty in October 1977 was of small magnitude and the benefits of the lower duty were not expected to flow on to the smallholder producers;

(2) the adoption of a four-week moving average for the gazetted price only reduced the weekly fluctuations of the gazetted price marginally; thus considerable scope remained for export tax exploitation by the producers and traders.

Since the October 1977 downward revision of export duty was small in magnitude, we have assumed that no revision took place. The tax schedule prior to October 1977 was applied to 1978 prices in the estimation of the supply response equations for 1956-1978. For details of this study, see Lim and Tay (1977).

Table 4.4: Export Duty Structure Announced in December 1980

Price (M$/tonne)	Price Range (M$/tonne)	Ad Valorem Export Duty (%)	
		RSS1 Grade	Other Grades
≤ 1430.00	0.00 - 1430.00	0.00	0.00
+ 110.00	1431.00 - 1540.00	20.00	0.00
+ 110.00	1541.00 - 1650.00	25.00	20.00
+ 110.00	1651.00 - 1760.00	30.00	25.00
+ 110.00	1761.00 - 1870.00	35.00	30.00
+ 110.00	1871.00 - 1980.00	40.00	35.00
+ 110.00	1981.00 - 2090.00	45.00	40.00
+ 110.00	2091.00 - 2200.00	50.00	45.00
+ Balance	≥ 2091.00	50.00	
	≥ 2201.00		50.00

Source: Malaysian Government Gazette P.U. (A) 356, 12 December 1980: 2043-2044;

The export tax functions[18] applicable for the post-1980 period can be calculated from Table 4.4; Figures 4.3 and 4.4 are graphical presentations of the export tax functions; *ad valorem* equivalent export tax functions for the smallholder and estate sectors respectively and are derived in accordance with Table 4.4.

Based on Figure 4.3 the generalised export tax function for the smallholder sector is:

$$(4.5) \qquad t^S \begin{cases} = 0.08 & \text{if } PN \leq \$1540 \\ = 0.08 + 0.1170(PN-1540/1000) & \text{if } \$1540 < PN \leq \$2800 \\ = 0.23 + 0.0750(PN-2800/1000) & \text{if } PN > \$2800 \end{cases}$$

From Figure 4.4 the *ad valorem* equivalent tax rates for estate rubber can be generalised as:

18 For smallholder rubber, total export tax payments include the export duty, Schedule III research cess and Schedule IV replanting cess; for estate rubber the total export tax payments include only the export duty and research cess payments since the replanting cess payments were refundable.

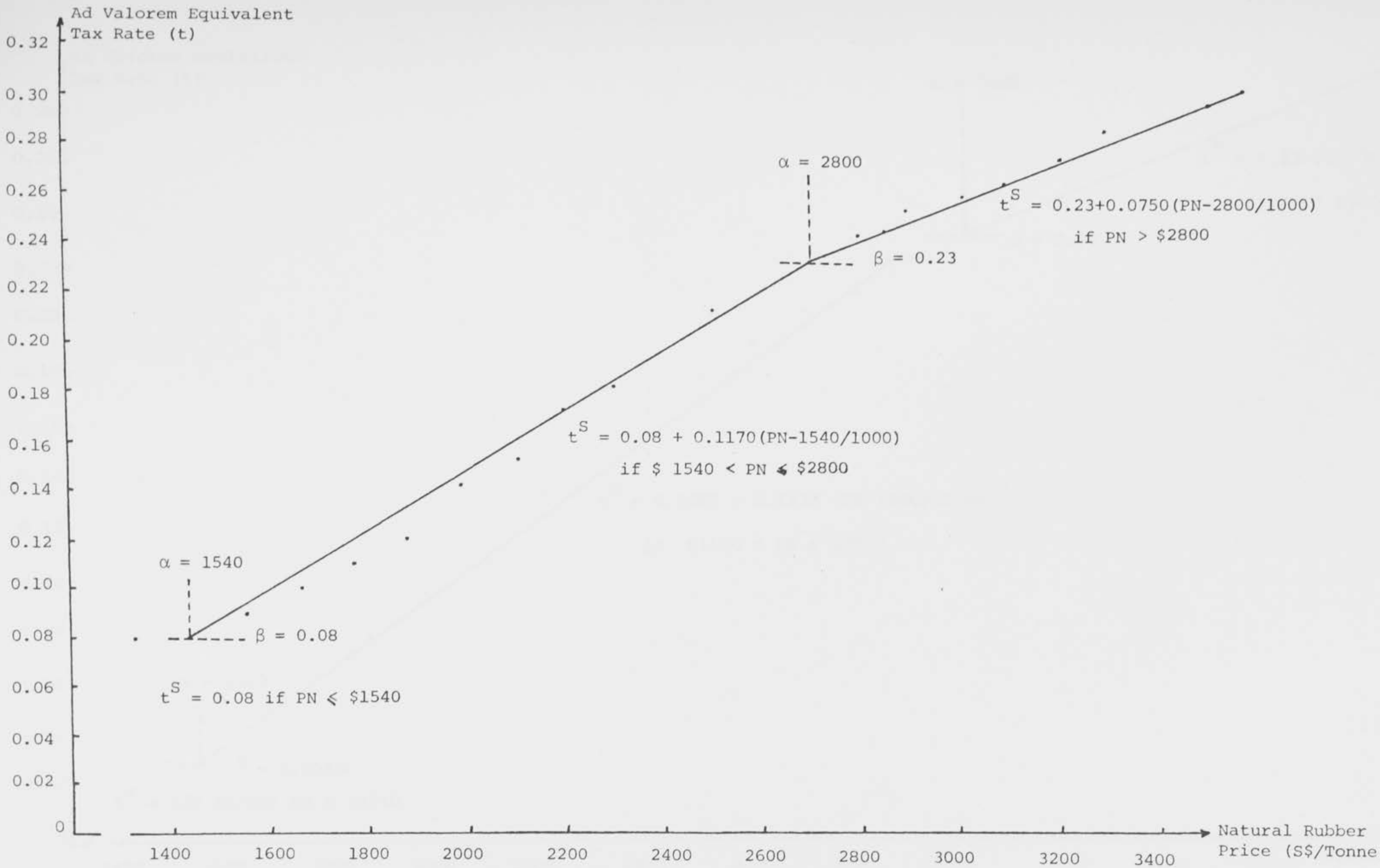


Figure 4.3: Generalised Export Tax Function for Smallholders, 1980-1995.

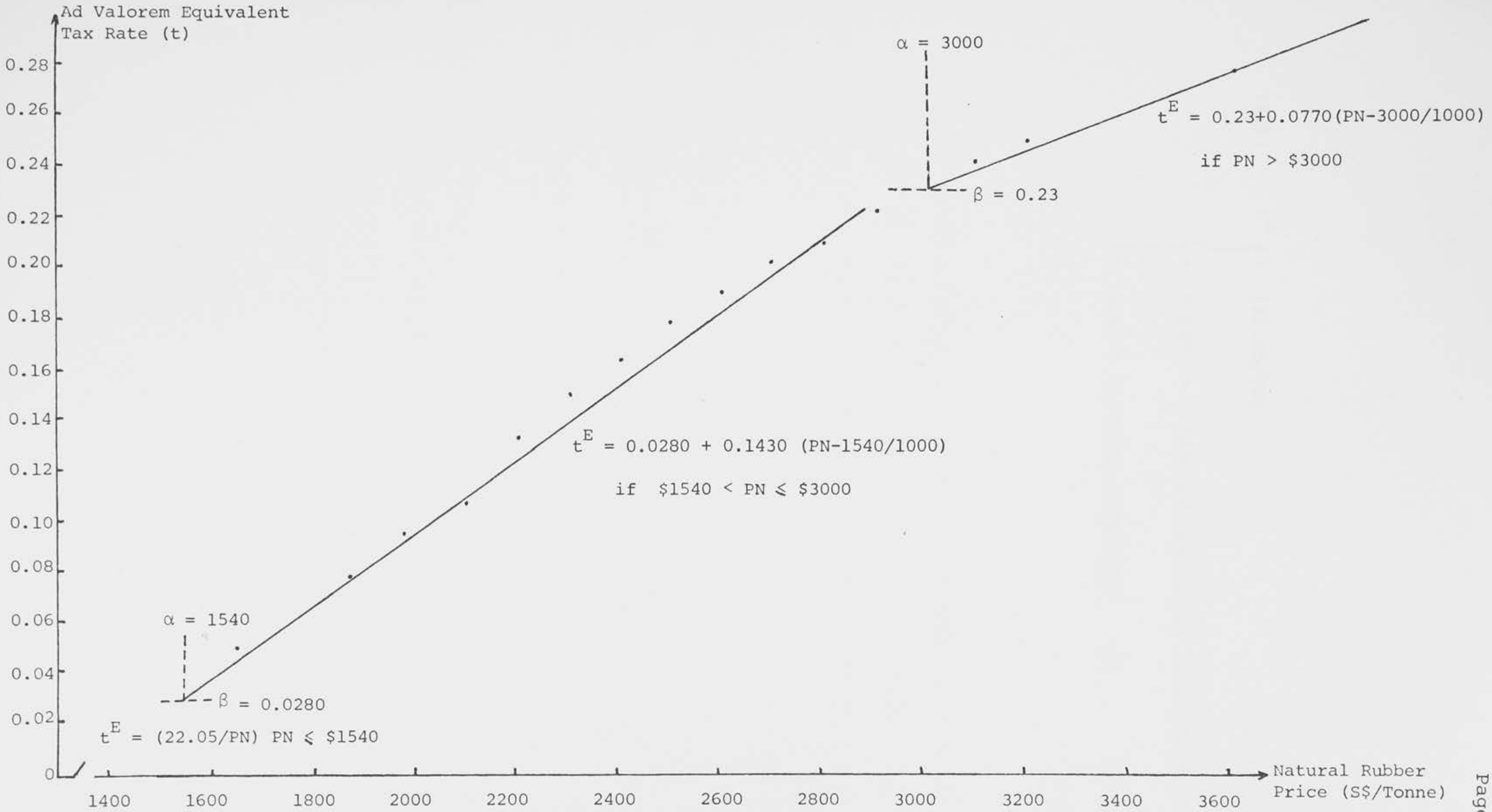


Figure 4.4: Generalised Export Tax Function for Estates, 1980-1995.

(4.6) $$t^{E} \begin{cases} = (22.05/PN) & PN \leq \$1540 \\ = 0.0280 + 0.1430(PN-1540/1000) & \text{if } \$1540 < PN \leq \$3000 \\ = 0.23 + 0.770(PB-3000/1000) & \text{if } PN > \$3000 \end{cases}$$

APPENDIX 4.A

SCHEDULES OF NATURAL RUBBER EXPORT TAX IN MALAYSIA, 1956 - 1978

In the schedules given in the following Tables, the price (PN) refers to the government gazetted price. All prices, taxes and cesses are quoted in Malaysian cents per pound natural rubber exported.

Tables 4.A.1: Schedule I Export Duty

June 1955 to December 1960

Export Duty $=0.04(PN)$	if $PN > 60$
$=0.18625(PN)-8.775$	if $60 \leq PN < 80$
$=0.3125(PN)-18.875$	if $80 \leq PN < 100$
$=0.25(PN-100/10)^2+0.75(PN-100/10)+0.125$	if $PN > 100$

<u>January 1961 to December 1979</u>

Export Duty $= 0.04(PN)$	if $PN > 60$
$= 0.18625(PN) - 8.775$	if $60 \leq PN < 80$
$= 0.4(PN) - 25.750$	if $80 \leq PN < 100$
$= 0.25(PN-100/10)^2 + 3.375(PN-100/10) + 14.250$	if $PN > 100$

Table 4.A.2(a): Schedule II Tax (Anti-inflation Cess)

<u>June 1955 to January 1961</u>

Cess $= 2.5\ (PN-100/10)$	if $PN > 100$

Table 4.A.2(b): Surcharge (Anti-inflation Cess)

<u>February 1970 to April 1974</u>

Surcharge $= 0.0$	if $PN > 60$
$= 0.125$	if $60.000 \leq PN < 60.125$
$= (PN - 60.125)$	if $60.250 \leq PN < 60.750$
$= (PN - 60.250)$	if $60.875 \leq PN < 61.250$
$= (PN - 60.375)$	if $61.625 \leq PN < 62.125$

$= (PN-60.500)$	if $62.250 \le PN < 62.375$
$= 2.0$	if $PN > 62.375$

From April 1974

Surcharge $=0.000$	if $PN > 60.000$
$=0.125$	if $60.000 \le PN < 60.250$
$=0.250$	if $60.250 \le PN < 60.375$
$=0.375$	if $60.375 \le PN < 60.500$
$=0.500$	if $60.500 \le PN < 60.625$
$=0.625$	if $60.625 \le PN < 60.875$
$=0.750$	if $60.875 \le PN < 61.000$
$=0.875$	if $61.000 \le PN < 61.125$
$=1.000$	if $61.125 \le PN < 61.250$
$=1.125$	if $61.250 \le PN < 61.375$
$=1.250$	if $61.375 \le PN < 61.625$
$=1.375$	if $61.625 \le PN < 61.750$
$=1.500$	if $61.750 \le PN < 61.875$
$=1.625$	if $61.875 \le PN < 62.000$
$=1.750$	if $62.000 \le PN < 62.225$
$=1.875$	if $62.225 \le PN < 62.375$
$=2.000$	if $62.375 \le PN < 70.000$
$=0.20(PN)-12.00$	if $70.000 \le PN < 80.00$
$=0.14(PN)-7.20$	if $80.000 \le PN < 90.00$
$=0.16(PN)-9.00$	if $90.00 \le PN < 100.00$

$$=0.18(PN)-11.00 \quad \text{if } 100.00 \leq PN < 110.00$$

$$=0.20(PN)-13.20 \quad \text{if } 110.00 \leq PN < 120.00$$

$$=0.22(PN)-15.60 \quad \text{if } 120.00 \leq PN < 130.00$$

$$=0.10(PN) \quad \text{if } PN > 130.00$$

Table 4.A.3: Schedule III Tax (Research Cess)

Tenure	Cess
March 1953 - December 1958	0.500
January 1959 - December 1964	0.750
January 1965 - May 1967	0.875
June 1967 onwards	1.000

CHAPTER FIVE

BEHAVIOUR OF RUBBER STOCKS AND PRICES

5.1 Introduction

In this chapter we discuss the modelling of the stocks and price behaviour of the natural and synthetic rubbers and present the estimates for the corresponding equations. Again the different levels of disaggregation adopted for the two types of rubber are dictated by data availability and the lengthier discussion of the stocks and price behaviour of natural rubber will be presented first. The emphasis is on the different scope and motivation for natural rubber stockholding by the various parties concerned.

5.2 Ownership versus Location of Natural Rubber Stocks

In dealing with natural rubber stocks it is necessary to consider the roles played by ownership and location of these stocks in the rubber price formation process. The disaggregated treatment of natural rubber stocks is facilitated by stocks data that are differentiated by their location. Data on natural rubber stocks therefore pertain to stocks located

(a) in the producing regions (about 30 percent during the historical period);

(b) in the consuming regions (about 46 percent during the historical period);

(c) at sea as "stocks afloat" (about 24 percent during the historical period).

Regrettably these stock data are of lesser analytical value than their disaggregation suggests because the organisation of the natural rubber market is such that stock ownership, a more relevant criterion, cannot be identified with the location criterion. As indicated before, while natural rubber production is concentrated in Southeast Asia, its consumption is concentrated in the Western industrial countries and Japan. Had these location-based stocks data distinguished and reflected mutually-exclusive ownership of stocks, an analysis of the role of separate producer- and consumer-owned stocks in the determination of natural rubber price could have been attempted. It would also have been pertinent to the stabilisation issue to examine the Nurkse hypothesis that the onus of stockholding is forced onto the primary-producing countries during periods of slump (Nurkse, 1958:252). However this is not the case. Instead the variously located stocks are owned severally by producers, rubber dealers/traders, consumers and agents as their interlocking ownerships reveal:

Stock Location	Stock Ownership
(1) Producing Regions	Producers, Dealers/Agents, Consumers
(2) Stocks Afloat	Agents, Consumers
(3) Consuming Regions	Agents, Consumers

From the above locational distribution of stockholdings and other evidence (Economic Intelligence Unit, 1978:80-90), it can be inferred that the bulk of the world's natural rubber stocks -- which average three months' world natural rubber consumption -- are in the hands of consumers and the trading agents. As indicated below, the activities and services provided by these natural rubber trading agents are integral to the natural rubber price formation process. A review of the reasons for maintaining stocks in different locations by their various owners is therefore pertinent to the specification of stockholdings according to their location. The following review serves to elaborate on the existing theory of storage developed by Working and others by highlighting those aspects of natural rubber stockholding that are important to the question of competition between natural and synthetic rubbers.

Producer-Owned Stocks

Since the bulk of natural rubber trading is on the basis of long-term contracts (generally of twelve to eighteen months), stockholding by rubber producers is motivated primarily by the need to meet the shipment requirements scheduled by these contracts. Such stockholding, motivated by supply management, may be referred to as stockholding for precautionary reasons. Although some producer stocks which are not for sale on long-term contracts are held for speculative purposes, this is understood to be minimal largely because smallholder producers in general lack both the financial and physical facilities required of speculative activities. While estate producers may hold stocks for speculative activities, this would be represented partially by the activities of their agents. In Malaysia for example, such activities are related to the specification of the export tax with respect to the government export tax as discussed in Chapter Four. Furthermore, where estates are owned by foreign rubber companies which are integrated with the tyre manufacturing industry, stockholdings are for ensuring smooth supply of raw rubber to their parent companies.[1]

1 For example 80 percent of natural rubber imports into USA were found by Helleiner(1979) to stem from related parties.

Agent-Owned Stocks

Agents serve producers and consumers as intermediaries. However, the role of trading agents in the natural rubber trade is complicated by the fact that they also act for producers and consumers (jointly in some cases), thus providing producer-agent and consumer-agent links. Consequently, stockholdings by agents are variously located in the producing and consuming areas and afloat (on board ships *en route* to the consuming regions).

In general, stocks are held by agents in the producing areas to fulfil the shipment schedules of long-term contracts to which they are committed. Some stocks are kept afloat to minimise storage costs through savings on warehousing costs. Stocks afloat that are uncontracted are generally sold by the time these stocks arrive at destination. The remaining agent-owned stocks are located in the consuming areas.

As representatives of and intermediaries between producers and consumers, the agents are likely to be best informed on the market situation. Given their wider access to market information and financial (banking) facilities, agents would naturally be more actively involved in speculative and hedging activities than would producers. In addition, fluctuations in exchange rates extend the scope for speculative and hedging activities from rubber shipments to exchange rate futures. Given the delivery lags caused by the geographical distance between the producing and consuming regions, the influence of speculation and hedging by agents on natural rubber spot price formation *per se*, in London becomes critically dependent on the distribution and timing of their stocks afloat. This is facilitated by the producer-agent links and the several terminal markets in Europe. For example, any natural rubber shipment can be packed in small lots, say of ten tonnes each, and shipped under separate bills of lading and destined for any European port. These small tonnages of natural rubber will then be unloaded at the European port closest to where the agent is able to find a buyer offering the best price. Such trading behaviour has implications for natural rubber price formation as discussed below in the section on consumer-owned stocks.

Consumer-Owned Stocks

In analysing the demand for natural rubber, it was emphasised that the competition between natural and synthetic rubbers is dominated by their competitive usage in the transport sector; to reiterate, this competition is restricted to the input range beyond the minimum requirement of either input. Since the approximate minimum requirement of natural rubber in each period is known to consumers,[2] long-term contracts for monthly deliveries of at least this minimum requirement should, ceteris paribus, ensure regular and smooth supplies of the necessary natural rubber input in rubber manufacturing.

2 See footnote 4 of Chapter Two on the role of natural rubber buyers in the rubber manufacturing industry.

Two other factors reinforce the <u>raison d'etre</u> for such long-term trading arrangements. The first factor is climatic-cum-seasonal. In the industrial countries (mainly located in the northern hemisphere temperate zone) natural rubber consumption also exhibits a marked seasonal pattern with consumption being lowest typically during the third quarter. When natural rubber is stored in colder climates it tends to harden, thus incurring higher processing costs when eventually used. Under such well-established seasonality in consumption it is therefore cheaper to have some portion of consumer requirements held as stocks in the producing regions, either directly or indirectly (through the scheduled long-term contracts). In either case, savings would be made on warehousing costs that would otherwise have been incurred at the consuming locales.

The other factor favouring the long-term contractual trading arrangement is the ready availability of synthetic rubbers and their associated discount trading. These factors, together with the proximity of several European and Japanese natural rubber markets to the rubber consumers,[3] are manifested in the observed speculative activities of the rubber consumers who have the choice of making up any balance input requirements by buying either natural rubber (on the spot market in London or that stock currently afloat and due to arrive soon) or synthetic rubbers. Given that synthetic rubber is traded under varying discounts proportional to (a) the volumes of synthetic rubber traded, (b) the tightness of the natural rubber and synthetic rubber feedstocks markets and (c) the seller-client relationship,

[3] For details of the varied roles of the rubber exchanges located across the world, see Ng and Sekhar(1977).

consumers utilise both rubber (natural and synthetic) markets to their advantage. This trading acumen is warranted by the vertical integration within the synthetic rubber industry against a highly competitive international market for natural rubber and rubber products. Since synthetic rubbers and synthetic textiles and fibres are based on the same petrochemical feedstocks, this scope for shifting feedstock resources between the two industries provides an additional instrument for the vertically-integrated rubber fabricating industry to exploit the natural rubber market.[4] Consumer-owned

4 The analysis of inter-reactions between the natural rubber, cotton, synthetic rubber and synthetic textiles industries should provide an interesting study which, to the best of this writer's knowledge, has not been undertaken to date. However, some evidence of the impact on cotton and natural rubber pricing from their synthetic counterparts are tangentially provided by the trend estimates obtained by Hwa(1979) in his analysis of prices for six commodities: cotton, rubber, copper, cocoa, coffee and sugar. Hwa incorporated a trend term to proxy increasingly efficient inventory control methods (during the period 1962-1975 for cotton and 1955-1975 for rubber). Of the six commodity prices, the trend estimates had conspicuously higher negative values for cotton and rubber. In private communication with Hwa on the alternative interpretation of these trend estimates, Hwa agreed that the trend estimates could "partially reflect the strong competition stemming from the synthetic substitutes of these two commodities". Thus his re-estimates for the period up to 1972 only (to exclude the high oil price era), for testing the stability of the price equation estimates, could also be interpreted as reflecting asymmetrical responses of synthetic rubbers and synthetic textiles to the energy crisis of 1973-1974.

stocks of natural rubber thus play a critical role in enabling consumers to operate on those features of input-substitution and market organisation that are peculiar to the rubber industry and market respectively.

In discussing the motivations for the variously owned and located stockholding, the precautionary versus the speculative and hedging activities have been differentiated to highlight the location factor. Built onto these basic reasons for stockholding are the use of stockholdings (via their shipment schedules) for exchange rates speculation and hedging and for fiscal purposes. Thus fluctuations in stockholding (via the flow of natural rubber stocks from producing to consuming regions) reflect natural rubber trading that results from perceived natural rubber consumption requirements and financial market trends. An in-depth study of these interactions is beyond the scope of this study. Yet this pattern of location and ownership of stocks suggests that the primary force determining the London natural rubber spot price emanates from stocks held in the consuming regions.

5.3 Stocks Location and Spot Price Formation

In the discussion of the dispersion of ownership and location of natural rubber stocks it was reasoned that it is the stocks held in the consuming regions that is central to the London spot price formation for the commodity. This is not to deny that stockholdings in the producing regions may influence price formation. However, because natural rubber is a primary commodity with a derived demand concentrated in the industrial countries, it is posited that the spot pricing process is dominated by stocks held in the consuming regions. The size of these stockholdings (nearly half of total stockholdings) and the operation of the spot market by consumers reinforce this argument. Thus it is the London spot price that exerts ultimate influence over natural rubber price formation in the producing areas in each period.[5] On an annual basis it is therefore the London spot price that calls the tune.

The role of location can be incorporated by juxtaposing the location factor with the supply management (precautionary) and speculative motives for stockholding,thus reducing stockholdings to two distinct groups: those held <u>within</u> the consuming regions versus those held <u>outside</u> the consuming regions. The hypothesis regarding the role of location can be tested by treating stocks in the producing regions and afloat jointly; in this way, the several ownerships of stocks can also be accounted for, albeit implicitly. Fortuitously,

5 Support for this hypothesis may be gleaned from Kanbur and Morris (1975) whose spectral analysis of monthly rubber prices led them to assert that the London market price fluctuations seem to be systematically in advance of those fluctuations observed in the Kuala Lumpur/Singapore markets. They consider this to be consistent with a market dominated by supply inelasticity and with London being closer and therefore more immediately responsive to demand changes. However, Kanbur and Morris do not take into consideration the presence of synthetic rubbers and their impact on natural rubber trading and price behaviour; such consideration adds further substantiation to their observation. For a general discussion of price formation in primary commodity trading, see Kaldor(1976).

the approach overcomes the problem associated with the quality of stocks data. This is particularly relevant to the belated realignment in 1973 of 1961 and 1962 stocks data in the Bulletin by the IRSG so as to provide more realistic estimates of stockholdings.[6] The stocks in the consuming regions will therefore be treated singly.

The specification of the stocks function for stocks held in the producing regions and afloat will now be discussed. Two hypotheses were tested for these stockholdings. The first hypothesis gives equal weight to the precautionary, speculative and hedging motives for stockholding, while the second hypothesis concentrates on the precautionary motive and emphasises the location factor. As the first hypothesis was not vindicated empirically, it will be discussed only briefly.

6 I am grateful to Dr. P.J. Watson of the IRSG for bringing this realignment to my attention upon my query of the sharp increase in stockholdings between 1961 and 1962. The realignment in early 1973 of stockholdings was striking in its concentration on stocks in the consuming regions. As a proportion of natural rubber consumption, these consuming regions' stockholdings increased from about 10 percent in 1961 to 22 percent in 1962. Although the IRSG does not elaborate on the cause of this data realignment, one reason may have been the releases of stockpiled natural rubber by various governments. In the post-Korean War period, the releases of natural rubber from the various government (notably Australia, Britain, Italy and United States) stockpiles began in 1960 with a release of 16,000 tonnes. This was followed by releases of 30,000 and 67,000 tonnes in 1961 and 1962 respectively. Subsequent huge releases were in 1965 and 1966 of 122,000 and 157,000 tonnes respectively. The releases in the early 1960s were prompted by the natural rubber demand in the postwar reconstruction period while those in the mid-1960s were probably due to the escalation of the Vietnam War. In both periods the increasing availability of improved synthetic rubber must have minimised the urgency of national stockpiling of natural rubber for strategic reasons.

The stockpiles held by the Australian, British, and Italian governments were completely disposed of by 1971. According to the Bulletin of December 1980, the US-government natural rubber stockpile then amounted to 122,000 tonnes.

In the first hypothesis, the precautionary motive for stockholding gives the producer- , agent- and consumer-owned stocks as functions of rubber production and consumption. Under the speculative and hedging motives, the desired stocks are functions of price expectations. Using a partial stock adjustment process to obtain actual stockholding from the desired stock level, and extrapolative expectations to translate expected price into observed spot price, the stockholding in the producing regions(SNP) and afloat(SNA) can then be specified as some function of natural rubber consumption(CN), production(QN), current spot price(PN^S) and the lagged values of stockholdings and prices. That is:

$$(5.1) \qquad (SNP+SNA) = f_1\{QN, CN, (SNP+SNA)_{-1}, PN^S, PN^S_{-1}, PN^S_{-2}\}$$

The estimated (SNP+SNA) equation under this hypothesis is:

$$(5.1a) \qquad (SNP+SNA) = \underset{(1.8)}{163.2141} + \underset{(0.8)}{0.1642QN} - \underset{(-0.2)}{0.0562CN}$$

$$+ \underset{(1.5)}{0.4208(SNP+SNA)_{-1}} - \underset{(-0.9)}{0.2589(PN^S)}$$

$$- \underset{(-0.1)}{0.0357(PN^S_{-1})} + \underset{(0.1)}{0.0256(PN^S_{-2})}$$

$$R^2=0.7991; \; F_{6,14} = 9.2785; \; DW = 1.9235;$$

The second hypothesis takes into account the fact that price fluctuations within the year are smoothed out in the annual data. Consequently, the focus is on the precautionary motive and the location factor will be highlighted. From the discussion of stocks by ownership, it is seen that the variously-owned stocks in producing regions are mainly held for supply management consideration. Bearing in mind the long-term contracts of a year or more, the stockholding by producers or their agents will be a function of production. For the consumers and their agents, such stockholdings are a function of consumption. The total stock in producing regions is then some function of rubber production and consumption; that is:

$$(5.2) \qquad SNP = f_2 \, (QN, CN)$$

Stocks held afloat (SNA) however, are motivated primarily by considerations of meeting consumption needs at minimal costs. Thus such stockholdings will be some function of consumption; that is

$$(5.3) \qquad SNA = f_3 \, (CN)$$

Then the total stocks held in the producing regions and afloat (SNP+SNA) is given by

$$(5.4) \qquad (SNP+SNA) = f_2 \, (QN, CN) + f_3 \, (CN)$$

$$= f_4 (QN, CN)$$

On an annual basis, the change in ownership of stocks in producing regions and afloat from producers and agents to the consumers can be implicitly analysed if we specify the stock function above in terms of rates of change.

If the increase in consumption during the year is greater than the increase in production during the same period, then stocks held in producing regions and afloat should, ceteris paribus, decline as more stocks would have been transferred to the consuming regions. In discrete terms, the equation can be written as

$$(5.5) \quad (SNP+SNA) = \beta_0 + \beta_1 \cdot \Delta(CN/QN) + \beta_2 \ (SNP+SNA)_{-1}$$

with $\beta_1 < 0$ when $\Delta(CN/QN) > 0$

and $\beta_2 \simeq 1.0$

Table 5.1 presents the estimates for equation (5.5) from which support for the hypothesis that the effect of stocks on spot price formation depends on their location may be inferred. The estimated value of β_2 is 0.8130 which is close to its expected unitary value. Thus stocks located away from consuming regions appear to fulfill the transactions (of producers) and precautionary (of consumers) needs more than influencing spot price formation.

There now remains to discuss the stocks in the consuming regions. In contrast to the stocks referred to above, these stocks influence price determination through their location and proximity to major consumers. Given the poor quality of stocks data (especially for stocks in the consuming regions), it was considered expedient to treat price formation directly. Consequently, stocks in the consuming regions are treated as a residual via the balance identity used to close the natural rubber submodel.

5.4 Spot Price Determination Under Stock Disequilibrium

Two hypotheses were tested for spot price formation. These hypotheses concern the demand for stocks and are based on the ideas of equilibrium/disequilibrium demand for stocks.

Since the hypothesis concerning price determination under stock equilibrium was not substantiated empirically, this approach will only be briefly outlined here. Under this hypothesis the location factor is subordinate to the globally dispersed but closely related and interacting natural rubber markets. The London spot price then results from equilibrium in the various demands for stocks. Under stock equilibrium, the estimated demand for the various consuming regions' stocks would equal their supply which is given by the balance identity. The spot price equation under stock equilibrium is obtained by substituting the total demand for stocks into the balance identity and selecting the spot price as dependent variable.[7] Since the demand for stocks in producing regions and afloat as a function of spot price was also not substantiated empirically, the impact of location (due to the time required to transfer stocks elsewhere to the consuming regions), cannot be ruled out. This leads to the alternative hypothesis of price determination under stock disequilibrium.

The hypothesis of price determination under disequilibrium in the demand for stocks hinges on the features of organisation and trade of the rubber market and industry and what they facilitate. The existence of several rubber exchanges in the consuming regions and the proximity of the synthetic rubber suppliers to consumers (all the major rubber consuming countries produce synthetic rubbers) allow any natural rubber requirement not covered by the long-term contracts to be made up from either natural rubber stocks already held in the consuming regions or by synthetic rubbers.[8] Which of the two categories of rubbers is finally selected to fill the demand shortfall thus depends on their current relative prices; this is substantiated empirically in the estimated demand equations. The long-term trading

7 The spot price function so obtained is given by

$$PN^S = f_5\{CN, CN_{-1}, QN, SNC_{-1}, SNC_{-2}, \Delta SNG, \Delta(CN/QN)\}$$

and the OLS estimation gives

$$PN^S = \underset{(3.0)}{4.1765} - \underset{(-1.6)}{0.0074}(CN) + \underset{(1.0)}{0.0019}(CN_{-1}) + \underset{(1.9)}{0.0077}(QN)$$

$$- \underset{(-2.4)}{0.0053}(SNC_{-1}) - \underset{(-2.1)}{0.0051}(SNC_{-2}) - \underset{(-0.6)}{0.0022}\Delta SNG$$

$$+ \underset{(0.6)}{4.6728} \cdot \Delta(CN/QN)$$

$$R^2 = 0.8028;\ f_{7,13} = 7.5595;\ DW = 1.5343;$$

arrangement for natural rubber and the activities of the various natural rubber exchanges is therefore reinforcing in that each facilitates the activities of the other.

Following the approach of Hwa (1979), the function for determining spot price under stock disequilibrium will now be derived. Basically the observed spot price in the terminal market results from partial adjustment of the spot price towards that price level which

8 This argument is similar to that of Adams (1958) who attributed price instability to changes in stockholdings in consuming regions, and argued that stockholding patterns of the consuming countries are related to whether these countries are trading centres for natural rubber as well, since stockholdings partially reflects fluctuations in trade. Hence price fluctuations are due to such stocks being too heavy (thus depressing prices) or below normal (thus causing a bullish impetus to the market). However Adams was writing in 1958 when the phenomenal growth of the synthetic industry was just beginning and when private stockholdings in consuming regions was a lower share of total stocks than was subsequently observed for the 1960s and 1970s because the national stockpiles precipitated by the Korean War had not then been released. Adams therefore argued that the smaller share of stocks held in consuming countries was a reason for price fluctuations because "unexpected increases in demand or decreases in the supply of (natural) rubber are more likely to cause a scramble for near-by (natural) rubber and in consequence exaggerate price movements, than would be the case if larger stocks were available to 'cushion' the effect." The observed higher share of stocks in consuming regions from the mid-1960s is partly a reflection of the higher levels of natural rubber consumption.

would yield stock equilibrium. Let

SNC^* be the desired (equilibrium) demand for consumer stocks of natural rubber;

SNC be the actual demand for consumers' stocks stocks of natural rubber;

CN be the total natural rubber consumption;

PN^S be the London spot price and

PN^{S*} be the expected London spot price in the next period.

Under the precautionary motive for consumers' stockholding of natural rubber, consumers' desired demand for stocks will be some function of their total consumption. Hence

$$(5.6) \qquad SNC^* = f_6(CN)$$

$$= \alpha_0 + \alpha_1(CN) \qquad (\alpha_1 > 0)$$

Under the speculative and hedging motives, demand for consumer stocks is determined by the difference between the expected and the current spot prices. Hence

$$(5.7) \qquad SNC^* = f_7\,(PN^{S*} - PN^S)$$

$$= \alpha_2(PN^{S*} - PN^S) \qquad (\alpha_2 > 0)$$

The total desired demand for stocks is then given by

$$(5.8) \qquad SNC^{*} = f_6(CN) + f_7(PN^{S*} - PN^{S})$$

$$= \alpha_0 + \alpha_1(CN) + \alpha_2(PN^{S*} - PN^{S})$$

On the other hand the supply of consumer stocks, given by the balance identity, is

$$(5.9) \qquad SNC = SNC_{-1} + SNP_{-1} + SNA_{-1} + QN - CN$$

$$- SNP - SNA + \Delta SNG$$

where ΔSNG refers to net releases from the various government stockpiles of natural rubber.

If the desired demand SNC^{*} is satisfied, then there is an equilibrium spot price $\overline{PN}^{S}$ such that

$$(5.10) \qquad SNC^{*} = SNC$$

Equating (5.8) and (5.9) and setting $\overline{PN}^{S} = PN^{S}$ gives

$$(5.11) \qquad \overline{PN}^{S} = \frac{1}{\alpha_2}\{\alpha_0 + \alpha_1(CN) - SNC\} + PN^{S*}$$

However, the equilibrium spot price $\overline{PN}^{S}$ is not attained in each period because the desired demand SNC^{*} cannot be attained. Since $SNC^{*} \neq SNC$, therefore

$$\text{(5.12)} \qquad SNC^{*} - SNC = \alpha_0 + \alpha_1(CN) + \alpha_2(PN^{S*} - PN^{S}) - SNC$$

Substituting PN^{*} from (5.11) in (5.12) gives

$$\text{(5.13)} \qquad SNC^{*} - SNC = \alpha_2(\overline{PN}^{S} - PN^{S})$$

Alternatively,

$$\text{(5.14)} \qquad \overline{PN}^{S} - PN^{S} = \frac{1}{\alpha_2}(SNC^{*} - SNC)$$

That is, the deviation of the observed spot price PN^{S} from the equilibrium spot price $\overline{PN}^{S}$ is proportional to the deviation of the observed consumer stockholdings (SNC) from their desired level (SNC^{*}). The adjustment of spot price and consumer stockholdings are inter-reacting. Assuming a partial adjustment process for the spot price to its equilibrium level yields

$$\text{(5.15)} \qquad PN^{S} - PN^{S}_{-1} = \mu(\overline{PN}^{s} - PN^{S}_{-1}) \qquad 0 \leq \mu \leq 1$$

giving

$$\text{(5.16)} \qquad \overline{PN}^{S} - PN^{S} = (\frac{1}{\mu} - 1)(PN^{S} - PN^{S}_{-1})$$

Substituting (5.16) into (5.15) leads to

$$\text{(5.17)} \qquad PN^{S} - PN^{S}_{-1} = \frac{\mu}{\alpha_2(1-\mu)}[SNC^{*} - SNC]$$

Substituting SNC^{*} in (5.17) gives

(5.18) $$PN^S - PN^S_{-1} = \frac{\mu}{\alpha_2(1-\mu)} \{\alpha_0+\alpha_1(CN)+\alpha_2(PN^{S*}-PN)-SNC\}$$

$$\therefore\ PN^S = k_o + k_1(CN) + k_2(PN^{S*}) - k_3(SNC) + k_4(PN^S_{-1})$$

where $k_0 = \alpha_0\mu/\alpha_2$ $\qquad k_1 = \alpha_1\mu/\alpha_2$

$k_2 = \mu$ $\qquad k_3 = \mu/\alpha_2$

and $k_4 = (1-\mu)$

Using the extrapolative model to translate the expected spot price PN^* into observable variable(s) gives:

(5.19) $$PN^{S*} = PN^S_{-1} + \gamma(PN^S_{-1} - PN^S_{-2}) \qquad 0 \le \gamma \le 1$$

Substituting into the spot price equation above gives:

(5.20) $$PN^S = k_0 + k_1(CN) + (k_2 + k_2\gamma + k_4)\ PN^S_{-1} - k_2\gamma(PN^S_{-2}) - k_3(SNC)$$

Hence the spot price is determined by the levels of natural rubber consumption and stockholdings in the consuming regions and spot price in previous period.

Some further modifications are needed. To obtain the real price of natural rubber the London spot price was deflated by the UK Wholesale Price Index (WPI^{UK}) for all commodities. With releases from government stockpiles of natural rubber occurring throughout 1959-1977, a variable for the net change (measured by the releases) in the government stockpiles was incorporated to reflect their dampening effects on the price level. To account for the episodic increases in spot price due to extraneous factors, three dummy variables were used: DV(1) for 1969 to proxy the racial riots in Malaysia during May of that year, DV(2) for the first oil crisis of 1973/1974 and DV(3) for the 1975 recession and the peak of the Malaysian "Crash Programme" activities (for details, see Appendix 6A). The modified equation is:

$$(5.21) \qquad (PN^S/WPI^{UK}) = f_8\{CN,\ SNC,\ \Delta SNG,\ (PN^S/WPI^{UK})_{-1}, (PN^S/WPI^{UK})_{-2}$$

$$DV(1),\ DV(2),\ DV(3)\}$$

In equation (5.21) spot price is expected to be an increasing function of natural rubber consumption and the one-period lagged spot price, and a decreasing function of stocks in consuming regions, the stockpile releases and the two-period lagged spot price. Estimation of (5.21) yields the following results:

$$(PN^S/WPS^{UK}) = \underset{(1.0)}{4.3275} + \underset{(0.5)}{0.0007}(CN) - \underset{(-1.9)}{0.0056}(SNC) - \underset{(-0.1)}{0.0007}(\Delta SNG)$$

$$+ \underset{(1.4)}{0.3346}(PN^S/WPI^{UK})_{-1} - \underset{(-0.1)}{0.0411}(PN^S/WPI^{UK})_{-2}$$

$$+ \underset{(1.2)}{1.1627} \cdot DV(1) + \underset{(1.4)}{1.0974} \cdot DV(2) - \underset{(-0.3)}{0.3114} \cdot DV(3)$$

$R^2 = 0.7630$; $F_{8,11} = 4.4257$; $DW = 2.3340$;

Although the estimates for lagged price and stocks were not highly significant, they have the expected signs. However the estimate for natural rubber consumption was negligible and insignificant. These estimates led to a reconsideration of the natural/synthetic rubber nexus and the influence of their substitutability on natural rubber spot price formation.

In the absence of synthetic rubbers, the impact of increased natural rubber consumption on spot price should be positive. However, the presence of synthetic rubbers appears to dilute the positive impact which unanticipated increases in rubber consumption would otherwise have had on the spot price formation through the advantages obtainable from consuming more synthetic rubbers. In other words, the observed spot price is the resultant effect of the level of stockholdings and the trading activities of consumers in both the natural and synthetic rubber markets. In the historical period when continuous expansion of synthetic rubber production under decreasing costs took place, the formation of spot price became dominated by the level of natural rubber stockholdings in the consuming regions and additional natural rubber (vis-a-vis synthetic rubber) was consumed only when warranted by relative prices. To account for that part of increased stockholdings required by higher consumption (that is, the precautionary requirements), stockholdings was deflated by consumption, giving

$$(5.22) \quad (PN^{S}/WPI^{UK}) = f_9\{(SNC/CN),\ \Delta SNG,\ (PN^{S}/WPI^{UK})_{-1},$$

$$(PN^{S}/WPI^{UK})_{-2},\ DV(1),\ DV(2),\ DV(3)\}$$

The estimation results of (5.22) are presented in Table 5.1; the equation with one price lag was selected since estimation with two price lags gave poorer (less significant) estimates.[9] Equation (5.22) will be used for model validation and simulation purposes. Although the estimate for DV(3) was insignificant, it was retained for aiding the simulation of the sharp decline in natural rubber price in 1975.[10]

As mentioned before, the natural rubber stocks in the consuming regions was then used as a balance identity (see equation 5.10). Owing to the large measurement errors in the stocks data, an estimated equation was used to proxy the balance identity for closing the natural rubber submodel. Table 5.1 also presents the estimates for this balance equation.

5.5 Primary-Terminal Markets Interaction and Price Linkage

Besides the natural rubber exchange in London, other rubber exchanges are to be found in the primary markets of Kuala Lumpur and Singapore and in the terminal markets of Hamburg, New York, Tokyo and Kobe. Because of the longitudinal and consequent time differentials between these centres, the activities of these markets are

9 The alternative of using a moving average price over three or more periods was not adopted because price expectations based on such long price lags are considered unlikely.

10 It should be mentioned that the volatility of natural rubber price is also exacerbated by the erratic natural rubber purchasing programmes of the centrally-planned economies. However since price behaviour in this study is not examined from the angle of rubber trade, this issue cannot be analysed directly.

Table 5.1: Natural Rubber Stocks and Spot Price Equations

Explanatory Variables / Dependent Variable	Cons.	CN	QN	SNC_{-1}	$(SNP+SNA)_{-1}$	$\Delta(SNP+SNA)$	$\Delta(CN/QN)$	(SN/CN)	ΔSNG	$(PN^S/WPI)_{-1}$	DV(1)	DV(2)	DV(3)	R^2	F	DW
(SNP+SNA)	93.8514 (1.5)				0.8749 (9.4)		-728.9927 (-2.7)							0.8435	45.8213 ($F_{2,17}$)	2.0570
(PN^S/WPI)	5.8449 (3.6)							-15.9685 (-3.3)	-0.0022 (-0.6)	0.3340 (1.7)	1.2696 (1.6)	0.8211 (1.4)	-0.4866 (-0.6)	0.7673	7.1430 ($F_{6,13}$)	2.4692
SNC		-0.4814 (-1.8)	0.5822 (2.7)	0.5725 (2.1)		-0.2456 (-1.1)			-0.2885 (-0.8)					0.9637	66.3335 ($F_{4,10}$)	3.0414

Notes: (1) (PN^S/WPI) denotes the London RSS1 spot price deflated by the UK Wholesale Price Index for manufactured goods.

(2) The sample period used in estimating the equation for stocks in consuming regions is 1963-1977. The reason for using 1963 as the initial year is so as to avoid the quantum jump given to stocks in the consuming regions as a result of the stocks data realignment undertaken by the IRSG in 1973. The sample period for the other two equations in Table 5.1 is 1958-1977.

(3) DV(1), DV(2) and DV(3) are the three dummy variables mentioned in the text.

continuously linked in that the daily closing of the primary markets coincides with the daily opening of the terminal markets (excluding Tokyo and Kobe which are relatively unimportant to the rubber markets beyond Japan). Thus prices in these different markets are interrelated.

Since it is the c.i.f./f.o.b. prices quoted in the London, New York and Singapore markets that are used in estimating the supply and consumption equations for the various countries, equations to explain these other prices are required. These price linkage equations are estimated by simple regressions, after converting the London spot price into the same currency as the local prices to be explained. Consequently there are six price linkage equations in the natural rubber submodel; these are presented in Table 5.2. To cater for the average natural rubber prices which were used in some instances, identities for generating these average price variables are also included.

5.6 Synthetic Rubber Supply and Price Determination

In Chapter Three (section 3.7) the salient features of synthetic rubber supply and pricing were discussed. To recapitulate, the industry is dependent on the oil industry for its raw material inputs and on the tyre industry for the bulk of its demand. The upshot of these interrelations is the observed vertically-integrated oligopolistic structure of the industry which facilitates intra-firm

Table 5.2: Natural Rubber Price Linkage Equations

Dependent Variables \ Explanatory Variables	Constant	PN^S	$PN^{1,UK}$	$PN^{1,NY}$	$PN^{1,Sing}$	R^2	F	DW
(1) $PN^{1,UK}$	-8.8825 (-0.6)	0.9838 (19.3)				0.9637	371.5403	2.2456
(2) $PN^{3,UK}$	8.0995 (1.2)		0.9488 (37.9)			0.9903	1433.2024	1.3860
(3) $PN^{1,Sing}$	109.6575 (0.7)	0.8372 (9.3)				0.8608	86.5816	2.2393
(4) $PN^{3,Sing}$	-39.9678 (-0.7)				0.9878 (28.5)	0.9831	811.9535	2.2250
(5) $PN^{1,NY}$	54.1210 (1.1)	0.9369 (12.8)				0.9217	164.8808	2.4684
(6) $PN^{3,NY}$	12.7488 (1.4)			0.9511 (72.4)		0.9960	5235.2000	1.3999

NOTES:

(1) Figures in parentheses denote t-values of the corresponding regression coefficients.

(2) PN^S denotes the London spot price.

(3) $PN^{1,UK}$ and $PN^{3,UK}$ are the c.i.f. prices in London for RSS1- and RSS3-grade natural rubber respectively.

(4) $ON^{1,Sing}$ and $PN^{3,Sing}$ are the f.o.b. prices in Singapore for RSS1- and RSS3-grade natural rubber respectively.

(5) $PN^{1,NY}$ and $PN^{3,NY}$ are the c.i.f. prices in New York for RSS1- and RSS3-grade natural rubber respectively.

pricing and price discounting. Such closed trading also harbours the synthetic rubber industry to some extent from general market instabilities.

In his study of the rubber market up to the mid-1960s, Behrman's (1971) explanation of the declining synthetic rubber price was in terms of the four technical change indices mentioned in Chapter Two. In modelling the synthetic rubber market in this study, the focus is shifted away from the technical change issue for two reasons. Firstly, technical change in synthetic rubber production in the more recent period has been more significant for the specialty than for the general-purpose synthetic rubbers. Furthermore the future impact of technological progress and economies of scale in production are expected to be far less significant than have been in the past two decades (Grilli *et al*., 1978). Given the reaction of synthetic rubber production and price to the oil crises since late 1973, and given the prospects of continually rising oil price, it was elected to focus on the impact of oil price and production capacity on synthetic rubber supply and price. This is pertinent because the future interaction between natural and synthetic rubbers now becomes hinged, to a large extent, to scenarios concerning oil pricing. In attempting to quantify this impact, albeit crudely, the estimation of synthetic rubber supply and price was based on the assumption of monopolistic behaviour for the total world synthetic rubber supply. Under this assumption, synthetic rubber supply and price are thus jointly determined.

Assuming cost-plus pricing for synthetic rubber, the average price of synthetic rubbers (PS) is given by

$$(5.23) \qquad PS = AC + m(PN)$$

where AC is the average cost of synthetic rubbers production

and m is the level of mark-up per unit synthetic rubbers sold.

As the general-purpose synthetic rubbers compete with natural rubber, the mark-up is hypothesised as being determined by the level of natural rubber price (PN) so that m is some function of PN. Since average cost consists of average fixed cost (which in an industry with scale economies is determined by the production capacity) and average variable cost (which is dependent on the price of raw material inputs, chiefly oil), average synthetic rubber price is then given by:

$$(5.24) \qquad PS = f_{10}(CQSR, P^{oil}, PN)$$

where CQSR is the total world synthetic rubber production capacity.

and P^{oil} is the price of oil.[11]

11 In the study by Man and Blandford (1980) the synthetic rubber sector was partially endogenised through a price equation for styrene-butadeine:

$$P^{SBR} = \alpha_0 + \alpha_1 (P^{oil}) + \alpha_2 . P^{SBR}$$

where P^{SBR} is the wholesale price of styrene-butadiene(SBR) quoted in the New York market and P^{oil} is the posted f.o.b. price of Saudi Arabian light crude oil.

However no mention is made of the grades of SBR for which the price refers. Man and Blandford do not concern themselves with the synthetic rubber sector since they are only concerned with the supply and demand of natural rubber.

Similarly synthetic rubber production (supply) is some form of

$$(5.25) \quad QSR = f_{11}\ (\ CQSR,\ P^{oil},\ PN)$$

where QSR is total world synthetic rubber production.

To reflect the interaction between economies of scale and prices the log-linear form was adopted in estimating the supply and price equations. In estimating these two equations, the average list prices for styrene-butadiene (grades 1500 and 1712) and polybutadiene quoted in France, Italy and UK were used after converting to US dollars. For oil the f.o.b. price of light crude oil, (ex-Saudi Arabian port of Ras Tanura), was used while the c.i.f. London RSS1-price was chosen as the natural rubber price. To obtain the real price of synthetic rubbers, the average list price was deflated by the US Wholesale Price Index (WPI^{UK}) for manufactured goods.

There is an argument for using unit export/import values (typically for US exports/UK imports respectively) instead of their list prices. This is that synthetic rubbers are traded under unpublicised variable discounts. Since consumers do not pay list prices, list prices are not representative of the actual cost of synthetic rubber consumption. However the relative superiority of using unit export/import values becomes less clear when it is remembered that not only are synthetic rubbers largely produced in the major tyre-producing countries but their production capacities are also largely owned by the vertically-integrated transnational tyre-producing corporations. The domestic production of synthetic rubbers implies that major tyre manufacturers consume synthetic rubbers that are mainly domestically produced. On the basis of list price quotations in France, Italy and UK it would appear that cross-country differences in production costs exist. On the other hand the transnational characteristic of the synthetic rubber industry provides scope for intra-firm transactions so that the unit export/import values need not reflect market-determined values either. Furthermore, the occasional "dumping" of synthetic rubbers in the international market would also affect unit export/import values. It is therefore argued that for the purpose of stabilising the natural rubber market, an understanding of list price formation is relatively more useful since such prices, which are published in advance, are held constant over a given period of time after they have been announced.

Based on the average European list price quotations, the estimates for the synthetic rubber supply and price equations for inclusion in the model are given in Table 5.3; the natural rubber price variable is omitted since its inclusion does not contribute significantly to the explanation of synthetic rubber production and price formation.[12]

The supply equation shows, as expected, that the observed synthetic rubber output is positively related to production capacity and negatively related to oil price, the net effect being dominated by the level of production capacity. In contrast the level of synthetic rubber price is a negative function of production capacity and a positive function of oil price. However, despite the fact that feedstocks and energy inputs constitute about 70 percent of synthetic rubber production costs (Grilli et al., 1978), the elasticity of synthetic rubber price with respect to oil price approximates only

Table 5.3: Synthetic Rubber Production and Price Equations

	Constant	ln CQRS	$\ln(p^{oil}/WPI^{US})$	R^2	F	DW
ln QRS	1.4172 (3.9)	1.1142 (18.8)	-0.0712 (-2.2)	0.9831	378.4948 ($F_{2,13}$)	2.4742
$\ln(PSR/WPI^{US})$	5.0869 (11.8)	-0.6104 (-8.7)	0.2768 (7.2)	0.8532	37.7877 ($F_{2,13}$)	1.8838

0.2768 in the historical period. The influence of capacity effect is reflected by the elasticity of -0.6104 of synthetic rubber price with respect to production capacity. Thus synthetic rubber supply and price are significantly dependent on the creation of new production capacities and the behaviour of oil price.

To close the synthetic rubber submodel a synthetic rubber stocks(SSR) balance identity was used; that is:

$$(5.26) \qquad SSR = SSR_{-1} + QSR - CSR$$

where QSR is the total world synthetic rubber supply

and CSR is the total world synthetic rubber consumption.

In view of the minor discrepancy in the synthetic rubber stocks data,

12 The synthetic rubber production and price equations when natural rubber price is included are:

(a)
$$\ln QSR = \underset{(1.2)}{0.4559} + \underset{(23.1)}{1.2217} \ln CQSR - \underset{(-4.4)}{0.1185} \ln (P^{oil}/WPI^{US})$$
$$+ \underset{(3.5)}{0.1935} \ln (PN^{S}/WPI^{UK})$$

$$R^2 = 0.9917; \quad F_{3,12} = 477.7798; \quad DW = 2.7450$$

(b)
$$\ln (PS/WPI^{US}) = \underset{(10.3)}{5.8474} - \underset{(-8.8)}{0.6954} \ln CQSR + \underset{(7.8)}{0.3143} \ln (P^{oil}/WPI^{US})$$
$$- \underset{(-1.9)}{0.1531} \ln (PN^{S}/WPI^{UK})$$

$$R^2 = 0.8861; \quad F_{3,12} = 31.1257; \quad DW = 1.4633;$$

The estimates show that the explanatory contribution of the natural rubber price variable is marginal, while the Durbin-Watson statistic is worsened. Furthermore the natural rubber price estimate has the wrong sign; a priori, increases in natural rubber price in (b) should provide scope for increasing synthetic rubber price. It is plausible that this relationship is not established empirically because it is the price discounts given to consumers rather than the known list prices that are affected by the behaviour of natural rubber price.

the balance equation (5.26) with unitary coefficients was adopted in the model.

As for the natural rubber sector, price linkage equations are also required for the synthetic rubber sector. This is because the various European list prices were used individually and in various combinations in the demand equations. Thus while the average synthetic rubber list price is explained by a price equation, the individual list prices will be explained separately. This is done by simple regression of the individual prices on the world average price, thereby linking the individual prices to the world price which is determined by total production capacity and oil price. Table 5.4 gives the simple correlation coefficients for the nine price linkage equations for styrene-butadiene (grades 1712 and 1500) and polybutadiene prices in France, Italy and UK. In general, the regressions gave good fits but with severe serial correlation in most cases.

Table 5.4: Synthetic Rubber Price Linkage Equations

	Constant	PSR	R^2	F	DW
France					
$PSBR^{1712}$	-47.5182 (-1.9)	0.9218 (21.4)	0.9807	456.7479	1.4011
$PSBR^{1500}$	-20.7280 (-0.7)	1.0646 (20.4)	0.9789	416.9732	1.6603
PBR	43.5738 (1.4)	0.9583 (18.4)	0.9740	336.9862	1.8924
Italy					
$PSBR^{1712}$	-47.1914 (-1.5)	0.9321 (17.3)	0.9707	298.5333	2.5318
$PSBR^{1500}$	8.1344 (0.2)	1.0098 (12.5)	0.9454	155.9352	1.1087
PBR	227.8280 (3.7)	0.7119 (6.8)	0.8367	46.1234	1.2985
UK					
$PSBR^{1712}$	-116.3742 (-5.1)	1.1389 (29.4)	0.9897	865.9875	1.2879
$PSBR^{1500}$	-82.0917 (2.6)	1.2366 (23.1)	0.9835	535.8682	1.2895
PBR	34.3674 (0.7)	1.0279 (12.2)	0.9428	148.2463	0.9523

CHAPTER SIX

MODEL STRUCTURE AND VALIDATION

6.1 Introduction

In this chapter the various components of the model developed in Chapters Two to Five are synthesised for empirical validation of the model for the historical period. Time paths of some key variables to demonstrate the *ex post* performance of the model will be presented after a discussion of (1) the data and econometric methods used in model estimation and (2) the causal structure of the model.

In view of the oil crises which substantially affected rubber demand behaviour during the latter one-third of the sample period (the 1970s), the penultimate section of this chapter examines the overall impact of the oil crises on the rubber market. This, together with the discussion on the overview of instability in the natural rubber market during the historical period, sets the stage for the subsequent chapter on evaluating crude oil availability, the prospect of its substitution by synthetic crude oil and the likely time paths of oil price so as to identify those factors relevant to the question of longer term stabilisation of the natural rubber market.

6.2 Data and Econometric Methods Used in Model Estimation

This section discusses the data and econometric methods used in estimating the model.

Most of the time-series data used were extracted from the Rubber Statistical Bulletin published by the IRSG. In addition, national statistical publications were referred to for data on industrial activity indices, wholesale price indices and the production of rubber goods. For synthetic rubber prices, the annual data on list prices were based on monthly list prices quoted in the European Chemical News. Of the data series used, those on natural rubber stocks and synthetic rubber price were most unsatisfactory. The problems with these two data series will now be discussed.

The problem of obtaining reliable data on stockholdings is well-known. For natural rubber stockholdings, the problem is compounded by the fact that stocks are distinguished by location. Thus separate series on stocks in producing countries, in consuming countries and afloat are available. A consequence of this differentiation by location is that the margins of error are widened. These errors lead to cumulative errors which can be severe as illustrated by the 1973 revision of stock data mentioned in Chapter Five. It will be recalled that the extensive data revision in 1973 pertained to stockholdings in 1961 and 1962, and was for the purpose of providing a more realistic estimate of the world stocks. Although this revision was made after deliberations by the Committee of Experts on Rubber Statistics of the IRSG, no reason was given for confining the revision only to data on stockholdings in the consuming countries.

Since stocks in consuming regions play a critical role in the natural rubber spot price formation equation, the errors in the stock data therefore affects the regression estimates. This is because estimation with data having measurement errors will result in bias and inconsistent estimates.

The other data problem concerns that of synthetic rubber list prices. As explained in Chapter Two, synthetic rubbers are traded under price discounts. In estimating the demand equations, the relative price variables should ideally be formed from the traded prices of natural rubber and synthetic rubbers. However, as traded prices for synthetic rubbers are not available, their corresponding list prices had to be used. This data inaccuracy introduces another source of bias in the regression estimates.

It is known that the use of ordinary least squares regression in estimating equations with lagged endogenous variables results in consistent but biased estimates. However, in view of the data deficiencies discussed above, it was considered that the use of two-stage least squares regression would yield only marginal returns over that from ordinary least squares regression. Two other reasons reinforce the choice of using ordinary least squares. First, since the time-series data are for the 1956-1978 period only, the sample size is small. If the property of consistency in the estimates is to be traded off for variance reductions, then ordinary least squares has the advantage. Second, since the model consists of 87 equations, it may be considered as a large model. In general, ordinary least squares and two-stage least squares are known to give similar results when the model is large, since the use of two-stage least squares requires a large number of instrumental variables. In such a situation, the values of the endogenous variables from the first-stage estimation will be very similar to the observed values.

A characteristic of the estimations is the use of Almon's lag scheme to represent the lagged price effects in the natural rubber supply equations and the natural and synthetic rubbers demand equations. The rationale for the presence of these lagged price effects has been discussed in Chapters Two and Three. The number of lagged periods used initially in estimating the equations of the model were based on a priori considerations.

In estimating the natural rubber supply equation, the number of lags used initially was based on the fact that the yield of rubber trees levels off about 10 years after the first tapping. Since tapping of rubber trees may begin in their fourth or fifth year, the yield of the trees would level off in about its fourteenth or fifteenth year. This feature is reflected in the supply response equation (3.22) which was obtained by first-differencing equation (3.21) in Chapter Three, whereupon the number of price lags is reduced to the number of years before the tree yield levels off. Thus 14 lags were first applied to the Almon scheme in the estimation of all supply equations. If the R^2 and the minimum standard-error statistics were unsatisfactory, then the equations were re-estimated with shorter lags. Throughout the estimations, no end-point constraint was used for the Almon scheme.

On the demand side, it is known that because of "habit persistence", the effects of relative price changes could be lagged up to four years. Thus lags up to four periods were first tried in the application of the Almon scheme to demand equations. Similarly, if R^2 and the minimum standard-error statistics were unsatisfactory, then the number of lags was progressively reduced until more acceptable test statistics were obtained. As for the estimation of the supply equations, no end-point constraint was used for the Almon scheme.

6.3 Causal Structure of the Model

The estimated model consists of an 87-equation system having 42 exogenous variables. It consists of various production and consumption blocks. The 87-equation model can also be viewed as consisting of two submodels, one for each group of rubber and interacting through their relative price effects on consumption. An overview of the model is provided by Figure 6.1 which summarises the various rubber production and consumption blocks in the model and their interaction. The 87 endogenous variables are listed below.

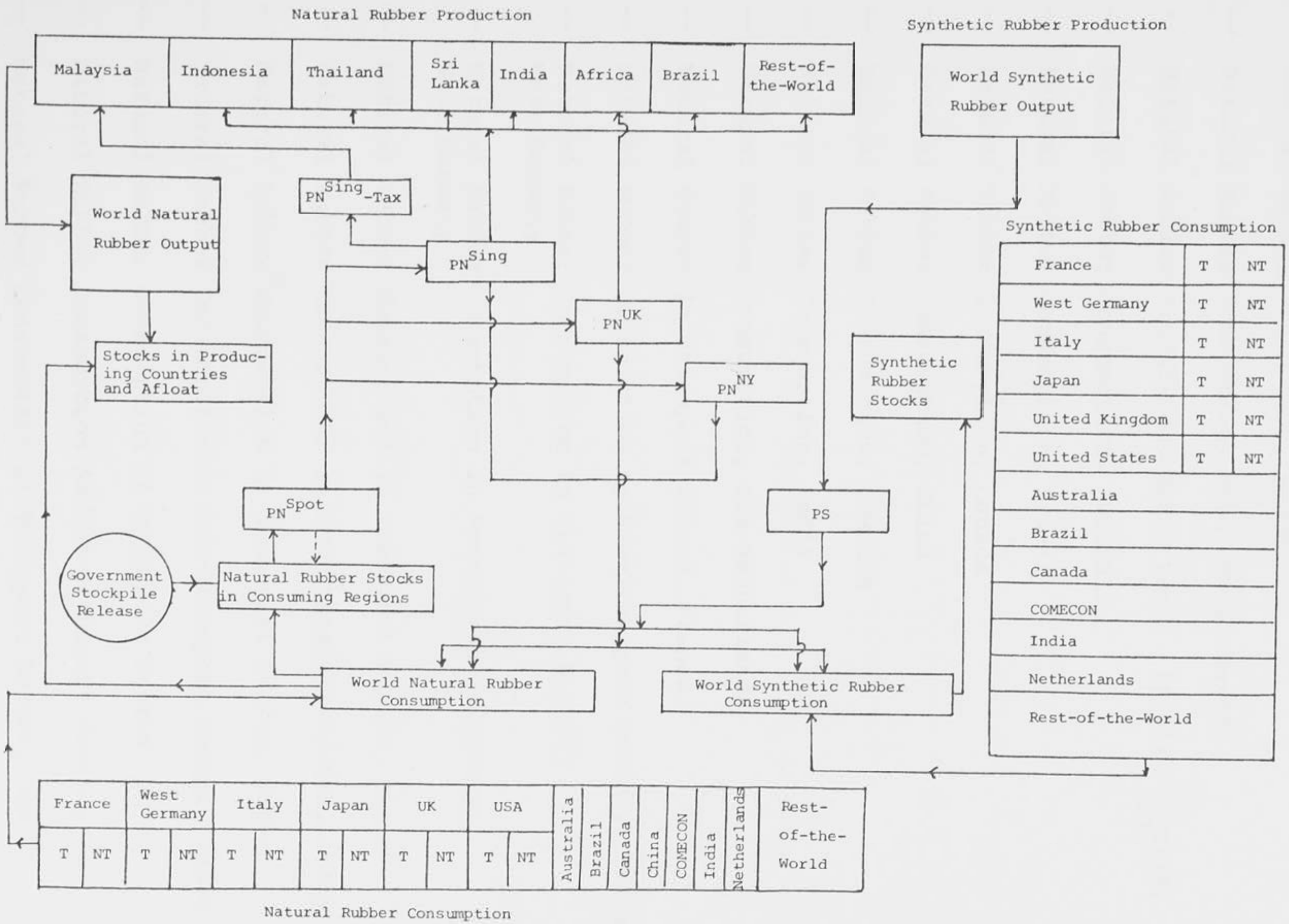
Endogenous Variables in the Model

Y(1) -- Estate Natural Rubber Production, Malaysia

Y(2) -- Smallholder Natural Rubber Production, Malaysia

Y(3) -- Estate Natural Rubber Production, Indonesia

Figure 6.1: Flowchart of the Interacting Flows in the Estimated Model



KEY:

T: Transport Sector

NT: Non-Transport Sector

Explanatory Variable ⟶ Dependent Variable

Y(4) -- Smallholder Natural Rubbber Production, Indonesia

Y(5) -- Natural Rubber Production, Thailand

Y(6) -- Natural Rubber Production, Sri Lanka

Y(7) -- Natural Rubber Production, India

Y(8) -- Natural Rubber Production, Africa

Y(9) -- Natural Rubber Production, Brazil

Y(10) -- Natural Rubber Production, Rest-of-the-World

Y(11) -- Natural Rubber Production, World Total [$Y(11) = \sum_{i=1}^{10} Y(i)$]

Y(12) -- Natural Rubber Consumption, Australia

Y(13) -- Natural Rubber Consumption, Brazil

Y(14) -- Natural Rubber Consumption, Canada

Y(15) -- Natural Rubber Consumption, China

Y(16) -- Natural Rubber Consumption, COMECON

Y(17) -- Natural Rubber Consumption, India

Y(18) -- Natural Rubber Consumption, The Netherlands

Y(19) -- Natural Rubber in Transport Sector, France.

Y(20) -- Natural Rubber Consumption in Non-Transport Sector, France

Y(21) -- Natural Rubber Consumption in Transport Sector, West Germany

Y(22) -- Natural Rubber Consumption in Non-transport Sector, West Germany

Y(23) -- Natural Rubber Consumption in Transport Sector, Italy

Y(24) -- Natural Rubber Consumption in Non-Transport Sector, Italy

Y(25) -- Natural Rubber Consumption in Transport Sector, Japan

Y(26) -- Natural Rubber Consumption in Non-Transport Sector, Japan

Y(27) -- Natural Rubber Consumption in Transport Sector, UK

Y(28) -- Natural Rubber Consumption in Non-Transport Sector, UK

Y(29) -- Natural Rubber Consumption in Transport Sector, USA

Y(30) -- Natural Rubber Consumption in Non-Transport Sector, USA

Y(31) -- Natural Rubber Consumption, Rest-of-the-World

Y(32) -- Natural Rubber Consumption, World Total $[Y(32) = \sum_{i=12}^{31} Y(i)]$

Y(33) -- Natural Rubber Stocks in Producing Regions and Afloat

Y(34) -- Natural Rubber Stocks in Consuming Regions

Y(35) -- Synthetic Rubber Consumption, Australia

Y(36) -- Synthetic Rubber Consumption, Brazil

Y(37) -- Synthetic Rubber Consumption, Canada

Y(38) -- Synthetic Rubber Consumption, COMECON

Y(39) -- Synthetic Rubber Consumption, India

Y(40) -- Synthetic Rubber Consumption, The Netherlands

Y(41) -- Synthetic Rubber Consumption in Transport Sector, France

Y(42) -- Synthetic Rubber Consumption in Non-Transport Sector, France

Y(43) -- Synthetic Rubber Consumption in Transport Sector, West Germany

Y(44) -- Synthetic Rubber Consumption in Non-Transport Sector, West Germany

Y(45) -- Synthetic Rubber Consumption in Transport Sector, Italy

Y(46) -- Synthetic Rubber Consumption in Non-Transport Sector, Italy

Y(47) -- Synthetic Rubber Consumption in Transport Sector, Japan

Y(48) -- Synthetic Rubber Consumption in Non-Transport Sector, Japan

Y(49) -- Synthetic Rubber Consumption in Transport Sector, UK

Y(50) -- Synthetic Rubber Consumption in Non-Transport Sector, UK

Y(51) -- Synthetic Rubber Consumption in Transport Sector, USA

Y(52) -- Synthetic Rubber Consumption in Non-Transport Sector, USA

Y(53) -- Synthetic Rubber Consumption, Rest-of-the-World

Y(54) -- Synthetic Rubber Consumption, World Total $[Y(54)= \sum_{i=35}^{53} Y(i)]$

Y(55) -- Synthetic Rubber Production, World Total

Y(56) -- Average Real Price of Synthetic Rubbers $[Y(78)/WPI^{USA}]$

Y(57) -- Price of Styrene-Butadiene 1712, France

Y(58) -- Price of Styrene-Butadiene 1500, France

Y(59) -- Price of Polybutadiene, France

Y(60) -- Price of Styrene-Butadiene 1712, (SBR1712), Italy

Y(61) -- Price of Styrene-Butadiene 1500, (SBR1500), Italy

Y(62) -- Price of Polybutadiene, (BR), Italy

Y(63) -- Price of Styrene-Butadiene 1712, UK

Y(64) -- Price of Styrene-Butadiene 1500, UK

Y(65) -- Price of Polybutadiene, UK

Y(66) -- Price of RSS1-grade Natural Rubber, c.i.f. London

Y(67) -- Price of RSS3-grade Natural Rubber, c.i.f. London

Y(68) -- Price of RSS1-grade Natural Rubber, c.i.f. New York

Y(69) -- Price of RSS3-grade Natural Rubber, c.i.f. New York

Y(70) -- Price of RSS1-grade Natural Rubber, f.o.b. Singapore

Y(71) -- Price of RSS3-grade Natural Rubber, f.o.b. Singapore

Y(72) -- Spot Price of RSS1-grade Natural Rubber, London

Y(73) -- Average Price of RSS1- and RSS3-grade Natural Rubber, c.i.f. London

Y(74) -- Average Price of RSS1- and RSS3-grade Natural Rubber, f.o.b. Singapore

Y(75) -- Average Price of SBR1712 in France, Italy and UK

Y(76) -- Average Price of SBR1500 in France, Italy and UK

Y(77) -- Average Price of BR in France, Italy and UK

Y(78) -- Average Price of SBR1712, SBR1500 and BR in France, Italy and UK

Y(79) -- Average Price of SBR1712 and SBR1500 in France, Italy and UK

Y(80) -- Average Price of SBR1712 and BR in France

Y(81) -- Average Price of SBR1712 and BR in UK

Y(82) -- Average Price of SBR1712 and BR in France, Italy and UK

Y(83) -- Synthetic Rubber Stocks, World Total

Y(84) -- Export Tax Rate for Malaysian Smallholder Natural Rubber

Y(85) -- Export Tax Rate for Malaysian Estate Natural Rubber

Y(86) -- F.o.b. Singapore Price of RSS1-grade Natural Rubber less Export Tax

Y(87) -- F.o.b. Singapore Price of RSS3-grade Natural Rubber less Export Tax

The system of 87 equations can be divided into two distinct blocks of equations. Block I contains 15 equations explaining the endogenous variables Y(15), Y(16), Y(20), Y(24), Y(30), Y(31), Y(37), Y(38), Y(42), Y(46), Y(48), Y(52), Y(53), Y(55) and Y(56). These equations are dynamically non-integrated so that the relationship is one way with no feedback effects. Block II contains the remaining 72 equations (16 of which are identities) for the balance endogenous variables; these equations are dynamically integrated in that each contains two or more endogenous variables. Thus the two blocks of equations form a block-recursive system with the simultaneous determination of the endogenous variables in Block II being dependent on all the structural equations of Block I.

To analyse the causal structure of the system, the causal ordering procedure of McElroy (1978) was adopted. The method consists of examining the relationship between variables in each equation and tracing their causality by means of a flow-chart. Tracing the causal ordering of the system provides a schematic view of the causal structure of complete subsets of co-determined (directly by being in the same class or indirectly by transitivity through a chain relationship) variables. Table 6.1 presents the causal structure of

Table 6.1: Causal Structure of the 87-Equation Model (Column Headings Indicate the Order of Complete Subsets)

Zero Order	First Order	Second Order			Third Order	Fourth Order	Fifth Order
Y(15)	Y(78)	[a],	[b],	[c],	Y(35),	Y(54)	Y(83)
Y(16)		Y(2),	Y(3),	Y(4),	Y(36),		
Y(20)		Y(5),	Y(6),	Y(7),	Y(39),		
Y(24)		Y(8),	Y(9),	Y(19),	Y(40),		
Y(30)		Y(22),	Y(23),	Y(25),	Y(41),		
Y(31)		Y(26),	Y(27),	Y(28),	Y(43),		
Y(37)		Y(33),	Y(57),	Y(58),	Y(44),		
Y(38)		Y(59),	Y(60),	Y(61),	Y(45),		
Y(42)		Y(62),	Y(63),	Y(64),	Y(47),		
Y(46)		Y(65),	Y(76),	Y(77),	Y(49),		
Y(48)		Y(73),	Y(75),	Y(79),	Y(50),		
Y(52)		Y(80),	Y(81),	Y(82),	Y(51),		
Y(53)		Y(84),	Y(85),	Y(87),			
Y(55)							
Y(56)							

Notes: (1) [a], [b] and [c] are variable classes wherein each Variable appear in the same equation as one or more of the other variables in the same class. Variables in the same class are therefore directly co-determined.

(2) Class [a] contains Y(1), Y(11), Y(34), Y(70), Y(72) and Y(86);

Class [b] contains Y(10), Y(11), Y(12), Y(17), Y(32), Y(34), Y(70), Y(71), Y(72), and Y(74);

Class [c] contains Y(13), Y(14), Y(18), Y(21), Y(29), Y(32), Y(66), Y(67), Y(68), Y(69), and Y(72).

the 6 complete subsets of 87 variables; the ordering of subsets denotes causality, the higher-order subsets being "causally-dependent" on those of lower order.

For an idea of the causal structure of the model the causality between natural rubber price and synthetic rubber price as revealed by the causal ordering will now be discussed. In the zero-order subset it will be noted that synthetic rubbers production Y(55) and its real price Y(56) are co-determined; the monetary price of synthetic rubbers is then determined in the first-order subset. Natural rubber price Y(72) and production Y(11) (both in class [a]) and consumption Y(32) (in class [b]) as well as some consumption of synthetic rubbers are determined in the second-order subset and hence are causally-dependent on synthetic rubber production and price. The balance synthetic rubber consumption are then determined in the third-order subset which then determines total synthetic rubber consumption. Synthetic rubber stocks are subsequently determined (as a residual) in the fifth-order subset. Thus the determination of natural rubber price in the historical period has been causally-dependent on the average price of synthetic rubbers and co-determined with natural rubber production and natural and synthetic rubber consumption.

6.4 Empirical Validation of the Model

The model was validated by one-period and dynamic (multi-period) *ex post* simulations of the sample period 1970-1977[1] using a simulation programme written by Carland,[2] and using the Gauss-Seidel method for solving the simultaneous equation system. The time paths generated by one-period and dynamic simulations for any variable can then be compared with the observed time paths to see how well the simulated values track the observed time paths.

Figures 6.2(i)-(viii) presents actual and simulated time paths for world natural rubber production and consumption, world synthetic rubber production and consumption, natural rubber stocks in consuming regions, world synthetic rubber stocks, natural rubber spot price in London and the average European price for the general-purpose synthetic rubbers. Based on the behaviour of the simulated time paths, the model may be considered as tracking the market behaviour during 1970-1977 quite well. Overall, the model is seen to perform

1 The model was validated for 1970-1977 only because several equations in the model were estimated from times series data ending in 1977.

2 The simulation programme was originally written as part of his doctoral research. Modifications made to the programme were for purpose of handling the larger number of equations and the tax functions discussed in Chapter Four above.

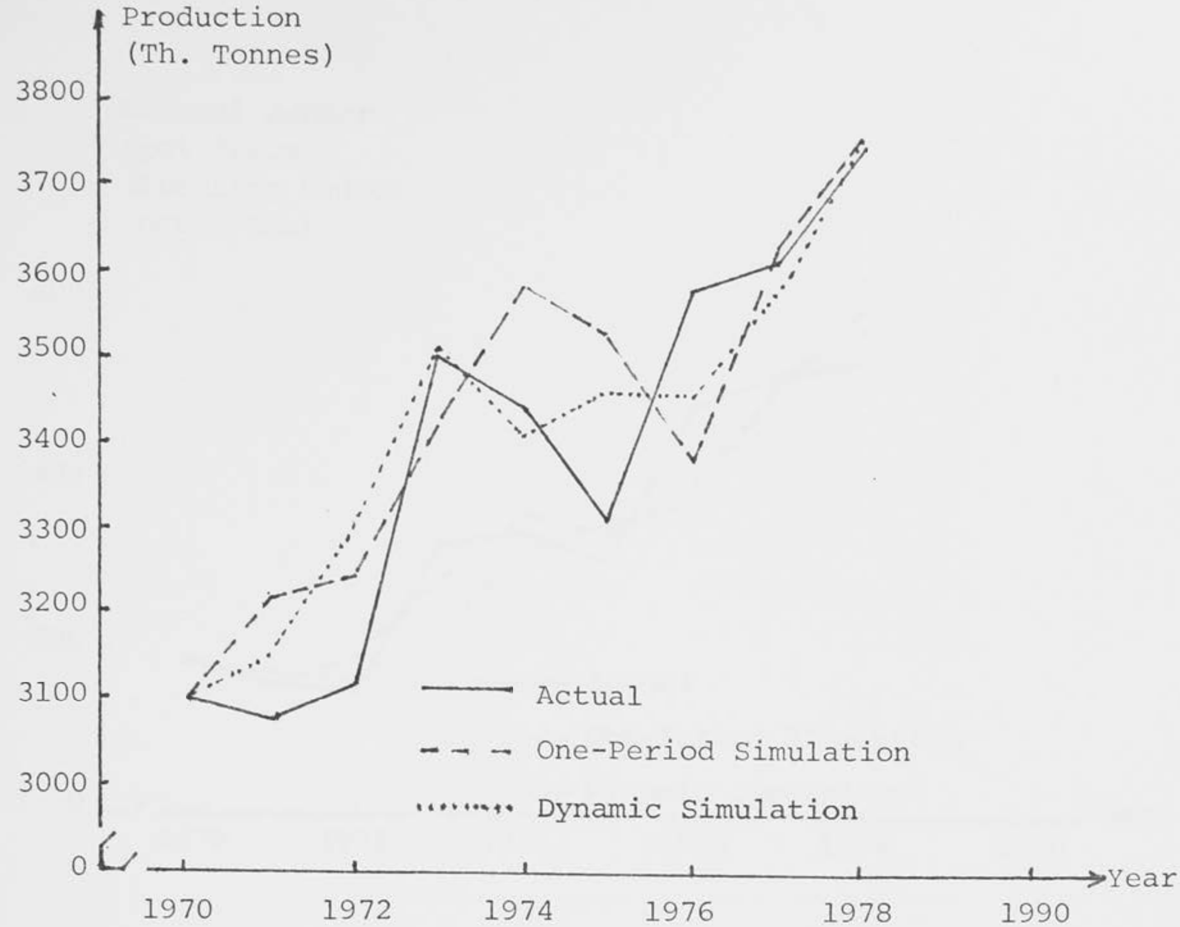


Figure 6.2(i): Time Paths of World Natural Rubber Supply, 1970-1978.

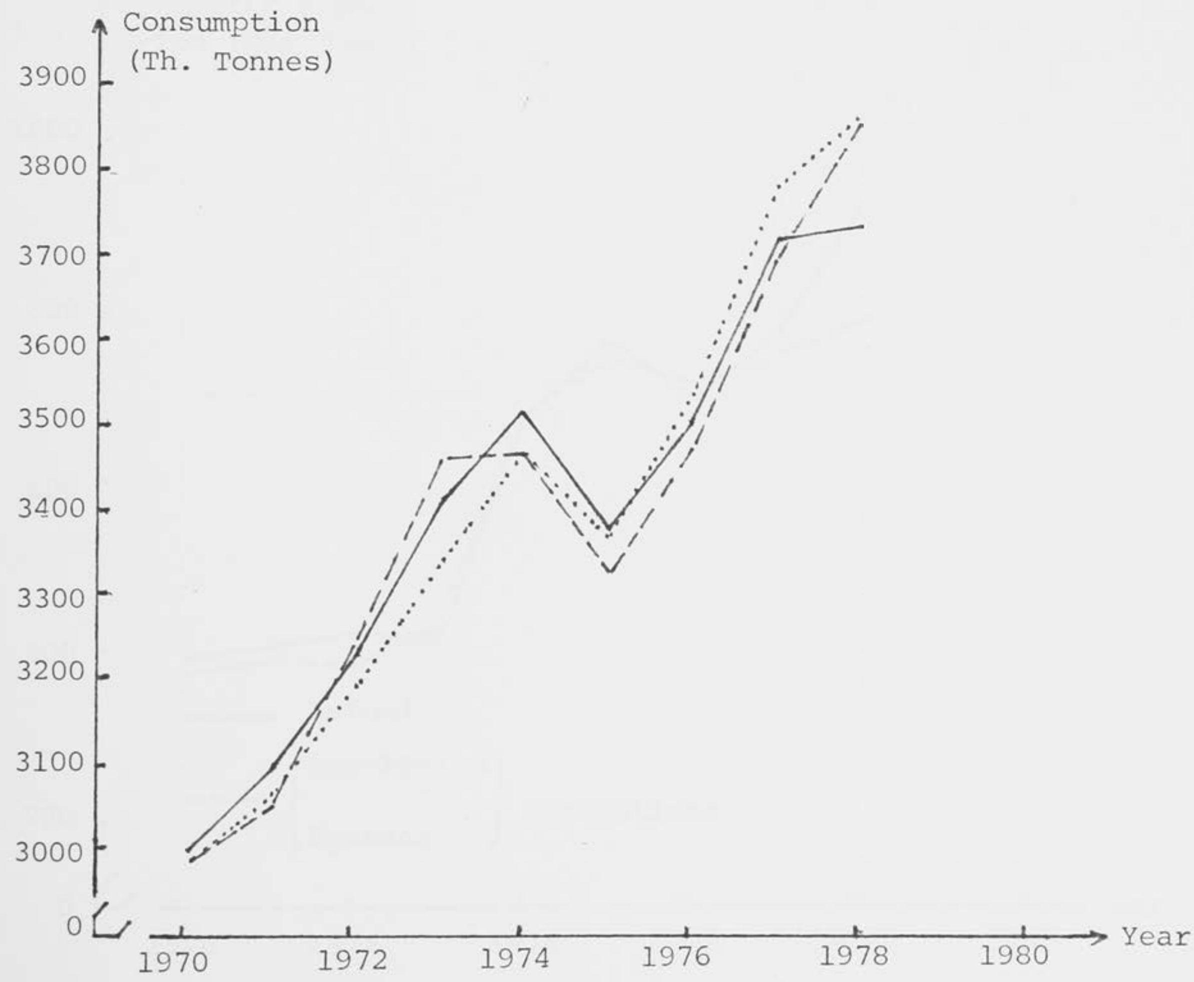


Figure 6.2(ii): Time Paths of World Natural Rubber Consumption, 1970-1978.

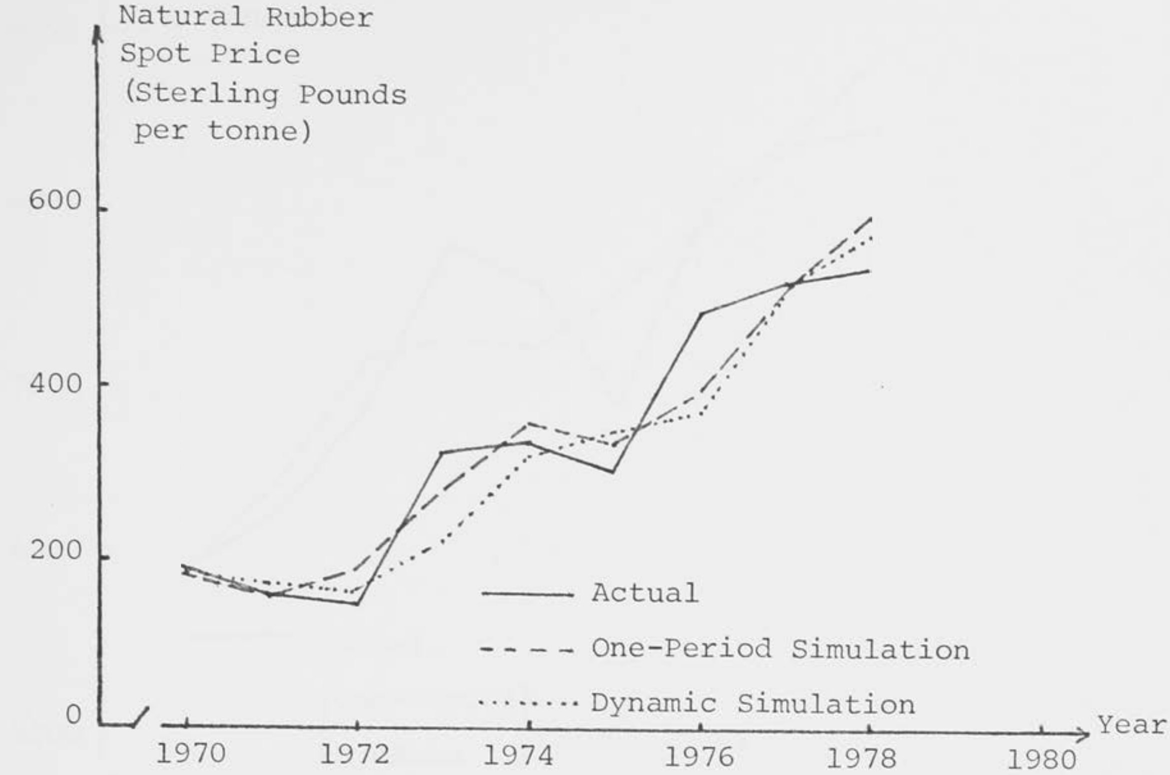


Figure 6.2(iii): Time Paths of London Spot Price for RSS1-grade Natural Rubber, 1970-1978.

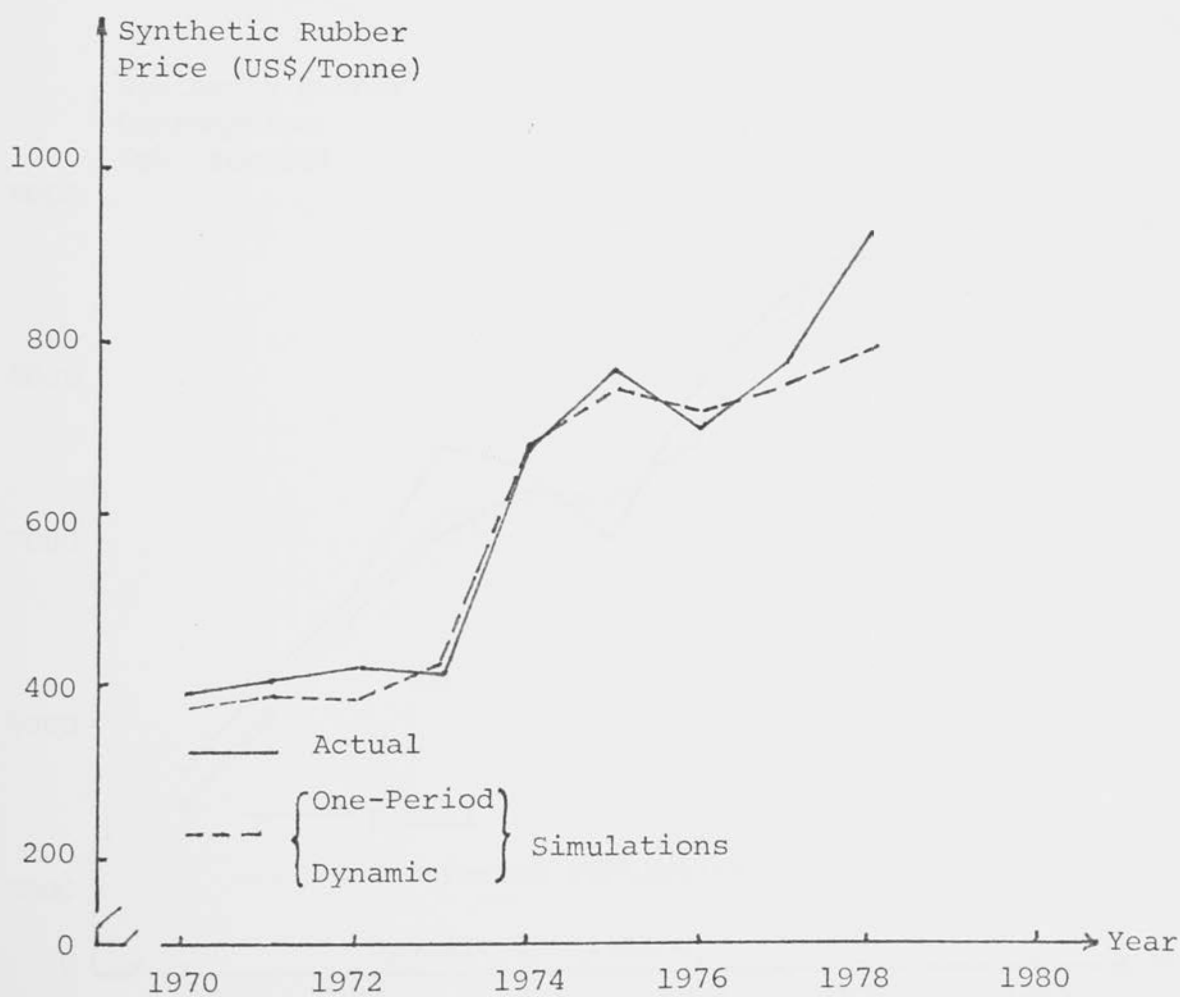


Figure 6.2(iv): Time Paths of Average European Synthetic Rubber Price, 1970-1978.

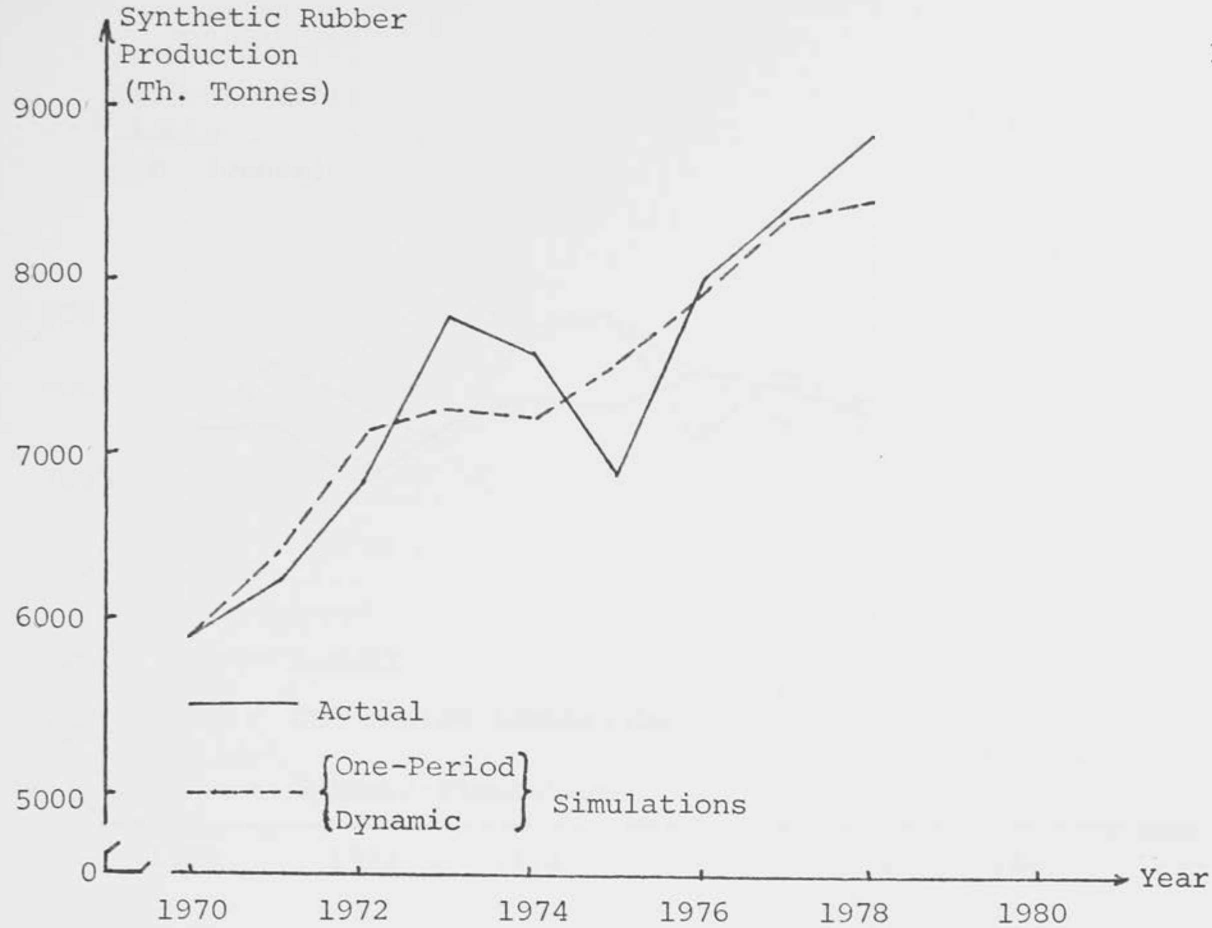


Figure 6.2(v): Time Paths of World Synthetic Rubber Supply, 1970-1978.

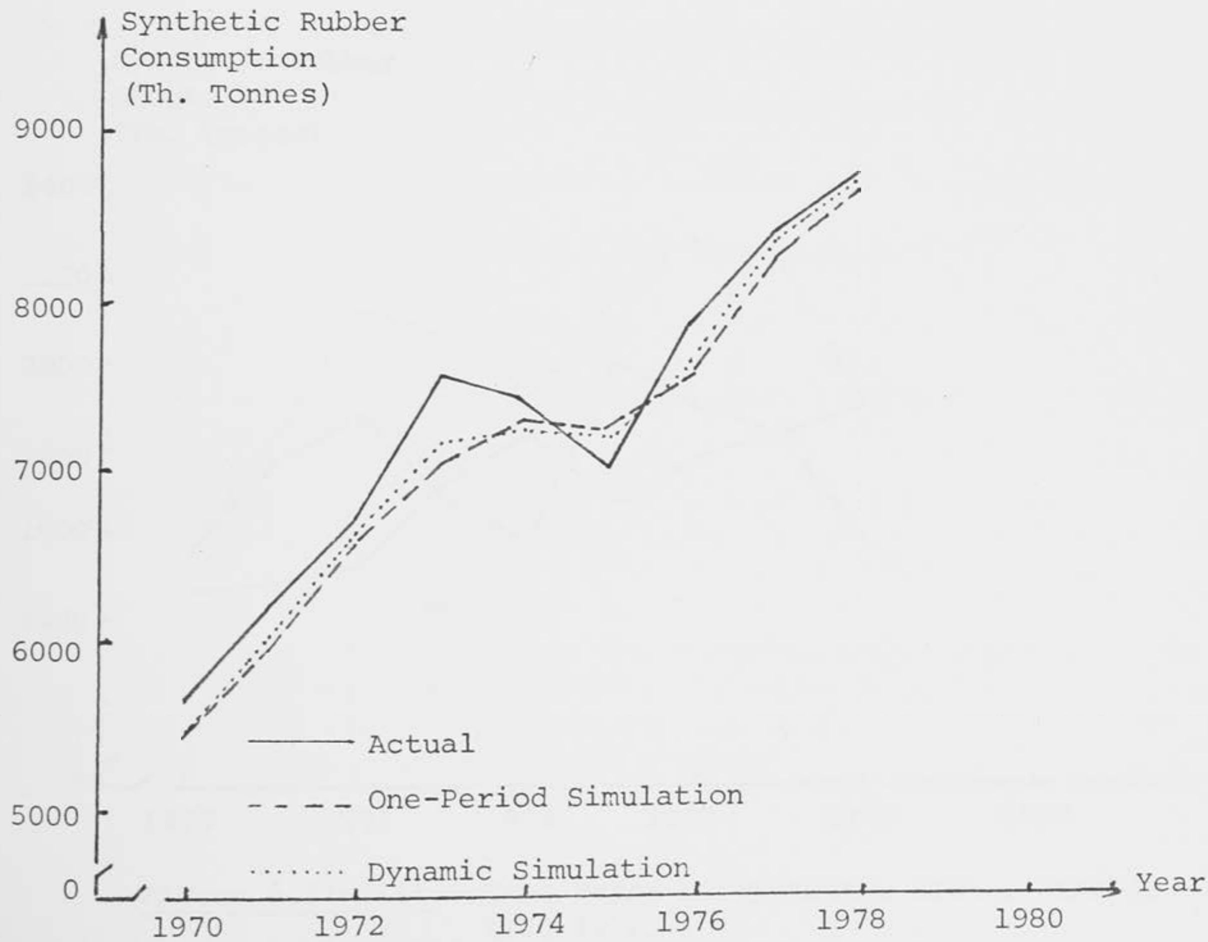


Figure 6.2(vi): Time Paths of World Synthetic Rubber Consumption, 1970-1978.

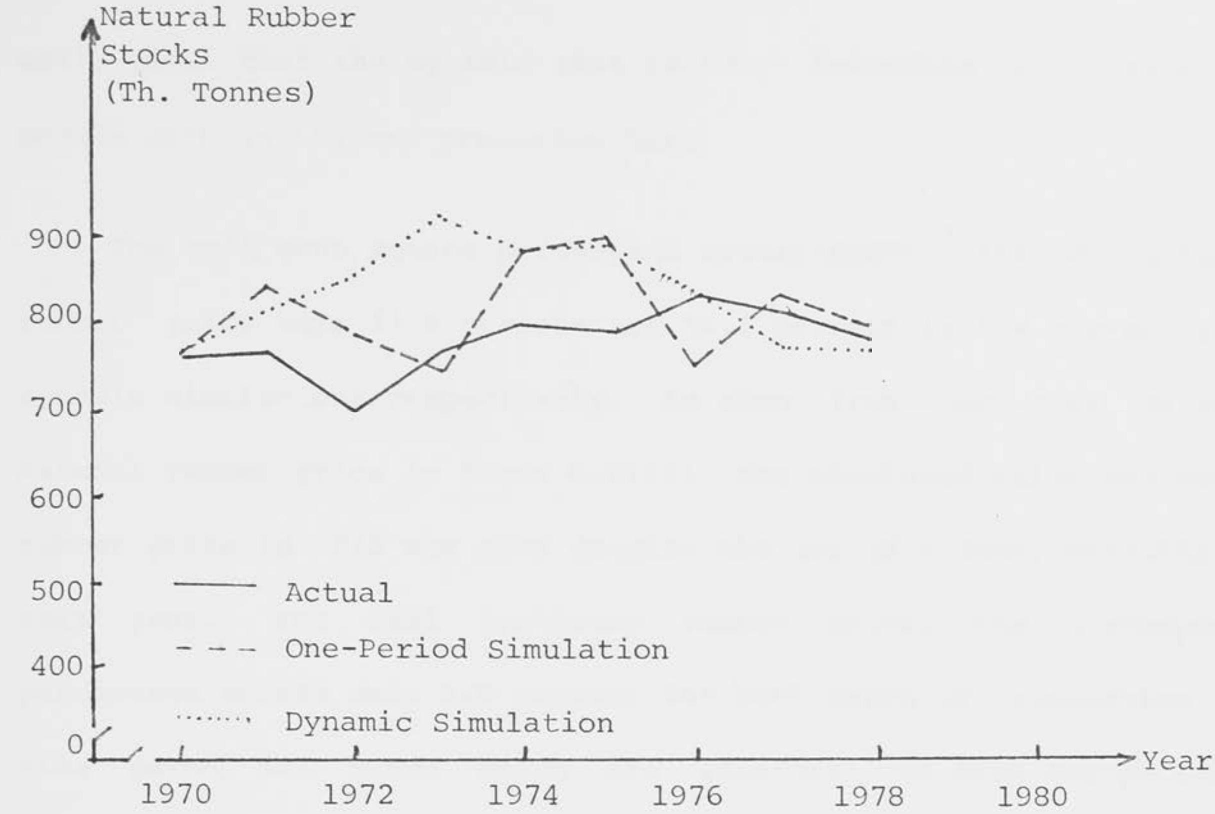


Figure 6.2(vii): Time Paths of Natural Rubber Stocks in Consuming Regions, 1970-1978.

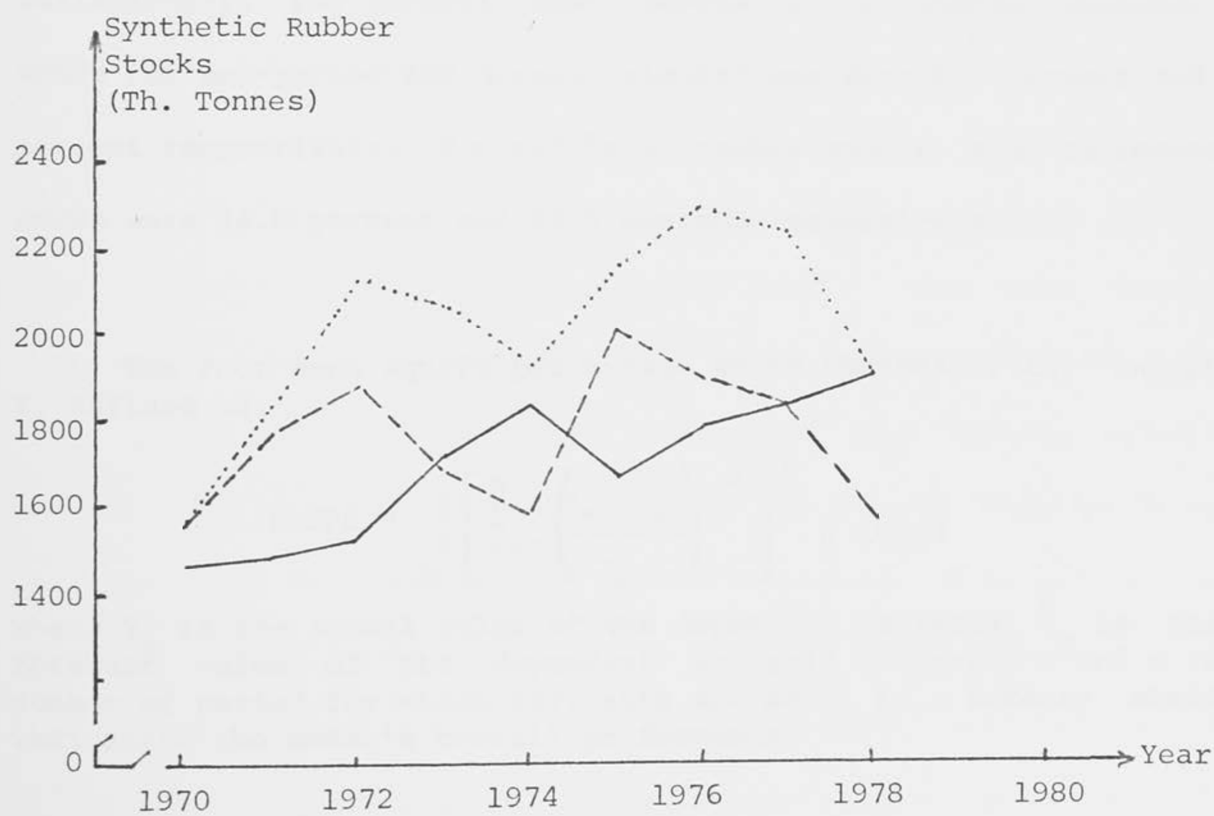


Figure 6.2(viii): Time Paths of Synthetic Rubber Stocks, 1970-1978.

well, given that the dynamic test is very demanding for large-scale models such as the one presented here.

The root mean square percentage errors (RMSPE)[3] for real natural rubber price were 11.5 percent and 14.5 percent in the one-period and dynamic simulations respectively. As seen from the time paths of natural rubber price in Figue 6.2(ii), the simulated value for natural rubber price in 1975 was poor despite the use of a dummy variable for that year. For real synthetic rubber price, the corresponding percentage errors were 6.8 percent for both types of simulation (the time paths and hence RMSPE are identical in both one-period and dynamic simulations because the average synthetic rubber price equations does not involve any lagged variables). However, the performances for the simulated time paths for natural rubber stocks in the consuming regions and for synthetic rubber stocks were less satisfactory. For natural rubber stocks in consuming regions, the RMSPE for one-period and dynamic simulations were 8.7 percent and 11.9 percent respectively. For synthetic rubber stocks, the corresponding RMSPE were 14.8 percent and 23.5 percent respectively.

3 The root mean square percentage error (RMSPE) of any variable Y, defined as:

$$\text{RMSPE} = \frac{1}{n}\left[\sum_{t=1}^{n}\left(\frac{Y_t - \hat{Y}_t}{Y_t}\right)^2\right]^{\frac{1}{2}} \times 100.0$$

where Y_t is the actual value of the dependent variable, $\hat{Y}_t$ is the forecast value of the dependent variable in period t and n is the number of period for which forecasts are made, is a summary statistic indicating the model's overall performance.

The interaction between variables is seen from the simulated time paths shown in Figure 6.2. Since the interaction between natural rubber stocks in consuming regions and natural rubber price formation is illustrated through their time paths, these two variables will be discussed. Figure 6.2(vii) shows that stocks are over-estimated in 1975 and under-estimated in 1976. From the natural rubber spot price equation, it is known that spot price is positively related to the level of stocks in the consuming regions. This over- and under-estimation of stocks in 1975 and 1976 respectively partially explains the over- and under-estimation of spot price in 1975 and 1976 respectively.

Prior to using the validated model in forecasting exercises, it is necessary also to validate the model for the interim period 1978-1980, a period for which data became available only after the data collection for this study had been undertaken. Having extended the time series data to 1980, the model was re-validated for 1970-1980, using both one-period and dynamic simulations; these simulations for the 1978-1980 period are called <u>ex post</u> forecasting and provides another test of the model. The root mean square percentage errors for natural rubber price now range from 11.6 percent to 13.2 percent in the one-period and dynamic simulations respectively. An examination of the simulation results show the residuals to be bigger in the 1978-1980 period. This may be due to a change in price relationship during the late 1970s from that used in the model. This change in price relationship will be discussed in detail in the next section. For synthetic rubber price, the root mean square is now increased to 11.0 percent.

6.5 Aftermath of the 1973 Oil Crisis

Before discussing the question of natural rubber market instability during 1956 to 1978, the aftermath of the 1973 oil crisis as observed in both the natural and synthetic rubber markets will first be reviewed. The period following the oil crisis provides an excellent illustration of the means by which the synthetic rubber industry reacts to random shocks, and the impact of these reactions on the natural rubber market. The review will therefore place in perspective the trend reversal of natural rubber price since 1973 from the declining trend observed since the mid-1950s; it will also highlight the importance of assumptions concerning the synthetic rubber industry in the subsequent evaluation of the future of natural rubber.

The effects of the oil crisis from late 1973 and the world recession in 1975 can best be discussed in the context of the trends in natural and synthetic rubber consumption shares during 1956 to 1980 -- a period which, from a historical perspective, has been labelled the "petrochemical era" by Allen (1979).

Table 6.2 shows that between 1956 and 1973, the consumption share of natural rubber fell from 62.3 percent to 31.0 percent while that for synthetic rubbers rose from 37.7 percent to 69.0 percent.[4] Upon the rise in oil and feedstock prices in 1973 these trends were reversed in 1974, the reversal being reinforced by the subsequent recession in 1975. However by 1976 the historical trend of declining share for natural rubber was reinstated, persisting through to 1980 when the second oil crisis of 1979 precipitated another trend

Table 6.2: Natural Rubber and Synthetic Rubbers Consumption Shares, 1956-1980 (%)

Year	Natural Rubber	Synthetic Rubbers	Total Rubbers
1956	62.32	37.68	100.00 (3060.7)
1957	60.13	39.86	100.00 (3210.6)
1958	61.57	38.43	100.00 (3321.2)
1959	57.23	42.77	100.00 (3759.2)
1960	53.11	46.89	100.00 (3945.0)
1961	52.21	47.79	100.00 (4132.5)
1962	50.14	49.86	100.00 (4487.5)
1963	42.90	57.10	100.00 (5297.5)
1964	40.86	59.14	100.00 (5825.0)
1965	39.56	60.44	100.00 (6187.5)
1966	38.08	61.92	100.00 (6677.5)
1967	37.25	62.75	100.00 (6805.0)
1968	36.33	63.67	100.00 (7652.5)
1969	35.21	64.79	100.00 (8280.0)
1970	34.67	65.33	100.00 (8625.0)
1971	33.33	66.67	100.00 (9277.5)
1972	32.43	67.57	100.00 (9960.0)
1973	31.00	69.00	100.00 (10977.5)
1974	32.07	67.93	100.00 (10967.5)
1975	32.40	67.60	100.00 (10395.0)
1976	30.69	69.31	100.00 (11420.0)
1977	30.61	69.39	100.00 (12135.0)
1978	29.85	70.15	100.00 (12480.0)
1979	29.90	70.10	100.00 (12910.0)
1980	30.76	69.24	100.00 (12450.0)

Notes: Figures within parentheses are the total volumes of natural and synthetic rubbers consumed (in thousand tonne units).

reversal. As these trend reversals can be identified with each major increase in oil price and its impact on synthetic rubber production, the behaviour of rubber consumption and prices during 1973-1980 will be used to trace the influence of the organisation of synthetic rubber production on natural rubber consumption; the focus will be on the short-lived increase in the share of natural rubber consumption in 1974 and 1975.

Table 6.3 shows that after the oil price increase in late 1973, the average synthetic rubber price promptly increased by some 60 percent in 1974. In contrast natural rubber spot price remained relatively unaffected even though oil price affects natural rubber production costs indirectly.[5] The subsequent slowdown in economic activity is reflected by the fall in both natural and synthetic rubbers production in 1974, albeit marginally. However, the

4 By this stage the loss in the natural rubber market share had provoked questioning by natural rubber producers of the natural rubber market share they may expect to have were natural rubber supply to grow at a higher rate than in the historical period and if the disadvantages faced by natural rubber, viz. natural rubber price instability and captive market of synthetic rubbers can be removed. The study by Allen *et al*. (1974) to answer this question concluded that on techno-economic grounds, natural rubber's potential share can range between 40 to 50 percent.

5 The case for natural rubber is also interesting in that the price increase observed for several primary commodities in 1972, the start of the 1972-1975 commodity boom, was not observed for natural rubber. With reference to Houthakker's(1976) hypothesis that the episodic commodity price rises in 1972/73 was a manifestation of inflationary pressures that had built up from the sixties and culminated in 1972, it would seem that the hypothesis does not apply to natural rubber -- possibly because of the competition posed by the lower-priced synthetic rubbers.

Table 6.3: Rubber Prices, Production and Stocks During 1973-1980

Year	Price (US$/Tonnes)		Production ('000 Tonnes)		Stocks ('000 Tonnes)	
	NR	SRs	NR	SRs	NR	SRs
1973	779.00	413.70	3505.0 (-1.7%)	7757.0 (-2.4%)	1585.0	1707.5
1974	775.40	674.00	3445.0 (-3.8%)	7575.0 (-9.5%)	1590.0	1832.5
1975	671.30	769.20	3315.0 (+8.2%)	6855.0 (+17.1%)	1550.0	1660.0
1976	875.80	703.40	3585.0 (+1.1%)	8030.0 (+5.4%)	1635.0	1775.0
1977	904.95	787.10	3625.0 (+3.6%)	8465.0 (+4.6%)	1545.0	1820.0
1978	1043.36	932.80	3755.0 (+2.8%)	8850.0 (+5.0%)	1575.0	1915.0
1979	1288.05	1188.00	3860.0 (-1.6%)	9290.0 (-7.1%)	1565.0	2155.0
1980	1487.94	1389.20	3800.0	8625.0	1495.0	2204.0

Sources: Rubber Statistical Bulletin, various issues;
European Chemical News, various issues.

Notes: (1) NR denotes Natural Rubber;
SRs denotes Synthetic Rubbers.

(2) Natural rubber price is the London spot price for RSS1 rubber.

(3) Synthetic Rubber Price is the average of list prices quoted for styrene-butadiene (grades 1712 and 1500) and polybutadiene in France, Italy and UK.

(4) Figures in parentheses are rates of change between consecutive years.

differential effects of market organisation in the two markets is made conspicuous by the 1975 world recession. The flexibility of synthetic rubber production meant that stocks depletion could be accompanied by prompt curtailment of production to a level compatible with demand. Since natural rubber production is relatively inelastic in the short-run the rate of fall in natural rubber production was less than half that for synthetic rubbers.[6] Thus while synthetic rubber production was reduced by 720,000 tonnes in 1975, the corresponding reduction of natural rubber production was only 130,000 tonnes. This was accompanied by depletion of synthetic rubber stocks of some 170,000 tonnes whereas the run-down of natural rubber stocks was only about 40,000 tonnes, (bearing in mind the Malaysian government stockpile of 22,000 tonnes), thus substantiating Behrman's observation that synthetic rubber producers are known to adjust capacity utilization and inventories in accordance with market conditions. By 1975, natural rubber which had always been more expensive than synthetic rubbers became almost US$100.00 cheaper per tonne. This is at variance with the historical pattern (during the cheap oil era) where, despite continued domination of rubber consumption by synthetic rubbers during recessionary periods and which depressed natural rubber price further, synthetic rubbers remained cheaper than natural rubber. For the first time (1975) the situation reversed, and natural rubber spot price became lower than synthetic rubbers.[7] In the event the increase in natural rubber's share of consumption in 1974 and 1975 resulted from the compound effects of the rise in oil and hence

6 Had the Malaysian government not implemented its own national stockpiling and production control "Crash Programme" in mid-1974, the decline would probably be less. For details of the said "Crash Programme" see Appendix 6.A.

synthetic rubber prices, the accompanying fall in synthetic rubber production and the world recession.

By 1976 as the oil crisis shock became accommodated and the world economy picked up, synthetic rubber production was promptly increased by 17.1 percent; in contrast, the constraint imposed by potential output in the case of natural rubber facilitated an increase in natural rubber production of 8.2 percent only. The increased demand for rubbers in 1976 and the supply inelasticity of natural rubber resulted in an increase of natural rubber price of about 30 percent in 1976, thus making natural rubber price higher than synthetic rubber price once again. This led to a <u>fall</u> in natural rubber consumption share to <u>lower than even before</u> the first oil crisis, thus suggesting that there are also secular factors at work. In addition, consumers may be discouraged from favouring more natural rubber consumption because of the emerging labour shortage in the Malaysian plantation sector as well as the competition between natural rubber and other plantation crops. The change in trading habits in the late 1970s which is discussed below is partly the manifestation of these considerations. This decline in share continued until 1980 when the second oil crisis of 1979 and the attendant world economic slump apparently precipitated another advantageous shift for natural

7 It should be emphasised that the price paid for the bulk of natural rubber consumed are the contract f.o.b. or c.i.f. prices which, on average, differ from spot price. Thus although spot price was higher than synthetic rubber prices before 1975, it was known, for example, that in the period just before 1970, that styrene-butadiene price per pound was about 3 to 4 cents higher than prices paid for comparable grades of natural rubber (Barlow, 1970).

rubber.[8]

Another interesting feature during the post-1973 period is the variance in the London spot and c.i.f. London price (which is used typically in longer-term contracts) relationship. Barring 1957 (the year after the Suez crisis), the London spot price has historically always been higher than the c.i.f. price. However for 1974 (beginning of the high oil price era) and from 1978 to early 1981 (the period of ex post simulation) a reversal was observed whereby the London spot price became lower than the c.i.f. London price. A plausible explanation for this revolves around a gradual structural change in natural rubber trading habits. This change may be viewed as beginning from the first oil crisis of late 1973 and accelerating after the second oil crisis by which time it was accepted that the era of cheap oil and synthetic rubber feedstocks was over, at least until the late 1980s. The question of adequate natural rubber supply therefore took on a new urgency.

To understand the change in natural rubber trading habits, recall that prior to the oil crisis consumers had been able to use the ready availability of synthetic rubbers and their known and stable administered prices to trade in the spot market for their balance natural rubber requirements. Following the oil crisis and resulting uncertainty concerning synthetic rubber supply, consumers now ensured supply of their natural rubber requirements by greater use of long-term contracts. This shift and the less stable synthetic rubber

8 The trend reversal observed in 1980 should not be considered to be definitive of a new trend direction since it reflects behaviour of only one year.

prices thus resulted in reduced interest in the spot market.[9] Two extraneous factors caused the shift to become marked in the late 1970s. Firstly, the second oil crisis exacerbated consumers' concern with the longer-term implications of palm oil and cocoa as increasingly attractive plantation crop alternatives to natural rubber, especially in Malaysia. Since at that time the world economy was expected to pick up in the ensuing years (that is end 1970s/early 1980s), the general expectation was that there will be a natural rubber shortage by the early 1980s. This reinforced the shift to greater reliance on long-term contracts for natural rubber supplies. Secondly, the declining interest in spot trading in the late 1970s was reinforced by the transfer of speculative and hedging activities from the natural rubber market to the precious metals markets which were especially buoyant then. Consequently throughout 1978 to the beginning of 1981 the spot price remained lower than the c.i.f. price.[10] This discussion of the relationship between the London spot and c.i.f. prices provides another reminder of the importance of the level of economic activity and oil price to future developments in the natural rubber market. It also shows that the two types of speculative buying distinguished by Krause (1976), and the recommended use of buffer stock operations to reduce speculative buying when such buying stems from fear of supply availability, should be considered

9 Another reason given by London traders is the decline in warehousing facilities in the London docks. This is a moot point since the warehouses may have been allowed to deteriorate because of the falling demand for their services (Allen, 1981).

10 Price data for July 1981 show that the earlier relationship of spot price being higher than c.i.f price has been reinstated by July 1981. This may be due to the excess purchasing of natural rubber by long-term contracts in the preceding years as well as to the levelling off of oil price in the first half of 1981. In addition, speculative interest in the natural rubber market might have been restored in view of the less buoyant bullion markets.

carefully in the case of commodities with close substitutes.[11]

6.7 Overview of Natural Rubber Market Instability, 1956-1978

The discussion of the rubber market in the aftermath of the oil crisis has highlighted the flexibility(inflexibility) of the synthetic(natural) rubber industries in the face of rapidly changing conditions. In this section the question of natural rubber instability with respect to price, export volume and value over the entire sample period will be surveyed. The contrasting impacts of the synthetic rubber industry on the natural rubber market under "normal" vis-a-vis "abnormal" conditions that emerge is useful in providing a basis for evaluating the prospects for natural rubber under differing degrees of uncertainties regarding the oil, and hence synthetic rubber, industries.

Figure 6.3 presents three time paths of f.o.b. Singapore price for RSS1-grade natural rubber in the historical period. While the annual average price show the trend, the highest and lowest monthly

11 The two types of speculative buying distinguished by Krause (1976) are:
(i) speculative buying for fear of unavailability;
(ii) speculative buying in anticipation of price rises.

Krause asserts that types (i) and (ii) speculative buying can be modified by buffer stock operations and intervention in the futures markets respectively. An implicit assumption in the recommendation of buffer stock operations for type (i) buying seems to be that such buying will be accompanied by a boom in industrial production as was the case in the early 1950s. If the assumption does not hold, that is, if industrial production was to stagnate as in the recent commodity boom, then the adverse effect will be higher capital costs for operating the buffer stocks. While consumers may now not force prices up through their speculative buying, the buffer stock management may, in the case of an industrial boom not eventuating, require larger capital resources than otherwise to prevent prices from falling below the floor prices.

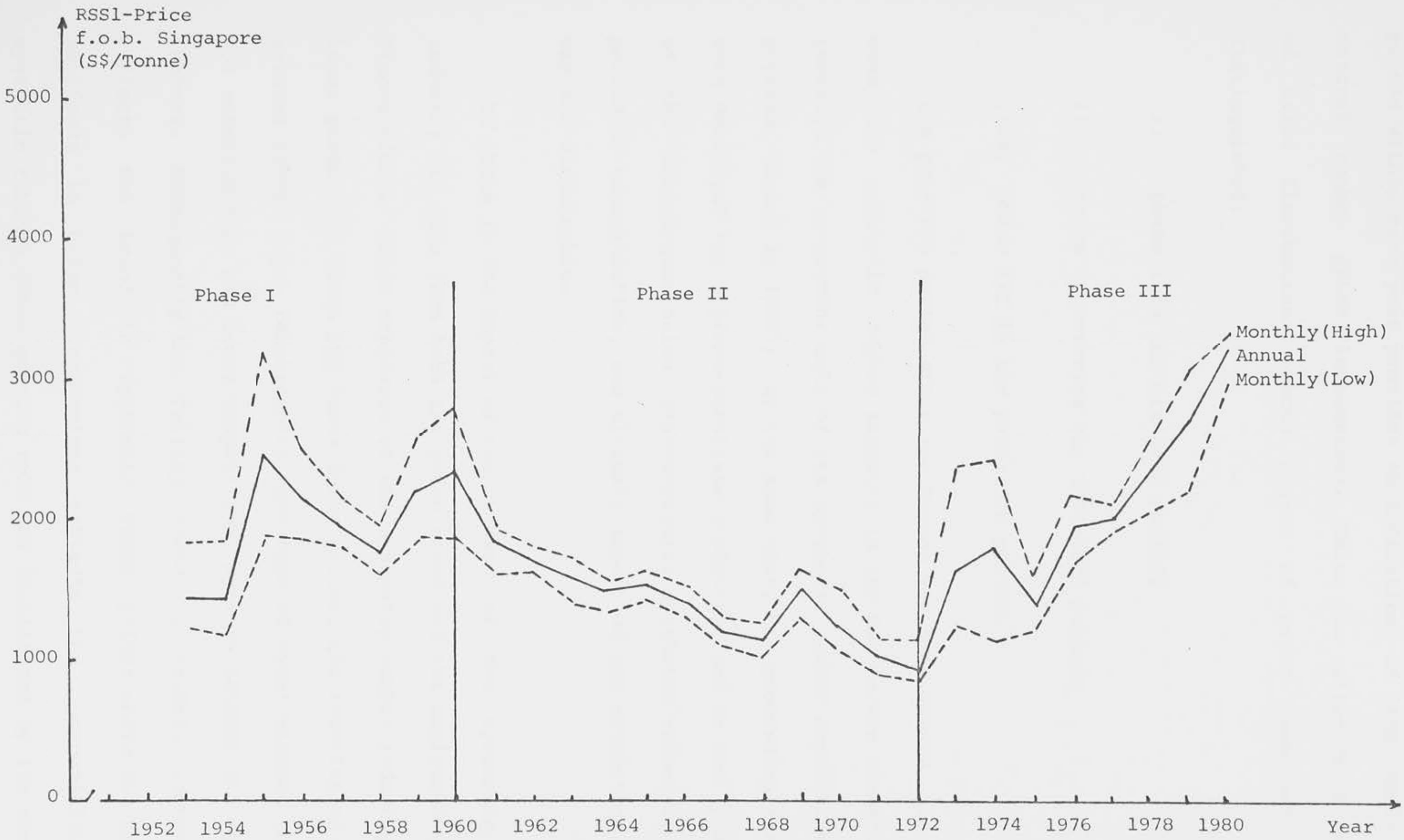


Figure 6.3: Time Paths of Average Monthly and Annual Natural Rubber Prices in Singapore, 1953-1980.

prices within each year provides an indication of the amplitude of natural rubber price fluctuations. Using the criterion of amplitude of price fluctuations, three phases of price behaviour may be distinguished:

(i) phase I in the pre-1960 period;

(ii) phase II covering the 1960-1972 period;

(iii) phase III in the post-1972 period.

The pre-1960 period after the Korean War boom covers the period when the synthetic rubber industry in the USA became commercialised (through the government sale of its synthetic rubber capacities to the private sector in 1956); at the same time, new processing techniques were developed for styrene-butadiene production and in the production of the second-generation stereo-regular synthetic rubbers. In this period of consolidation, the ultimate impact of the synthetic rubbers was not discernible.

In phase II the impact of the growth of the synthetic rubber industry is seen from both the price trend and the amplitude of price fluctuations. While expansion of the synthetic rubber industry led to lower production costs and hence lower prices, the lowering of minimum natural rubber input requirements (per type of tyre) widened the scope for substitution, and hence competition, between natural and synthetic rubbers. Consequently the falling trend in natural rubber price reflects the trend in synthetic rubber prices while the narrowing amplitude in price fluctuations reflects the competition from synthetic rubbers whose growing role was facilitated by its short lead times in production.

Phase III illustrates natural rubber price behaviour when the relative stability in the synthetic rubber industry was disturbed by the oil crises. Apart from the price trend reversal -- largely explained by the rise in synthetic rubber prices -- the amplitude of price fluctuations also widened. As the discussion of the market in the aftermath of the oil crisis revealed, much of the market instability was shifted onto the natural rubber market because of the ability of the synthetic rubber industry to adjust its production and inventory programmes accordingly.

The three phases show that so long as the oil industry remained relatively stable, the synthetic rubber industry was a stabilising factor for the natural rubber market. However, when instability was introduced to the oil industry, the flexibility of the synthetic rubber industry was used to protect the industry from market instability. By shifting the onus of instability, this flexibility therefore worked to the disadvantage of the natural rubber market.

Figure 1.2 in Chapter One had shown the time paths of natural rubber export earnings for Indonesia, Malaysia, Sri Lanka and Thailand during the historical period. It can be seen now that three phases corresponding to those for natural rubber price could also be delineated. As the behaviour of global export volumes and values for natural rubber during 1950-1976 has been succinctly summarised by a set of indicators calculated by Blandford (1979), his results will be presented here.

Blandford examined the annual growth rates and degree of instability of the global export volume and value for 1950-1976 and for the three subperiods 1950-1959, 1960-1969 and 1970-1976, which correspond closely to the three phases discussed above. Before presenting his estimated annual rates of growth and degree of instability, the data and methodology used will first be discussed. The gross export volume data refer to figures published by FAO; these figures include rubber re-exports, and no correction was made to the data for the possible bias it might have contained. The nominal value of these rubber exports was then calculated as the product of export volume and export price, where price refers to the New York c.i.f. price for RSS1-grade natural rubber. Since the New York price served only as an "indicative" price, the export values obtained should also be viewed as "indicative" in the same sense. (These export values are over-estimates since not all rubber exported is of RSS1-grade.) To obtain "real" value of rubber exports, the nominal value of exports was then deflated by the index of prices of manufactured goods exported by the developed countries. The export volume and "real" value figures were first converted to indices (using 1970=100) before use. The annual growth rates for export volume and value are obtained from exponential trend lines that are fitted to the indices, and the standardised coefficient of variation was used to measure the degree of instability.[12]

Table 6.4 presents the annual growth rates and degree of instability of natural rubber export volume and value obtained by Blandford. From Table 6.4 it can be seen that although 1960-1969 was a phase of relative stability of export value, the period also witnessed the most dramatic decline in natural rubber export earnings. Over the period 1950-1976, export value experienced a negative rate of growth of 2.8 percent annually while the annual rate of instability amounted to 10.4 percent.

Figures 6.4 and 6.5 are scatter diagrams based on the analysis given in Table 6.4. Figure 6.4 presents a scatter diagram of the rates of growth of export value against export volume; while export volume growth rate was positive throughout 1950-1976, the export value growth rate only became positive in 1970-1976. Figure 6.5 gives a scatter diagram of export value growth against its degree of instability. When taken together, these two figures highlight the impact of oil price on natural rubber export and hence value. In contrast to the 1950-1969 period when <u>increase</u> in export volume was accompanied by a <u>decrease</u> in export value, the first half of the

12 The standardised coefficient of variation V(S) is defined as

$$V(S) = \frac{V(D)}{V_{max}(D)} = \frac{\left[\dfrac{\sum_{t=1}^{n} |u_t|^2}{n}\right]^{\frac{1}{2}} \Big/ \bar{x}}{2(1 - 1/n)}$$

where u is the deviation from the exponential trend;
n in the number of time periods;
x is the arithmetic mean,
V(D) is the coefficient of variation
and $V_{max}(D)$ is $2(1-1/n)$.

Table 6.4: Growth and Instability of Natural Rubber Export Volume and Value.

Time Period	Export Volume		Export Value	
	Rate of Growth	Degree of Instability	Rate of Growth	Degree of Instability
1950-1959	1.0	3.2	-3.8	12.7
1960-1969	0.0	3.5	-6.0*	4.8
1970-1976	2.0	2.3	2.7	11.2
1950-1976	1.4*	3.0	-2.8*	10.4

Source: Blandford (1979 : 59)

Notes: (1) Export Volume and Export Value converted to Volume and Value indices using 1970=100.

(2) Rate of growth measured in percentage change per annum.

(3) Degree of Instability measured by standardised coefficient of variation.

(4) * indicates statistical significance at 10 percent confidence level.

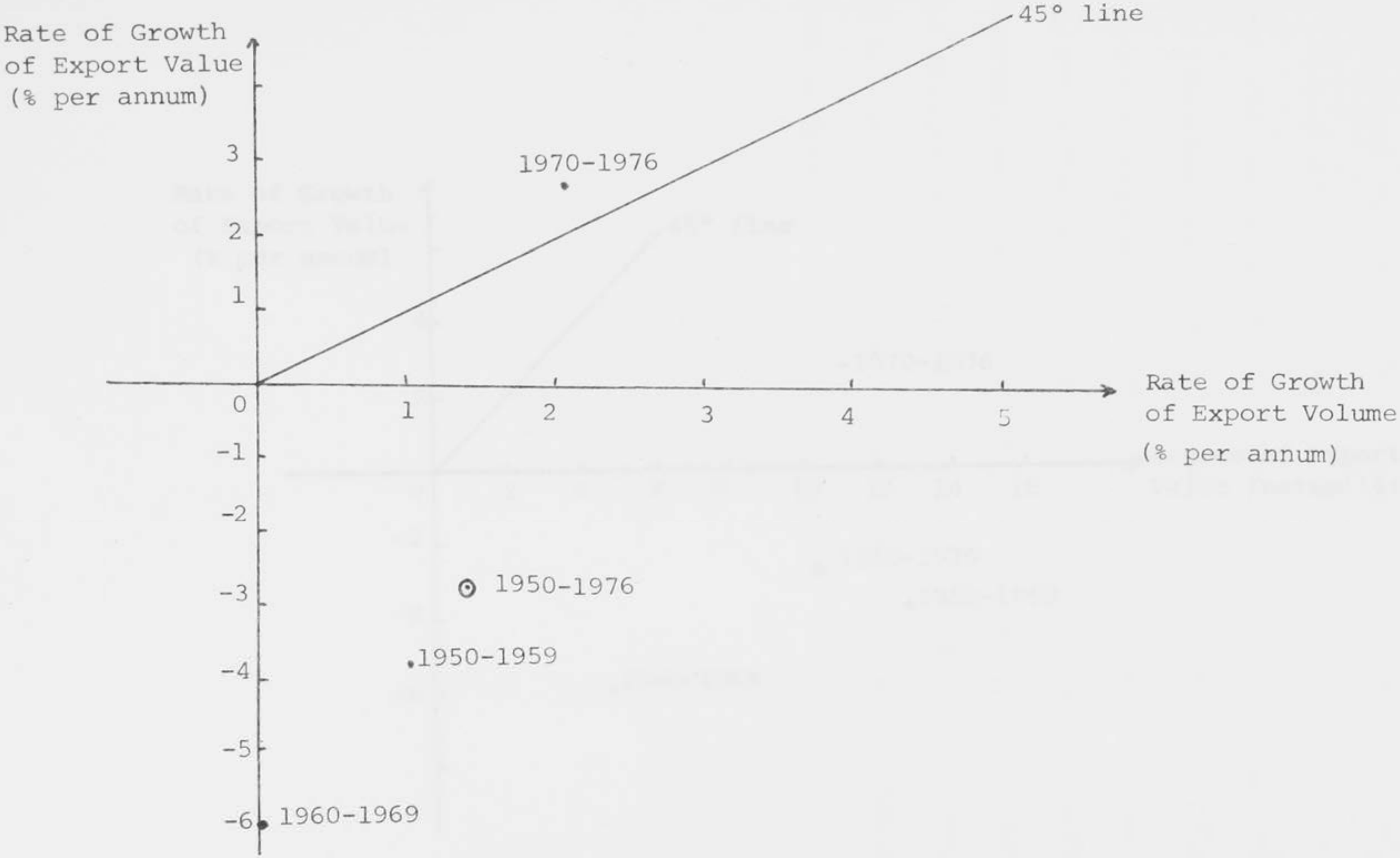


Figure 6.4: Natural Rubber Export Value Growth Rate against Export Volume Growth Rate, 1950-1976.

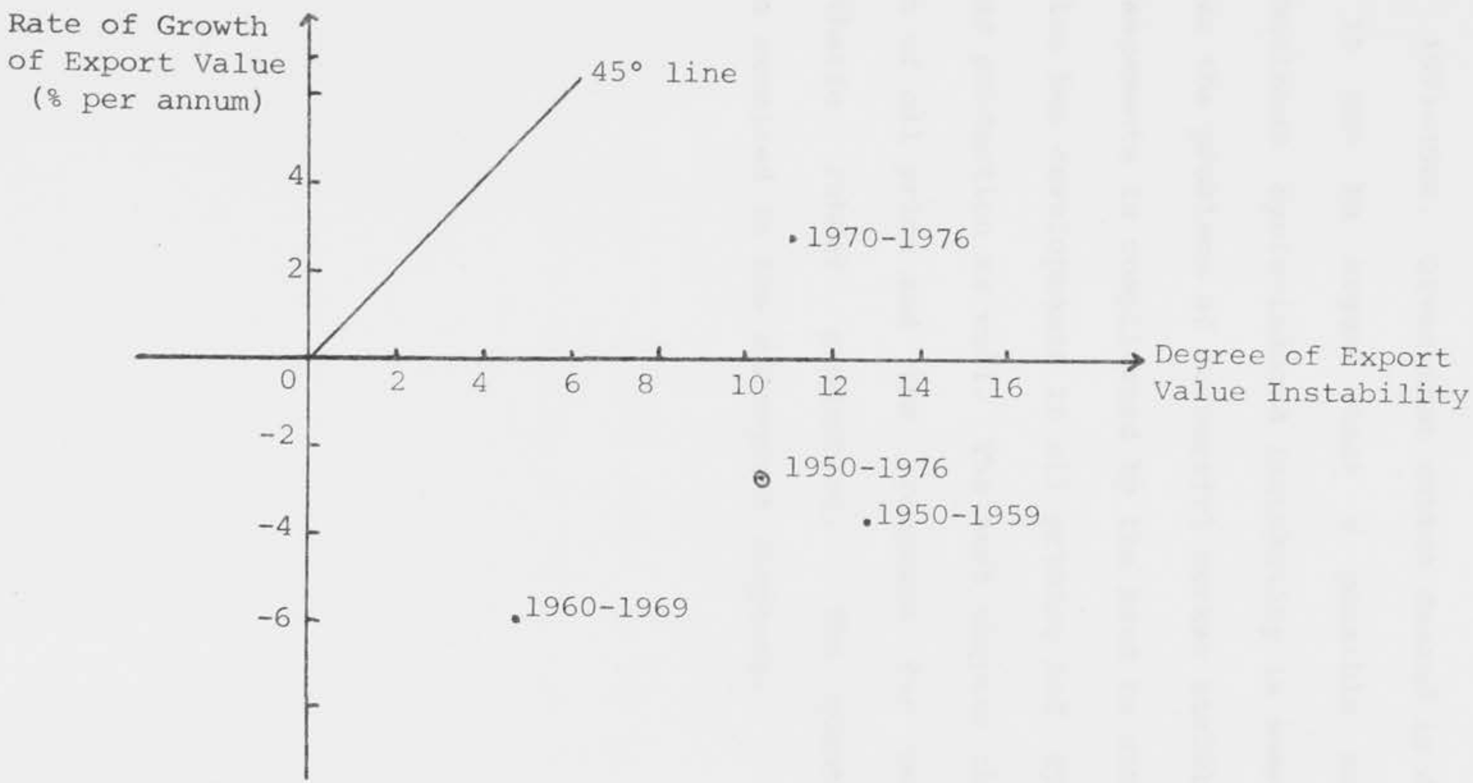


Figure 6.5: Natural Rubber Export Value Growth Rate against Export Value Instability, 1950-1976.

seventies saw an increase in export volume now accompanied by a correspondingly greater increase in export value.

The influence of economic activity on rubber demand and of synthetic rubber supply flexibility on price and their interaction with supply inelastic natural rubber is clearly illustrated by the developments during 1973-1980. Given that rubber demand is dictated by business cycles it can be argued that a possible means of counteracting the business cycle-induced instability is some buffer stock scheme. However the problems of successful market stabilisation via such stock arrangements is complicated by the need to anticipate not only busines cycles but developments in oil pricing and synthetic rubber investment and production as well. The next chapter therefore examines the question of oil price and the prospects for continued expansion in synthetic rubber production. The question of stabilisation is then examined in the subsequent chapters.

APPENDIX 6.A

THE MALAYSIAN NATIONAL "CRASH PROGRAMME" OF 1974-1976

6A.1 Introduction

The so-called Malaysian national "Crash Programme" (hereafter referred to as the Programme) for natural rubber was introduced in November 1974. In order to view the Programme in perspective, it is necessary to refer to the behaviour of natural rubber prices in the period immediately preceding the Programme. The reference to natural rubber price during 1972-1974 will also highlight the vagaries of the natural rubber industry. The socio-political repercussions of falling natural rubber prices, particularly against rising price levels resulting from rising oil price, provides an added dimension to the need for government intervention; this dimension is seen by some to have been instrumental in the implementation of the Programme.[1]

[1] For details of the manifestations of social unrest in Malaysia during this period and its political overtones, see Meyanathan (1980:151-152).

6A.2 Events Precipitating the Programme

Table 6A.1 gives the RSS1-grade natural rubber price during September 1972 to October 1974. The UK list price for styrene-butadiene grade 1712, the major synthetic rubber competitor (used mainly in tyre treads) to natural rubber, is also provided for the purpose of comparing price behaviour during the critical period of structural change in the oil industry.

The volatility of natural rubber price is vividly illustrated by the prices for September 1972 and September 1973 given in Table 6A.1; following the quadrupling of oil price in October 1973, the rubber price also increased in the ensuing months, reaching a peak in January 1974. Thereafter prices began to dip; although oil prices remained high, the price of natural rubber had, by July 1974 fallen to less than the pre-oil crisis price of September 1973. In an effort to arrest the price decline observed up to that time (but anticipated to be transient), the Malaysian government announced a plan on 18 July 1974 to reduce the country's natural rubber supply to the world market by 10 percent through an upward adjustment in commercial stockholdings.[2] This was originally intended to last only a month. However, despite increasing synthetic rubber prices, natural rubber price continued to decline; thus between January and November 1974, while synthetic rubber prices rose by about 64 percent, natural rubber price had instead declined by about 58 percent. This continuous price descent precipitated the government-supported Programme on 28 November

2 Such short-term palliative measures had been used by the Malaysian government previously (viz. September 1967, March 1968 and March 1971). As Lim (1976b) pointed out, in this as in earlier instances, the price response was immediate but transient since they were due to the dominant speculative activities. See Lim (1976b). See also Economic Intelligence Unit (1974).

Table 6A.1: Natural and Synthetic Rubber Prices, 1972-1974

Date	Natural Rubber Price (Malaysian Dollars per Tonne)		Synthetic Rubber Price (Sterling Pounds per Tonne)	
September 1972	868.00		142.50	
September 1973	1731.00		153.00	
November 1973	1898.00		168.50	
December 1973	2432.00			
January 1974	2691.00		198.50	
May 1974	2027.00		290.60	
July 1974	1623.00	-58%	308.00	+64%
October 1974	1422.00		325.00	
November 1974	1134.00			

Sources: Rubber Statistical Bulletin; European Chemical News.

Notes: (1) * denotes the month before the occurrence of the oil crisis in 1973;

(2) The price for synthetic rubber (styrene-butadience 1712) quoted for each month is actually the price for the corresponding quarter. Thus price for the months of November and December 1973 is actually the overall price for the fourth quarter of 1973. Since the figures in this Table are presented for purpose of comparing the trend underlying the two price series, this approximation is not critical to the broad pattern emerging.

1974.

The decision to undertake the Programme was prompted by consideration of the rubber market outlook in the face of two discouraging phenomena:

(i) Despite the marked increase in oil prices in late 1973 (which in turn affected synthetic rubber production costs) and thereafter, the natural rubber price fell continuously throughout the first ten months (and longer as events were later to prove) of 1974;

(ii) The fall in natural rubber prices throughout 1974 was such that for the first time in nearly two decades (a period corresponding to the dramatic growth in the synthetic rubber and transport industries), natural rubber prices had fallen below that for synthetic rubber.

The observed phenomena thus emphasised the dependence <u>to date</u> of the natural rubber industry on the business activity of the industrialised countries for its survival, and the influence of economic activity on natural rubber price formation. The Programme was therefore an attempt at supply management to counter the worldwide recession anticipated for 1975.

6A.3 A Six-Point Programme[3]

The twin objectives of the Programme were:

(1) to reduce supply from the world market during periods of falling demand;

(2) to raise productivity in the long-run by taking advantage of recessionary periods (and its concomitant demand shortfall) to accelerate replanting.

Under the Programme a financial outlay of three hundred million Malaysian dollars was made by the Malaysian government to implement a six-point package of instruments.

For the first objective of reducing natural rubber from the world market, the four instruments were:

(1) the banning of the use of chemical stimulants, especially ethrel; this would lower productivity and therefore help to reduce overall supply;

(2) the reduction of tapping frequencies by the estate sector via the implementation of a new Wage Agreement which provided workers with weekly rest days and a 14-day paid holiday annually which would reduce output in the short-run;

(3) the packer-remiller-exporter levels were given supply quotas; supply to the market was thus reduced and the traders forced to hold

[3] Based on reporting in Natural Rubber News, (1975:2-4) Rubber Market Review (1975:8).

higher stocks during this period;

(4) the direct buying of smallholder rubber by the government who would then stock the rubber, since smallholder tapping frequencies cannot be controlled;

For the second objective of accelerated replanting to raise future productivity, the <u>two</u> instruments were:

(1) the compulsory replanting within two years by all estates of all their acreages having yields below 800 kilograms per hectare (or 712 pounds per acre);

(2) the encouragement of further smallholder replanting (including those smallholdings under five acres) through the assistance of the Rubber Industry Smallholder Development Authority(RISDA).

The organisations that were simultaneously established to implement the Programme were:

(1) a government Committee on Rubber to monitor the Programme;

(2) a Special Unit to supervise the direct government purchasing of smallholder rubber;

(3) an Operations Centre to administer the daily buying operations of smallholder rubber;

(4) an Estate Sector Unit to supervise the acceleration of estate replanting and to ensure that the ban on ethrel usage and reduced tapping frequencies were being observed;

(5) a Packer-Remillier-Exporter-Dealer Unit to check that their supply quotas were being observed.

6A.4 One-and-a-Half Years of the Programme

In implementing the Programme the Malaysian government was fully aware of its efficacy as a short-term measure only. Consequently a proposal for an international Buffer Stock Scheme among producing nations and those consuming countries wishing associate membership[4] was presented by Malaysia in January 1975 to the Association of Natural Rubber Producing Countries (ANRPC).[5]

While negotiations at ANRPC continued, the Malaysian government meanwhile passed a Natural Rubber Price Stabilisation Bill at the end of 1975 (a year after the introduction of the Programme). The Bill enabled the establishment of a national advisory council to supervise the government's natural rubber stockpile activities.

Throughout 1975 the Kuala Lumpur (and world) price of natural rubber remained fairly stable in the range of M$1,200 - M$1,400 per tonne. By virtue of the six-point Programme natural rubber stocks in Malaysia (averaging 230,000 tonnes) were simultaneously being monitored. However natural rubber price began rising again from M$1614 in December 1975 to $2101 in May 1976. Malaysian stocks for the corresponding months fell from about 231,000 tonnes to 180,500 tonnes (which was lower than the monthly stock level during the 1963 commodities boom period).[6] The Malaysian authorities then felt that

4 The proposal was therefore not an attempt at cartelisation.

5 For further details on the difficulties of reaching as consensus, even among ANRPC members only, on a buffer stock scheme, see various issues of the Economic Intelligence Unit's quarterly review for the economies of Malaysia, Singapore and Brunei during 1976 and 1977. While timing made this proposal a de jure forerunner of the Buffer Stock Scheme under the UNCTAD International Natural Rubber Agreement (INRA), this proposal served as a contingency scheme that would have been implemented had the INRA negotiations failed. The idea of a buffer stock operation amongst producing countries was first proposed by Indonesia soon after the establishment of the ANRPC in 1970.

the bans on chemical stimulants usage and Sunday tappings could be lifted,[7] thus bringing the one-and-a-half years' Programme to a close.

6A.5 Gains Bestowed by the Programme

The effects of the Programme have been quantified by Lim (1976b) soon after the Programme terminated. Cost-benefit estimations by Lim to evaluate the efficacy of the Programme to stall falling prices between mid-1974 to early 1976 indicate gains received by the various national rubber sectors. For an idea of the magnitudes involved, the major findings in Lim (1976b) will be summarised.

Lim estimated the gains to the government, smallholder, estate and trade sectors by assuming that the gross difference between prices obtained with and without the Programme amounted to about 15-20 Malaysian cents per kilogram.

During the Programme, the Malaysian government acquired 22,000 tonnes of smallholder output, of which 4,000 tonnes was subsequently lost in a fire outbreak. The remaining 18,000 tonnes natural rubber stock was entirely disposed of in February 1976 at a net (of salaries,

6 A misreporting by the Economic Intelligence Unit that the stock level in early 1976 was about 10 percent of the stock level in 1975 should be mentioned. See Economic Intelligence Unit (1976, no. 2:5). It is relevant to note that as prices declined in 1974 and stabilised in 1975, world total natural rubber production fell and was lower than consumption by an average of about 60,000 tonnes annually in both years. Obviously consumers were running down stocks because of the uncertain economic outlook, thus partially explaining the increased share of natural rubber consumption in 1975.

7 See Economic Intelligence Unit (1976).

staff allowances, warehousing, insurance and transportation expenses incurred by the stocks) profit of M$1.4 million. This was comparable to a 6 percent return had the capital been invested commercially.

For the smallholder sector, Lim distinguished the direct and indirect effects of the Programme. The direct effect referred to the smallholders' increased rubber earnings due to the implementation of the Programme; according to Lim's estimations, the smallholders were found to receive increased earnings of about M$110-$159 million. The indirect effect referred to the non-quantifiable spillover effect of higher prices on marginal producers. Since prices for lower rubber grades are related to the RSS1-price, the higher RSS1-price would induce marginal producers to enter production.[8]

For the estate sector Lim estimated that to maintain the price level an additional 26,000 tonnes of rubber stocks had to be retained by this sector. The net profit from the sale of this stock in early 1976 approximated M$1.8 million, an amount comparable to an 8 percent net return on commercial investments.

On the above evidence it may be concluded that the three-pronged Programme of government stockpiling, enforced private stockholding and production control succeeded in stabilising both price and earnings (by avoiding loss in earnings had the price fall been permitted to occur). However stabilisation at the floor level _per se_ is insufficient evidence that comprehensive stabilisation will be equally

[8] While Lim does not qualify this positive indirect (spillover) effect, it is necessary to point out that the effect is positive only in so far as the impact of the behaviour of marginal producers on price is definitely negligible. If marginal producers form a significant production force, then their increased production may well become a counteracting element to the Programme's effort to uphold the price level.

beneficial. Any international price stabilisation agreed to by producers as well as consumers necessarily encompasses ceiling price levels. Thus gains from floor price stabilisation should be weighed against earnings foregone/lost through ceiling price stabilisation. Overall gains/losses must further be discounted to reflect maintenance and operational costs of the national stockpile even when prices are within the agreed price bands.

CHAPTER SEVEN

EXOGENOUS VARIABLES PROJECTIONS: 1980-1995

7.1 On Projecting Oil Price

In the historical period under study, the synthetic rubber industry stemmed largely from the dynamic oil and petrochemical industry upon which it is dependent for its energy and raw material inputs (feedstocks). Owing to its critical dependence on oil for energy and feedstocks, the price of synthetic rubbers is thus highly correlated with oil price as the estimated equation for synthetic rubber price confirmed. In this chapter the interest in oil pricing is restricted to its direct impact on synthetic rubber production cost and therefore on synthetic rubber price.

To examine the future role of synthetic rubbers in the world rubber market during 1980-1995, expectations about synthetic rubber price behaviour are required. Hence the need to explore the possibilities on the energy front and translate them into oil price projections. The synthetic rubber industry currently depends on the oil industry for about 85 percent of its feedstocks and this situation is expected to persist through to the end of this century (Norton, 1981). However, in view of the extensive intersectoral linkages (within an economy) between the petrochemical industry and other industries and the long lead-times associated with energy development projects, it is not unrealistic that in its current concerted efforts at developing alternative energy resources, the energy industry should also be searching simultaneously for alternative sources of feedstocks supply for the longer-term future.[1] Thus in projecting oil price it would be desirable to have assumptions about alternative energy resources and their potentials in competition with oil, both as sources of energy as well as of industrial raw material inputs.

Given the growth rate of the world economy, the demand for the various types of energy will primarily be determined by their relative availability and supply. The supply of oil and non-oil energy is therefore the cornerstone for projecting the price of oil for 1980-1995. The non-oil energy resources are coal, natural gas, hydro-energy, alcohol fuel, nuclear energy, solar energy, primary motive powers and others. Before presenting the method used in projecting the price of oil, the question of oil and non-oil energy supply in the next 15 years will first be discussed. Through the discussion the constraints in the demand choice for alternative energy resources will be defined. Against alternative assumptions regarding the various supply and demand growth rates, the price of oil can then be projected.

In the following some background information on various types of energy resources will first be presented. The constraints likely to influence supply of each during the next 15 years will then serve as criteria for dividing the 15 years into subperiods. For each subperiod, the likely supply situation will be discussed.

1 Synthetic rubbers only constitute about 10-15 percent of all petrochemical products end uses. Given that the polymer industry at present provides materials that is the equivalent of agricultural production from 3 million square miles of land, it is not unrealistic to expect that efforts to sustain the past gowth of this industry will be continued. For details on the role of petrochemical feedstocks in synthetic rubber production vis-a-vis other synthetic materials production, see Horton (1979).

7.1.1 Supply of Oil

In evaluating the future supply of oil, it is helpful to distinguish oil reserves from oil resources. Oil reserves, also known as proven reserves, refer to those oil deposits that have been well investigated and worked and are therefore well-known. Oil resources refer to those oil deposits that are less well investigated and to those which eventually would be found in new regions with oil potential.[2] The distinction between reserves and resources is important in considering the future leverage of the Middle-Eastern oil producers on oil pricing since a primary reason for the Arab-instigated oil crises since late 1973 is that although their share of the world's reserves is substantial, their share of the world's resources is insignificant. While they can chiefly count on their remaining proven reserves, their share of current world oil production has been proportionately higher than their share of the world's total oil resources.

Since oil is a depletable resource, the determinants of oil supply hinge to a large extent on the feasibility of employing the earnings from oil production to generate future income. The determinants of oil supply are therefore:

(1) the producing countries' absorptive capacity of investment (from oil revenues) without causing social disruption (a major consideration especially in the Arab oil-exporting nations);

2 The quantity of oil found or expected to be found in a given region can be expressed either as recoverable amount or as amount in place, the former being the product of amount in place and the recovery factor. Since it is impossible to recover all the oil contained in an underground formation, the recovery factor is less than 1.0 in value.

(2) the current price of oil versus the expected price of oil;

(3) the current yield versus the expected yield of foreign assets and investments that can respectively be bought and made with the oil revenues.

The question of absorptive capacity of investment is less constraining elsewhere than in the Middle-East where the political factor adds another dimension[3] to the already complicated issue of oil price formation.

The question of present oil price versus the expected price of oil is related to questions of alternative new (viz. hydrogen, nuclear, atomic and solar) and renewed (viz. coal and oil shale) energy resources, of primary motive (wind and tidal) power and of reversal in oil refining objectives (from refining crude oil chiefly for fuel as at present to refining crude oil chiefly for feedstocks).

3 Up the late 1960s, the political situation within the Middle-East oil producing countries was relatively stable and was an unimportant factor for oil pricing. By the 1970s, the situation had changed because of the various perceptions of oil as a political instrument by the "monarchic bloc" countries (of Saudi Arabia, Kuwait, United Arab Emirates and Qatar) and the "socialist bloc" countries (of Algeria, Libya and Iraq). The relative political stability within the Middle-East oil producing countries was thus affected. Consequently oil pricing in the 1970s had also to contend with the conflicting interests and relative strengths of the two blocs of countries within the Organisation of the Arab Petroleum Countires (OAPEC). For a formal study of influence based on the coalition of states within OPEC, see Doran(1979). Doran's study concluded that for most of 1969-1978, Saudi Arabia seemed to have shaped the cartel policy through a dominant and primarily stable coalition of states that included Iran. With the change of regime in Iran and the changed nature of this coalition, Saudi Arabia is expected to become the focal point of two sets of pressures: (1) pressures involving price escalation or price stability and (2) pressure involving the security of the Saudi Monarchy and that of political unity within Arab and Muslim circles.

The question of existing versus expected yield in foreign assets bought and investments made with the oil revenues is related to the problems of balance of payments, resource transfers and the recycling of surplus oil funds.

7.1.2 Supply of Coal

Of the primary energy resources, coal is predominant. Table 7.1 illustrates the share of main primary energy resources in China, USSR and the USA.

The importance of coal resource is two-fold: as a source of energy *per se* and as a raw material in synthetic crude oil (hereafter syncrude) production. In comparison with other non-oil energy resources, coal is not only cheap and abundant but also enjoys existing supply (transport) infrastructure. Thus increased production and international trade in coal are expected in future.[4]

The process of coal liquefaction for obtaining syncrude from coal has been known since the 1930s. So long as oil remained cheap and readily available, coal liquefaction was not economically viable.

4 For details, see Shell Briefing Service (1979). In the light of the available coal resources and the accompanying transport infrastructure, it is unclear as to why the World Bank (1980b:16) should only credit coal with a projected steady 30-32 percent share in world energy supply throughout the 1970-2020 period. It can only be surmised that bulkiness, the non-aesthetic features of coal and pollution considerations were implicitly used to discount the rate of development of coal resources. Perhaps natural gas possess less of a pollution problem and does not produce as much waste material as coal (the waste material from natural gas is about 1 percent carbon black). However, if pollution was the dominant factor influencing the World Bank projections, then it should be emphasised that the waste disposal problem associated with coal consumption is much less harmful than that deriving from nuclear energy consumption.

Table 7.1: Share of Primary Energy Resources in China, USSR and USA (percentages)

Type of Primary Energy	China	USSR	USA
Oil	7.48	4.68	5.88
Coal	90.42	92.76	64.89
Natural Gas	0.40	1.42	2.73
Oil Shale	1.70	1.13	26.50
TOTAL	100.00	100.00	100.00

Source: Ikonnikov (1982)

With the quadrupling of oil prices, coal liquefaction has reappeared[5] and (although still an expensive process) is expected to be of increasing importance generally as well as to the synthetic rubber industry for both its fuel and feedstock potentials.

7.1.3 Supply of Natural Gas

Like coal, natural gas also is a source of energy *per se* and a raw material for the petrochemical industry. Hence natural gas is also potentially important to the energy sector in general and synthetic rubber industry in particular for both its fuel and feedstock supply capabilities.

Natural gas resources are known to be widely spread and many countries are known to have significant production prospects. The natural gas supply constraint is that its production and transport infrastructure is, relatively speaking, not as well-developed as in the coal industry. Furthermore, in many cases, transportation of natural gas would also entail investment in facilities for liquefying the gas.

5 Ironically the reappearance has exacerbated oil price increases in recent years, possibly because the Middle-East oil producers now see the remaining period during which they can exercise their price leverage as being curtailed.

7.1.4 Supply of Hydro and Nuclear Energy

Both hydropower and nuclear power are important for electricity generation. The production of hydroelectricity is expected to be encouraged and expanded without hindrance but will have little impact on the total energy supply because of its minute share of total energy resources. The potential of nuclear power is very much larger but the basic issue here concerns the pollution (waste disposal) problem; thus development of nuclear energy relies on the reconciliation/solution of the environment problem.

7.1.5 Supply of Alcohol Fuel

Alcohol can be derived from biomass, from cultivated food materials (viz. cereals, sugar crops and root crops) and natural biomaterials (viz. dried leaves, twigs, weeds, woodchips, et cetera.). The technology for producing alcohol is well-established, with its production for fuel becoming increasingly viable as oil price increases. However, because of its agro-base the long-run economic viability of alcohol fuel production rests on the availability of land and the impact of alcohol fuel production on food prices.

The importance of alcohol fuel lies in its potential as (a) a source of transport fuel and (b) a source of feedstocks for the synthetic rubber industry. In the transport industry, a mixture of gasoline and alcohol (where a minimum of 80 percent of the former and a maximum of 20 percent of the latter is reported to be the limits suitable for existing car engines) is used in Brazil[6] which is presently a leader in world production of alcohol fuels for the transport industry. Thus the potential exists for reducing the transport industry's dependence on oil for its fuel. Alcohols such as ethanol and methanol can also be used to obtain ethylene and butadiene (which are key inputs in the production of general-purpose synthetic rubbers). Alcohols therefore provide the synthetic rubber industry with another source of feedstocks inputs.

7.1.6 Supply of Other Energy Resources

The remaining sources of energy supply are those based on solar energy, hydrogen, primary motive powers and others. Although these energy resources are important to the question of oil pricing, they do not directly impact on the transport and rubber industries. This is because to date they are not viewed as potential supply sources for transport fuel nor for synthetic feedstock raw material inputs.

Against the prospect of continued escalation of oil prices for a period of time and the problem of environmental protection, primary motive (wind and tidal) power concepts have become increasingly attractive. Some of these concepts, though still relatively new, are on the horizon and are expected to be viable by the next decade.

6 The Brazilian production of gasohol has striven to maximise the use of alcohol as the alcohol shares of the mixture testify: in 1977 the share was a mere 4.3 percent but by 1979 it had risen to 19.0 percent which is very close to the maximum feasible share. Brazil is also producing modified car engines operational on pure alcohol; for further details, see World Bank (1980b:chapter 3).

7.2 Three Subperiods of Energy Supply

From the above brief survey of the various known energy resources and the problems concerning the potential substitution of non-oil for oil energy, the 1980-1995 period can be treated as three distinct subperiods. The survey of the various energy resources has indicated that the course of oil/non-oil energy substitution is dictated (a) by investment outlays on known technologies in the shorter-term and (b) by technological developments over the longer-term. These criteria provide a natural subdivision of the 15-year period into the three subperiods 1980-1985, 1985-1990 and 1990-1995.

In 1980-1985, oil is expected to retain its dominant role and there remains potential scope for price leverage by the Middle-Eastern producers. Oil price may therefore continue to escalate at a rate above inflation, especially if the Middle-Eastern producers perceive this period as their final opportunity to maximise earnings from their balance oil reserves.

While oil is expected to remain prominent amongst energy resources during the 1985-1990 subperiod, the leverage of Middle-Eastern producers in oil-pricing policies will be diluted by the expected increased oil production from regions outside the Middle-East. Increased oil production is expected from China, Egypt, Indonesia and Mexico -- countries which are not only rich in oil and other natural resources but also capable of absorbing their oil revenues for development ends. This is expected to be complemented by increased production and liquefaction (conversion) of oil shale, coal and natural gas, with shifts to their further consumption expected to be accompanied by increased efficiency and conservation. Furthermore the trend set by Brazil in using alcohol fuel may become widespread so that the demand for natural oil by the transport industry may relax to some extent. Hence the pressure on natural oil demand may ease off slightly and the rate of oil price increases may be expected to be slower than during 1980-1985.

By the 1990-1995 subperiod, it is envisaged that a new "equilibrium" position will emerge for oil. The key determinant of that is the expected investment during the mid-1980s in the production of coal, oil shale and natural gas and in their conversion to liquid fuels. Given the lead-times for these undertakings, such fuel production is not expected until the early 1990s. The feasibility of non-oil energy resources to relax the demand pressure on natural oil also raises the possibility of a reversal in oil refining priorities -- oil may then be refined chiefly for its petrochemical feedstocks. Such a reversal provides scope for mitigating the scenario of limited alcohol fuel production due to the constraint of land for food production. With the widening spectrum of technologies available for the remaining energy sources viz. hydrogen, nuclear and motive powers, the role of oil to the modern industrial economy is not likely to resume its critical position as in the 1970s.

Thus given the lead-times for the energy industry, the key feature in price projections for the 1980-1995 period is that three distinct subperiods emerge. The supply leverage of the Middle-East dominated oil industry is expected to remain severe in 1980-1985; during 1985-1990 expansion of the traditional non-oil energy sectors, viz. coal, natural gas and hydroelectricity and the supply of oil from new regions (mainly outside the Middle-East) should relax the oil supply constraint. During 1990-1995 the uncertainties thrown up by the 1973-1974 oil crisis are expected to recede as new technologies for utilising non-oil energy resources are finalised and brought on-stream. Based on these expectations, the outlook for further expansion of the synthetic rubber industry appears promising. This argument probably underlies the pervasive attitude within the synthetic rubber industry of viewing natural rubber as a "rapidly changing and worthy competitor" (Ruebensaal, 1979) to synthetic rubbers rather than vice-versa.

The three subperiods emerging from the above discussion are delineated by supply considerations. From Table 7.2, which presents the world energy supply composition in 1956-1974, it can be seen that only the share of coal declined during the period. This is in contradistinction to coal being the most abundant energy resource.

7.3 Demand for Energy

Since energy demand is derived from demand for heating and transport fuels, total energy demand with respect to economic activity is fairly inelastic. Over the longer-run the demand mix of different energy resources will be influenced by their relative supply potentials. In conjunction with the three subperiods delineated by the supply factors for 1980-1995, two types of energy demand can be distinguished:

Table 7.2: Composition of World Energy Supply, 1956-1974 (percentages)

Year	Crude Petroleum	Natural Gas Liquids	Natural Gas	Coal	Hydro & Nuclear Electricity	Total Supply
1956	33.8	1.3	11.4	51.8	1.7	100.0 (3,649.0)
1960	33.9	1.3	13.4	48.9	1.9	100.0 (4,478.0)
1965	39.7	1.5	16.1	40.6	2.1	100.0 (5,588.0)
1970	45.0	1.7	18.7	32.6	2.1	100.0 (7,420.0)
1974	47.5	1.7	19.4	29.1	2.4	100.0 (8,641.0)

Source: United Nations, World Energy Supplies, Series J.

Note: Figure in parentheses denote energy consumption measured in million tonnes of coal equivalents.

(1) energy demand which is not oil-specific and for which alternative energy sources are substitutable with relative ease. Such demand stem from the heavy industries and heat and electricity generation plants. For these demands coal, oil shale, natural gas and nuclear power are expected to assume increasing importance. This market for non oil-specific energy resources may be called the "heat market";[7]

(2) energy demand which is oil-specific and for which significant substitutes by non-oil energy is not envisaged in the medium-term (say to 1995). This refers to demand for liquid fuels and feedstock raw materials by the transport and synthetic manufacturing industries and may be called the "premium market".

Table 7.3 presents the composition of world energy consumption in 1956-1974 from which movement of shares are seen to correspond to the situation on the supply side. The declining share of coal consumption over the two decades is to be emphasised. Table 7.4 compares the price of the different energy resources during 1965-1978.

7.4 Time Paths for Oil Price:1980-1995

In projecting oil prices for 1980-1995, the approach adopted here is based on several assumptions derived from the salient features of energy supply and demand. The assumptions are:

7 This terminology is adopted from Cornia and Mayorga-Alba (1980).

Table 7.3: Composition of World Energy Consumption, 1956-1974 (Percentages)

Year	Crude Petroleum	Natural Gas Liquids	Natural Gas	Coal	Hydro & Nuclear Electricity	Total Consumption
1956	30.2	1.1	12.0	54.9	1.8	100.0 (3,431.0)
1960	30.9	1.2	14.0	52.1	2.0	100.0 (4,243.0)
1965	36.2	1.3	17.0	43.3	2.2	100.0 (5,212.0)
1970	41.2	1.6	20.0	35.2	2.2	100.0 (6,877.0)
1974	43.1	1.6	21.0	31.8	2.6	100.0 (7,971.0)

Source: United Nations, World Energy Supplies, Series J.

Note: Figures in parentheses denote energy consumption measured in million tonnes coal equivalents.

Table 7.4: Price of Various Energy Resources
(US Dollars per Tonne Coal Equivalent)

Year	Oil	Coal	Natural Gas
1965	8.46	14.30	
1966	8.46	14.15	
1967	8.46	14.20	
1968	8.46	15.23	
1969	8.46	15.65	28.41(a)
1970	8.46	18.26	
1971	10.31	19.48	
1972	11.58	20.10	
1973	15.48	22.10	68.50 [a]
1974	54.45	33.80	74.69 [b]
1975	50.39	49.45	69.39 [b]
1976	54.11	51.20	
1977	58.29	50.85	92.31 [b]
1978	59.70	49.28	

Sources: IMF *International Financial Statistics*;
OECD *Foreign Trade Statistics*, Series C.

Notes: (a) Unit price of USA exports
(b) Unit price of USA imports

(1) that positive efforts will be made to develop alternative energy resources in the coming decade;

(2) that positive efforts will be made to develop synthetic fuel production. However, because of the lead-times and present high production costs (relative to current oil price), commercial synthetic fuel production is not expected to begin until the 1980s;

(3) in view of the known abundant coal resources and its price competitiveness (as seen from Table 7.4 which gives a comparison of prices of the different energy resources), the rate of coal production will be increased. The counter-balancing force to price leverage of oil producers will therefore be provided by coal;

(4) there will be increased oil production from regions outside the Middle-East, primarily from China, Egypt, Indonesia and Mexico. For an indication of their relative supply shares, see Table 7.5. Since oil is a depletable resource, these new major oil producers are expected to follow the pricing policy of OPEC so as to maximise their earnings from oil production;

(5) Middle-East oil production will continue at its present rate;

(6) the fall in oil consumption in the industrialised countries due to the gradual substitution of oil by non-oil energy in the "heat market" and increased conservation and efficiency in use will be offset by the increased oil consumption (especially in the "premium market" transport industry) in the developing and newly-industrialised and industrialising countries.

Table 7.5: Share of Crude Oil Supply in Developing Countries, 1956-1974 (Million Tonnes)

Year	Middle East	Mexico	Indonesia	Egypt	Total
1956	170 (48.2)	13 (3.7)	13 (3.7)	2 (0.6)	353 (100.0)
1960	261 (52.7)	14 (2.8)	20 (4.0)	3 (0.6)	495 (100.0)
1965	416 (52.4)	17 (2.2)	24 (3.0)	6 (0.8)	794 (100.0)
1970	695 (53.1)	22 (1.7)	42 (3.2)	16 (1.2)	1,309 (100.0)
1974	1,087 (64.4)	30 (1.8)	68 (4.0)	8 (0.5)	1,687 (100.0)

Source: United Nations World Energy Supplies, Series J.

Note: Figures within parentheses are percentages of the corresponding totals.

Overall the above assumptions imply that during 1980-1995 oil supply will not be a constraint. The issue is therefore not of oil availability but of the price at which this oil will be made available. Consequently the relevant issue for this study are the floor and ceiling levels within which oil price may be expected to settle.

For the floor price of oil during 1980-1995, the assumption used is that pricing policy within OPEC will be dominated by the moderate "monarchic bloc" countries; these countries will aim at maintaining the real price of oil, so that the rate of increase in oil price will equal or exceed the world rate of inflation. Consequently the floor price of oil during 1980-1995 will be set by the 1980 price under an assumed world rate of inflation of 10 percent per annum.

The ceiling price of oil over the long-term is assumed to be given by the cost of producing synthetic fuels. This is in fact one of the pricing approaches considered by OPEC for correcting the supply/demand imbalances, despite their recognition of the fact that the "physical limitations and technological problems resulting from the process of substitution are still to be tested." (Al-Chalabi, 1980:127-128). Table 7.6 presents the estimated costs of synthetic fuels from different primary energy resources from which coal is seen to be the most competitive mode of liquid oil production to date. Assuming liquid oil production from coal comes on-stream in 1995, the estimated 1979 per barrel production cost of $28.00 for coal-based liquid oil will act as a ceiling price for oil in 1995. To obtain a plausible range for the price of oil, the 1995 price will be calculated from assumed rates of inflation during 1980-1995 of 12

Table 7.6: Estimated Cost of Synthetic Fuels (1979 US Dollars)

Source of Liquid Oil	US Dollars per Barrel of oil equivalent
Coal	20.00 - 28.00
Oil Shale	32.00 - 68.00
Alcohol Fuel	36.00 - 65.40

Source: World Bank (1980a).

percent and 14 percent for medium and ceiling price levels respectively.

Given the floor, medium and ceiling oil price levels, their time paths during 1980-1995 will then be in accordance with the positions outlined for the three subperiods. The time paths presented in Figure 7.1 are derived from the floor, middle and ceiling prices presented in Table 7.7. For the ceiling price case two alternative time paths are presented. Time path (a) is obtained from the calculated values in Table 7.7 while time path (b) is a modification of time path (a) under the additional assumption that the Middl-Eastern producers will exercise their supply leverage during 1980-1990 which they perceive to be their final opportunity of maximising earnings from their balance oil reserves.

The above oil price projections stemmed primarily from the focus on future synthetic rubber feedstocks supply. The discussion on oil and non-oil energy supply and substitutability in the coming decades has revealed that liquid oil, and hence oil products, can be manufactured from several sources. Consequently the search for non-oil energy is likely to solve the question of energy and feedstock raw material inputs supply simultaneously, thus widening the spectrum of raw material availability for all synthetic materials, viz. fertilisers, fibres and rubber. The tendency is reinforced by the vertical integration of the petrochemical feedstocks and synthetic goods industries. For the purpose of this study the implication is that the oil supply constraint on the transport and synthetic rubber industries is expected to diminish over the longer-term. For the natural rubber industry the implication therefore is that the

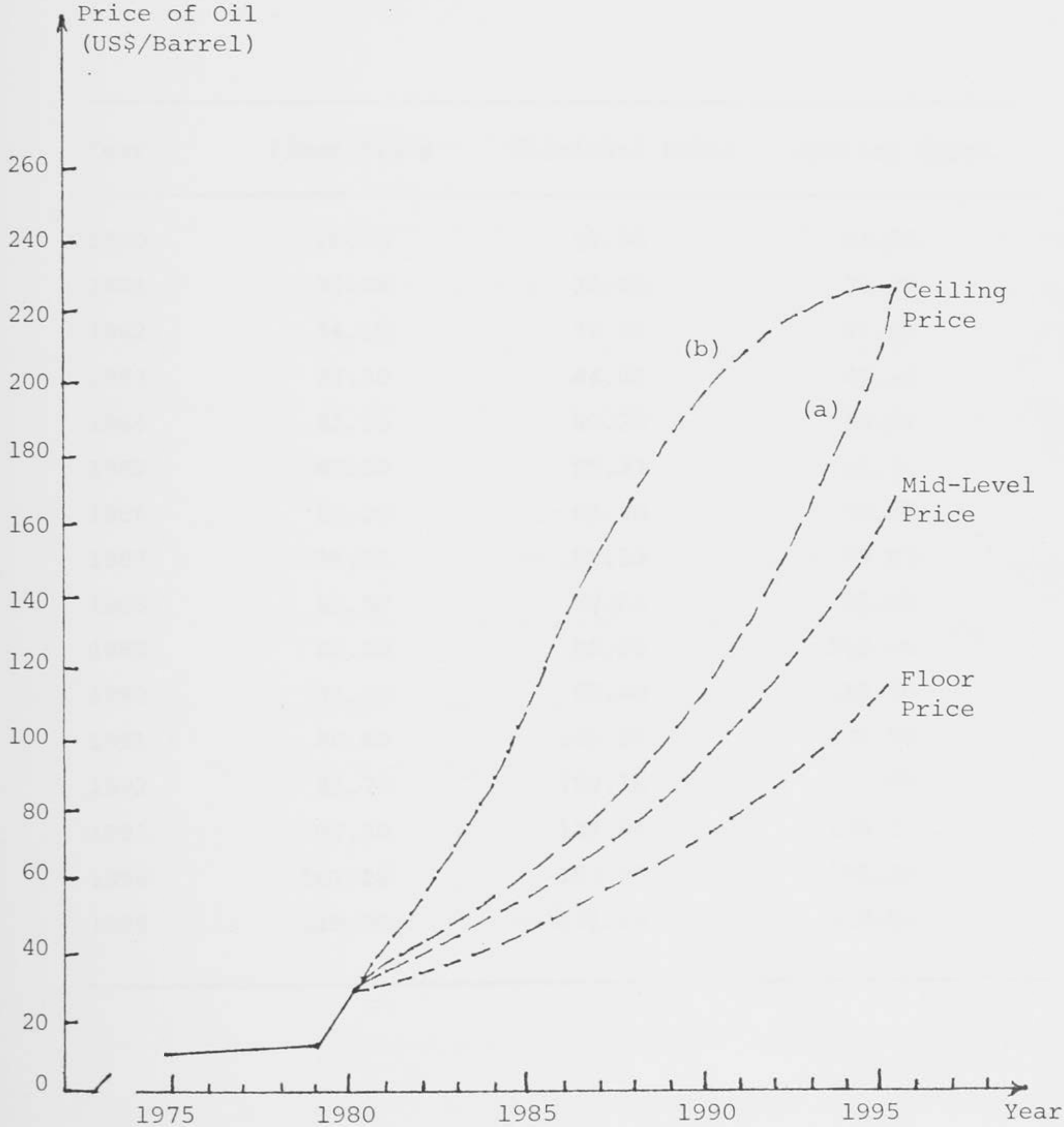


Figure 7.1: Time Paths of Oil Price Under Alternative Scenarios, 1980-1995.

Table 7.7: Alternative Price Level for Oil, 1980-1995 (current US Dollars per Barrel)

Year	Floor Price	Mid-level Price	Ceiling Price
1980	28.25	31.36	31.92
1981	31.08	35.12	36.39
1982	34.18	39.34	41.48
1983	37.60	44.06	47.29
1984	41.36	49.35	53.91
1985	45.50	55.27	61.46
1986	50.05	61.90	70.06
1987	55.05	69.33	79.87
1988	60.50	77.65	91.05
1989	66.60	86.96	103.80
1990	73.30	97.40	118.33
1991	80.60	109.09	134.90
1992	88.70	122.18	153.79
1993	97.50	136.84	175.32
1994	107.28	153.26	199.86
1995	118.00	171.65	227.84

competition from the synthetic rubbers sector is likely to persist energetically in the foreseeable future.

7.5 Projecting Remaining Exogenous Variables

The remaining exogenous variables that require projecting for purpose of simulating the estimated model are the industrial production indices of the individual countries and/or their production of tyres and tubes. The three assumptions used for simplifying the projection procedures are:

(1) that the growth of industrial production will proceed at the same rate as gross domestic and/or national product;

(2) the production of tyres is correlated with, and thus derivable from, the projected industrial production indices;

(3) the production of tubes is correlated with the production of tyres.

Consequently the projections of exogenous variables depend on the projected growth rates of gross domestic and/or national product. As such growth rates have been projected by various organisations, the published figures were referred to. The choice of growth rates used in this study followed from an evaluative review of projections by the World Bank (1980a, 1980b).

7.5.1 Economic Growth Rates and Price Indices

As the level of oil price is seen to remain an influential determinant of economic growth rates attainable in the coming decade, the projected growth rates should be consistent with the projected price of oil. In evaluating growth rate projections for their consistency, it is therefore helpful if the oil price projections (on which they are based) be known. The advantage of using the World Bank projections is that the projected growth rates and oil prices for 1980-1995 are available simultaneously. A comparison of the oil price projections in Figure 7.1 with those by the Bank thus provides a link (between the price projections and the Bank's growth projections) which lends perspective from which to project alternative growth rates.

Since the Bank's published growth rates refer to the high growth case, alternative medium and low growth rates were projected to correspond to the situations when medium and floor levels of oil price will obtain respectively.

In projecting the wholesale price indices (WPI) it was assumed that the behaviour of prices during 1980-1995 will, to a large extent, be influenced by the behaviour of oil price. Using oil price as the explanatory variable, the projected low/medium/high wholesale price indices for UK and USA were estimated from simple regressions of the relevant price index on the price of oil.

7.5.2 Activity Indices and Rubber Manufacturing

Industrial activity, measured by either the index of industrial production or of rubber goods production, is an exogenous variable for the input demand equations. In projecting this and other activity-related exogenous variables, the industrial production growth rates were assumed to be identical with those for GDP. Thus for each country the projected GNP growth rates were assumed as the rate of industrial production. The growth rates for USSR were assumed to be representative of the growth rates within COMECON and therefore used as rates for that bloc of countries.

To project the output of tyres, it was assumed that the rate of tyre production is associated with the rate of industrial activity.[8] Since tubes are jointly used with tyres, their production depends on the level of tyre production. Except for Italy, the parameters used for projecting output of tyres and tubes were obtained by simple linear regressions. For Italy, despite the use of log-linear regression, the coefficient of determination remained low. The estimates used in projecting tyre and tube output are given in Table 7.8. Since industrial production indices compiled on a calendar year basis for Australia are unavailable, the GNP growth rates were assumed to be the growth rates of tyre production.

Finally it is necessary to project the world synthetic rubber production capacity. The rapid expansion of the synthetic rubber production capacity in the historical period arose from the

8 This is vindicated by Smit's projections of world rubber demand under alternative scenarios, where rubber demand was found to be highly sensitive to levels of economic growth but insensitive to different saturation levels. For further details of Smit's approach, see Smit (1981).

Table 7.8: Projected Low(L), Medium(M), and High(H) Rates of Growth of Industrial Production, 1980-1995. (Percentages)

Country	1980			1981			1982			1983 - 1985			1985 - 1990			1990 - 1995		
	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H
Australia	2.8	3.0	3.5	2.5	3.0	3.5	3.0	4.0	4.5	3.5	4.5	5.5	3.5	5.0	6.0	3.5	5.0	6.0
Brazil	5.0	5.0	5.5	4.5	5.0	5.5	4.5	5.5	6.0	5.0	6.0	7.0	5.5	7.0	8.0	5.5	7.0	8.0
Canada	1.5	2.0	2.5	1.5	2.0	2.5	1.5	2.5	3.0	2.0	3.0	4.0	2.5	4.0	5.0	2.5	4.0	5.0
China	5.5	5.5	6.0	5.0	5.5	6.0	5.0	6.0	6.5	5.5	6.5	7.5	6.0	7.5	8.5	6.0	7.5	8.5
COMECON	3.0	3.0	3.5	2.5	3.0	3.5	2.5	3.5	4.0	3.0	4.0	5.0	3.0	5.0	6.0	3.0	5.0	6.0
France	2.0	2.0	2.5	2.0	2.0	2.5	2.0	3.0	3.5	2.5	3.5	4.5	3.0	4.5	5.5	3.0	4.5	5.5
West Germany	2.3	2.5	3.0	2.0	2.5	3.0	2.5	3.5	4.0	3.0	4.0	5.0	3.5	5.0	6.0	3.5	5.0	6.0
India	5.0	5.0	5.5	4.5	5.0	5.5	4.5	5.5	6.0	5.0	6.0	7.0	5.5	7.0	8.0	5.0	7.0	8.0
Italy	2.0	2.0	2.5	1.5	2.0	2.5	2.0	3.0	3.5	2.5	3.5	4.5	3.0	4.5	5.5	3.0	4.5	5.5
Japan	4.8	4.5	5.0	4.0	4.5	5.0	4.0	5.0	5.5	4.0	5.0	6.0	4.5	6.0	7.0	4.5	6.0	7.0
Netherlands	1.8	2.0	2.5	1.5	2.0	2.5	1.5	2.5	3.0	2.0	3.0	4.0	2.5	4.0	5.0	2.5	4.0	5.0
UK	-2.0	1.0	1.5	-1.0	1.0	1.5	0.0	1.0	1.5	0.5	1.5	2.5	1.5	3.0	4.0	1.5	3.0	4.0
USA	-1.3	0.5	1.0	-1.0	0.5	1.0	0.0	1.5	2.0	0.5	1.5	2.5	1.5	3.0	4.0	1.5	3.0	4.0

availability of low-priced oil and feedstocks and technological progress in producing synthetic rubbers not only more economically but with improved physical properties. These factors were reinforced by the economies of scale in synthetic rubber production, all of which enhanced the world expansion of synthetic rubber production capacity.

Since the price of oil is an important determinant of synthetic rubber production cost, the future growth of the industry will depend partly on further technological progress to offset this source of increased production cost. The synthetic rubber industry is expected to step up research and development on two complementary fronts: the short-to medium-term search for new and/or improved rubbers to further compete with natural rubber both qualitatively and quantitatively is expected to be complemented by the longer term search for alternative sources of feedstocks. Thus the production capacity is some function of the price of oil and technological progress (proxied by a trend variable). The estimates obtained from log-linear regression of the historical data and presented in Table 7.9 are used in projecting the synthetic rubber production capacity for 1980-1995. The low/medium/high levels of production capacity are generated from the ceiling/middle/floor levels of oil price respectively. For technological progress it is simply assumed that the historical rate of development to persist. These projected production capacities were then revised in the light of lower observed values for 1980. The observed difference between these values as a percentage of the observed 1980 value were then used to scale down the low/medium/high levels of production capacities accordingly.[9]

[9] The scaling factors were 7.5 percent, 13.8 percent and 15.0 percent for the low, middle and high levels respectively.

Table 7.9: Estimates Used in Projecting Values of Exogenous Variables.

Dependent Variable	Constant	IPI	QTY	p^{oil}	$\ln p^{oil}$	Trend	R^2	F	DW
France									
QTYC	-12074.4351 (-4.8)	451.8766 (17.0)					0.9444	288.7231	0.5100
QTYV	288.8001 (1.1)	40.8964 (14.9)					0.9291	222.6200	1.0575
West Germany									
GPIC	19.1382 (3.4)	0.7654 (11.8)					0.8697	140.1315	0.5883
GPIV	-13.6284 (-2.0)	1.0812 (13.4)					0.8951	179.1941	1.0910
Italy									
QTY	3.4321 (4.7)	0.4321 (2.8)					0.3871	7.5604	1.0768
QTU	-5.0656 (-0.9)		0.1322 (5.8)				0.7378	33.7579	1.9519
Japan									
QTY	-6.3450 (-4.0)	0.3364 (39.9)					0.9870	1590.4401	1.8220
QTU	14.9853 (4.8)		0.4165 (8.7)				0.8267	76.3379	0.4488
UK									
QTYC	-19512.3717 (-8.0)	431.9557 (16.1)					0.9253	259.9225	0.8964
QTYV	420.4762 (1.1)	33.1630 (7.8)					0.7423	60.4790	0.7316
USA									
QTYC	24.0354 (2.0)	1.2668 (10.4)					0.8368	107.6919	0.8623
QTYV	-6.440 (-3.9)	0.3140 (18.9)					0.9446	358.1726	1.3352
QTYT	2.1009 (3.6)	0.0246 (4.2)					0.4528	17.3781	1.0407
WPI^{UK}	33.3040 (8.0)			0.0737 (10.9)			0.8675	117.8705 ($F_{1,18}$)	1.0806
WPI^{USA}	85.9227 (25.7)			0.0829 (15.3)			0.9285	233.9126 ($F_{1,18}$)	1.3056
ln CQSR	5.6923 (79.1)				-0.0561 (-2.9)	0.0768 (21.6)	0.9917	771.9240 ($F_{2,13}$)	0.9287

CHAPTER EIGHT

STABILISING THE NATURAL RUBBER MARKET

8.1 Introduction

This chapter examines the issue of stabilising the natural rubber market. In contrast to some recent wider-ranging empirical studies on commodity market stabilisation, the present study is limited in that the natural rubber market is considered in isolation. This is so as to focus on natural rubber stabilisation from the longer-term perspective of 15 years during which two trends are anticipated: (1) increasing natural rubber supply availability as a result of increased and more productive investment in natural rubber production in Southeast Asia and also in Latin America, viz. Brazil and Mexico, and (2) the widening range of synthetic rubber feedstock supply sources as synthetic crude oil production technologies improve. With the enforcement of the International Natural Rubber Agreement (INRA) under the Integrated Programme for Commodities, the stabilisation targets of the INRA provides the terms of reference for this analysis of stabilising the natural rubber market by buffer stock operations.

The aim of this chapter is to evaluate price stabilisation in a longer-term setting which considers the outlook and prospects for natural rubber. In this context, the starting point is the scenario assumed for oil price. The analysis of medium-term price stabilisation under the low oil price scenario will be presented in this chapter. In the next chapter longer-term price stabilisation will be analysed.

In the following discussion the possible benefits of price stabilisation will first be surveyed. Then the theoretical underpinnings of price stabilisation, namely the positive and normative aspects, will be discussed. In discussing the positive aspects of price stabilisation, the array of trade-offs that are critical in evaluating any stabilisation programme will be highlighted. Then stabilisation targets and operational rules specified by the INRA for both the short-term (daily and monthly) and longer-term (one-and-a-half to five years) operation of a buffer stock will be presented.

In order to use the annual model presented in Chapter Six to evaluate the INRA, it is necessary to focus on the operational rules specified for the longer-term. This is because these operational rules amount to constraints which provide guidelines for formulating a viable buffer stock policy to achieve the broad stabilisation targets of the INRA. As the study is concerned with the longer-term, and as the INRA is proposed for a 5-year period only, stabilisation over a 10-year period will be analysed in the next chapter on the basis of a hypothetical extension of the INRA for a further 5-year term.

8.2 Alleged Benefits from Price Stabilisation

Although this exercise concerns the analysis of the positive aspects of price stabilisation, a brief discussion of the alleged benefits from price stabilisaton will be presented first. This is useful in placing the subsequent stabilisation results against the background of conflicting attitudes towards price stabilisation.

Arguments for price stabilisation may be divided into (a) those from the standpoint of producer-countries, an aspect of which is the UNCTAD Common Fund position and (b) those from the standpoint of the consumer-countries. From the standpoint of the producing countries, it is sometimes alleged that the primary benefit of stabilisation lies in providing producing countries with bargaining strength to counter that of the consuming countries (Avramović, 1978). This argument implicitly relies on the distinction between pure price stabilisation and stabilisation which also changes average price. The bargaining strength of producing countries is enhanced only when stabilisation results in a higher average price than that without market intervention. Moreover, whether the greater bargaining strength actually conveys gains to producers requires further analysis. In contrast, pure price stabilisation allegedly benefits producers in two ways. First it is frequently assumed that risk-averse producers benefit from the resulting reduction in price variations. Second, although price stabilisation may be a short- to medium-term solution, the period of stabilisation would provide producing countries with time to evaluate their medium- to long-term resource allocation problem and to implement the necessary structural adjustment policies. The greater economic benefits of stabilisation is therefore viewed as stemming from the dynamic effects associated with increased investment through more successful implementation of development plans enabled by more stable export earnings (Avramović, 1978; Cline, 1979).

Because of the interdependence between the primary producing and industrialised countries, price stabilisation also yield secondary effects beneficial to industrial countries. Such benefits are seen to stem from the levelling out of business cycle effects and may also impact on inventory policies in the industrialised countries (Harrod, 1958). Cline (1979:17) has argued that the largest economic benefits from commodity stabilisation would be the gains to industrialised countries through the reduced inflationary pressures (as a result of dampening price rises) in these countries. Such gains accrue because if price fluctuations cause importing countries to implement macroeconomic policies aimed at reducing inflation caused by higher input prices, then the resultant effect may be lower levels of economic activity and employment and reduced real output. Over the longer-run, price stabilisation would probably also yield further macroeconomic gains for the industrial countries through minimisation of the "ratchet effect" of price increases of industrial raw materials. Price stabilisation would also lead to improvements in the overall world economy because more stable export earnings would improve the debt servicing of the developing countries and thus contribute to the international credit system. Other proponents of market intervention argue on the basis of the imperfection in commodity markets: in general, free trade need not be optimal because the assumptions of the free trade model are not satisfied in reality (Baldwin and Kay, 1975; Law, 1975; Rangaranjan, 1978). This last argument is of relevance to the natural rubber market because of the contrasting industrial organisation of the synthetic rubber industry.

There are counter arguments to these supposed benefits of price stabilisation. The argument for increasing producers' bargaining strength can be counteracted for two reasons. Firstly, where there is an existing, readily available substitute, as is the case with natural rubber, price leverage depends not only on overall supply and demand forces, but also on the "degree of essentiality" for the commodity (Stern and Tims, 1975). This "essentiality" condition is reflected in the minimum requirements for natural rubber in tyre production. Secondly, the price band that emerges in a stabilisation agreement is the outcome of bargaining between the participants; the agreed price band therefore reflects the resolution of price and political (due to the strategic nature of the commodity) leverage of the producers and consumers at the outset. Since stabilisation agreements typically provide clauses for re-negotiation of the stabilisation price bands (to avoid exhaustion of financial resources), the price leverage attained through the agreement can be negated if the price bands are subsequently revised downwards.

On the wider issue of dynamic macroeconomic effect from commodity market stabilisation, there is also a spectrum of views. Cline, who argues for stabilisation, also admits that "Unfortunately, the state of the art does not provide any basis for estimating these (dynamic) effects, but they are probably much larger than the "static" benefits from stabilisation." (Cline, 1979:17). However, Adams (1979) asserts that the empirical findings from his work COMLINK (linking commmodity models to the LINK system) suggest that the behaviour of commodity markets do affect commodity prices, trade unit values, domestic prices and real economic activity. This still leaves open the question of whether price stabilisation is necessarily the best policy to adopt.

The argument against price stabilisation stem from similar considerations of commodity market features and economic interdependence between countries to those considered above. Opponents of price stabilisation agree in general that commodity markets do not operate under conditions of perfect competition, but tend to emphasise the complexities of market instability. Bauer and Myint (1976) for example, argue against price stabilisation because of the hidden costs involved and because controlled markets are considered to be so full of complexities that they will be difficult to beat. Moreover, they argue that there is inherent stability in commodity markets and that producers are not always poor. The latter point warrants careful consideration in a situation such as that for natural rubber where production is largely in the hands of smallholders. Opponents of price stabilisation also question the efficiency of price stabilisation by emphasising the essential divergence between producer and consumer interests. These writers then argue that the problem of price and export instability may be better approached by considering other instruments, viz. commercial policies, domestic macroeconomic stabilisation, compensatory financing, exchange rate adjustments, etc. It suffices to indicate here that each of these instruments raises an attendant host of possible outcomes and qualifications. For example, in the use of compensatory financing, the question raised is whether to consider such financing with respect to the total export earnings or to export earnings on a commodity-to-commodity basis, since these have differential implications for different primary producing countries (Morrison and Perez, 1976).

Another position taken against price stablisation is that it is arguable whether export instabilty leads to negative effects, viz. reduced development finance and hence reduced investment (Knudsen and Parnes, 1975). Thus MacBean (1966), for example, queries whether export instability is really a bad thing or whether its negative impact has been exaggerated. In this vein Ariff (1972) for example, argues that the long-term effects of export instability for Peninsular Malaysia has been neutralised by means of the built-in stabilisers in that country's fiscal policy.

8.3 Some Results of Theoretical Models

In considering the theoretical results, it is pertinent to distinguish the normative from the positive results. The normative issue concerns the indirect welfare effects while the positive issue has concentrated on the direct price and income effects of stabilisation. The ultimate aim is to identify the gainers and losers from price stabilisation. Since the early studies concentrated on the welfare effects of stabilisation, these will be briefly discussed first.

Most theoretical analyses of stabilisation assume complete price stabilisation, while in practice attempts at stabilisation have been of the partial type aimed at defending a price band rather than a price level.[1] The analytical results discussed here will first relate to complete price stabilisation. In theoretical studies prices are normally assumed to be serially uncorrelated so that there is no time cycle for price behaviour. As will be mentioned later, natural rubber prices have been observed to follow cyclical patterns.

Early studies on price stabilisation generally assumed linear supply and demand functions with additive disturbances. Waugh (1944) focussed on the effects of price stabilisation on consumers only, and Oi (1961) concentrated on the effects on producers only. Massell (1969) considered the effects of price stabilisation for producers and consumers simultaneously. Using linear functions and additive stochastic disturbances, Massell showed that while price stabilisation will unambiguously lead to a net welfare gain, the distribution of this welfare gain was not unambiguous; this was because the welfare gains/losses of the producers and consumers severally depend critically on the source of instability causing the price fluctuations. The level and distribution of the net welfare gain between producers and consumers also depends on the demand and supply elasticities. But as Porter (1969) indicated, it is not easy to assess accurately the "blame" for the price fluctuations from observed market behaviour. Such assessments require a very specific set of (explicit and implicit) assumptions regarding the trend around which the fluctuations are to be measured and about the short-run price elasticities. Moreover, over a broad spectrum of commodities, the basic cause of price fluctuations is the interdependence of supply and demand fluctuations.

1 For a recent study on the optimality of price-band stabilisation by buffer funds, see Quiggin and Anderson (1981).

More recently, work by Turnovsky (1978) and Just et al. (1978) with nonlinear functions have questioned the relative importance of the source of instability for determining the distribution of the welfare gain from price stabilisation. In their models, stochastic disturbance terms are multiplicative and the supply and demand functions are nonlinear.

Using nonlinear or linear functions poses an initial problem in terms of the price about which to stabilise, if the buffer stock is to be self-liquidating at the stabilised price. Under linearity, the stabilisation price for a self-liquidating buffer stock would be the arithmetic average of all observed prices; in contrast, self-liquidating stabilisation with nonlinear functions need not be about the expected price (Turnovsky, 1978).

Assuming the stable price is chosen so as to be self-liquidating, the desirability of price stabilisation for either producers or consumers depends "only upon the shapes of the deterministic portions of the supply and demand curves. If one group benefits from having price stabilised, it will do so whether the random price arises from stochastic disturbances in demand or in supply." (Turnovsky, 1978:127). In other words, the effects of stabilisation depends on the interaction between the supply and demand elasticities and the random disturbances. In these circumstances, Just et al. (1978) have shown that opposite results to those found by Massell (1969) may obtain; for example, if the stochastic disturbance terms of the supply function is multiplicative, then consumers may still benefit from price stabilisation, despite the fact that the instability lies with supply. (Massell had earlier shown that if the source of instability is on the supply side, then consumers would lose from price stabilisation.) Broadly speaking however, price stabilisation under nonlinear supply and demand functions with multiplicative stochastic disturbances tends to lead to an overall welfare gain which generally favours consumers. All of this means that the normative results of stabilisation depend crucially on the specifications of the model in question.

Because the functions and disturbances may differ among individual producing and consuming countries, these results also imply that the extent of gains/losses may differ among producing or consuming nations.

Another difficulty with empirical evaluation of the welfare effects of price stabilisation lies in the choice of the welfare criterion (criteria) for measuring the stabilisation benefits. In the main the concepts of consumers' surplus and producers' surplus have been used; for example, Turnovsky (1978) derived the change in producers' welfare (surplus) in terms of the change in producers' abnormal profits.

The choice of the profits criterion raises the further question of the method by which producers' price expectations are formed, as the following discussion will show. Using linear supply and demand functions, and additive stochastic disturbances, Turnovsky (1978) shows that the change in profits depends on the slopes of the supply and demand functions as well as on the disturbance terms. The change in consumers' welfare as measured by consumers' surplus is shown to be determined by the same terms. Turnovsky then introduced price expectations into producers' behaviour. If expected prices are based on adaptive expectations, then the producers' gains from price stabilisation is found to be determined by the difference between the expected and market prices. The importance of introducing price expectations is the introduction of lagged prices and hence autocorrelation in the disturbance terms into the system. However, under adaptive expectations, producers could still benefit from price stabilisation under demand shifts provided the fluctuations in demand are not excessively autocorrelated. But if producers' price expectations are formed along the lines of Muthian rational expectations, where expectations are made conditional on <u>all</u> the information available at the time of price forecasting, then producers will not benefit from price stabilisation for demand fluctuations.

The problem of using expected consumers' surplus as a measure of welfare change from stabilisation under conditions of price uncertainty has also been examined recently by Turnovsky, Shalit and Schmitz (1980). By using the consumer's indirect utility function in order to derive demand functions, it is shown that assumptions about risk attitudes are implied by the expected value of consumers' surplus as the measure. This implies the restrictive assumption that the "income elasticities of those goods subject to price variation all equal the coefficient of relative risk aversion." (Turnovsky <u>et al</u>., 1980:141). Alternatively, if welfare change is measured by the more general expected utility criterion, then consumers' gains from price stabilisation is shown to be determined by (1) own price elasticity for the good under stabilisation, (2) coefficient of relative risk aversion, (3) the share of the consumer's budget allocated to the good under stabilisation and (4) income elasticity of demand for the good under stabilisation.

These examples illustrate the difficulty of measuring the welfare effects since the price expectations hypothesis together with the choice of welfare criterion lead to further consideration of the assumptions made in the formulation of the objective function to be used. On this question, Labys (1980) has succinctly summarised all the issues that warrant simultaneous consideration for effectively determining whether producers or consumers gain or lose from stabilisation; these are:

(1) the source of the price instability;

(2) the nature of the stochastic disturbances (additive or multiplicative) and the autoregressive properties;

(3) the nature of producer response and their formation of price expectations and attitudes towards risk;

(4) the definition of the surplus used;

(5) the choice of partial as compared to complete price stabilisation and

(6) the identification of importing or exporting nations as distinct from consumers and producers.

Various writers have not only pointed to the drawbacks in the use of consumers' and producers' surpluses as conventionally defined, but have also proposed that the welfare criteria be extended to include the incorporation of the difference between consumer and producer prices, the recognition of final product prices in the consumers' surplus and the consideration of input prices in the producers' surplus (Labys, 1980).

The discussion will now turn to the positive issues of the direct price and income effects of stabilisation. In considering market stabilisation, it is essential to distinguish two types of effects:

(1) the effects of stabilising a variable x on the change in the average level of the variable itself and

(2) the effect of stabilising a variable x on the stability and the average level of variable y as a result of interaction between x and y.

Two variables other than price are commonly considered, namely producer incomes and export receipts. The difference between producer incomes and export receipts is dependent on (a) whether the commodity exported is also consumed domestically, (b) whether the export price differs from the domestic price for the commodity in question and (c) the use of imported inputs. It is therefore necessary to be clear about the following separate effects of price stabilisation and their interaction; namely,

(a) the resultant change in average price;

(b) income stabilisation/destabilisation and the resultant change in average income;

(c) export stabilisation/destabilisation and the resultant change in export earnings.

Price stabilisation is distinct from income stabilisation, although it is commonly assumed that price stabilisation must lead to stabilisation of producers' incomes. Indeed the two objectives may not be compatible. Hence even if average price can be maintained by a self-liquidating buffer stock scheme, income stability may still be negatively affected. Radetzki (1970) has shown that whether price and income stabilisation are compatible would depend on the demand and supply elasticities as well as on the relative sizes of demand and supply fluctuations.

Even if price and income stabilisation can be simultaneously attained, there is a question of whether average income (and export earnings) will be affected negatively. This is because many primary commodities face derived demands which are determined by business cycles. The argument that demand for these commodities tend to be highly inelastic during the upswing then facilitates the optimistic result that price and export instability provides opportunities for maximising export and foreign exchange earnings; in other words, price stabilisation may lead to a loss in export earnings during the boom period (Grubel, 1964) and to lower total export earnings over the entire period. The relevance of this for natural rubber lies in the minimum (essential) rubber requirements in tyre production. If producers' revenues are correlated with export revenue, then total producers' revenue over the stabilisation period may similarly be negatively affected.

The co-financing of stabilisation schemes by the producing and consuming countries participating in the schemes also raises the question of the stability of incomes shares; price stabilisation may benefit producers differentially so that their gains from stabilisation need not correspond to their production, and hence financial contribution, shares. If buffer stocks are used to stabilise price, then the trade-off between stabilisation gains and the capital and operational costs of the buffer stock programme have also to be taken into consideration. Consequently, evaluation of stabilisation schemes involves examining the effects of price stabilisation on incomes, export earnings and welfare of each country.

Given all these difficulties, an alternative to estimating the distribution of welfare gains and losses is to analyse the positive aspect of price stabilisation on the distribution of prices, producer incomes and total sales. This approach is also more tractable and is adopted here.

8.4 The International Natural Rubber Agreement (INRA)

Natural rubber is one of the ten key primary commodities included for price stabilisation under the proposed UNCTAD Integrated Programme for Commodities. The first United Nations Conference on Natural Rubber was held in 1978 and the INRA subsequently drafted and in principle agreed upon in October 1979. The INRA was to come into provisional force on 1 October 1980 provided that it was ratified by countries representing 65 percent of world producers and 65 percent of world consumers. Failing this, the INRA "will enter into force definitively on 1 October 1980 or any other date thereafter when countries/governments accounting for 80 percent of net exporters and 80 percent of net importers have ratified the agreement". (Natural Rubber News, 1980:4) It is only when the INRA enters into force definitively and when the participating members have made the necessary contributions that the proposed Buffer Stock can commence operations. Once enforced the INRA will remain in force for five years unless otherwise extended or curtailed. The INRA was made operational at the first meeting of the International Rubber Council (IRC) in Geneva in January 1981. At this meeting, Kuala Lumpur was chosen as the headquarters of the IRC and the principal officers of the IRC were named. By November 1981, the buffer stock manager had begun buying on the Malaysian and Singapore markets when natural rubber prices had fallen below the S$2100 floor price.

The declared aims of the INRA are

(a) to stabilise natural rubber price and

(b) to obtain steady growth of the natural rubber export revenues of the producer-countries.

In this Agreement a natural rubber buffer stock is the sole instrument for market interventions to attain the primary objective of price stabilisation. The total buffer stock capacity of 550,000 tonnes is to be divided between normal and contingency buffer stocks of 400,000 and 150,000 tonnes respectively.

To implement a buffer stock scheme it is necessary to specify the terms of reference for its operations, these terms referring to price range and time horizon. For a given time period (assuming that the reference price is realistically and correctly set), the price range defendable is inversely related to the buffer stocks capacity; that is, the narrower the range within which price is to be stabilised, the larger the buffer stock required. Since the buffer stock is set, *a priori*, by the INRA, the time horizon is crucial in determining the price range which the buffer stock is expected to, and can, adequately defend. The determination of this price range hinges on the choice of a reference price about which price fluctuations are expected to occur; thus the reference price links the buffer stocks and commodity market since the buffer stock operation rules are specified in relation to the reference price. If price stabilisation about the free market (that is, free in the sense of no intervention by stabilisation schemes) price is the primary purpose for operating a self-liquidating buffer stock, then the reference price may be approximated by the free market trend price.

8.4.1 INRA Buffer Stock Price Bands

To guide the buffer stock management on the timing of intervention, four sets of alternative price ranges relating to optional/compulsory INRA interventions have been specified. These are:

(a) Reference Price

This is the level about which price is expected to fluctuate; for the initial term, the reference price is set at the nominal price of M$2100 per tonne for one-and-a-half years.[2]

(b) Intervention Prices

2 Hereafter all prices with regard to INRA specifications refer to the price per tonne of natural rubber in Malaysian Ringgits(Dollars).

The intervention prices which define the no intervention price band are plus or minus 15 percent of the reference price (that is, \$1790 and \$2420). Within the no intervention price band the only operations required are those for stock rotation.

(c) Trigger Prices

These are plus or minus 20 percent of the reference price (that is, \$1680 and \$2520) and draw the line between optional versus compulsory buffer stock operations.

(d) Indicative Prices

These are the reference price plus or minus \$600 (that is, about 30 percent of S\$2100) and contain the price band delineating the permissible price fluctuations. In contrast to the time horizon for the reference price, the indicative prices of \$1500 and \$2700 are to be valid for two-and-a-half years.

The relation of the various price levels to the Reference Price and their significance for buffer stock operations are summarised in Figure 8.1.

The daily buffer stock operations will be based on the daily market indicator (different from indicative) price. The daily market indicator price is to be a composite weighted average of daily official current-month prices on the Kuala Lumpur, Singapore, London and New York markets. Initially the daily market indicator price will

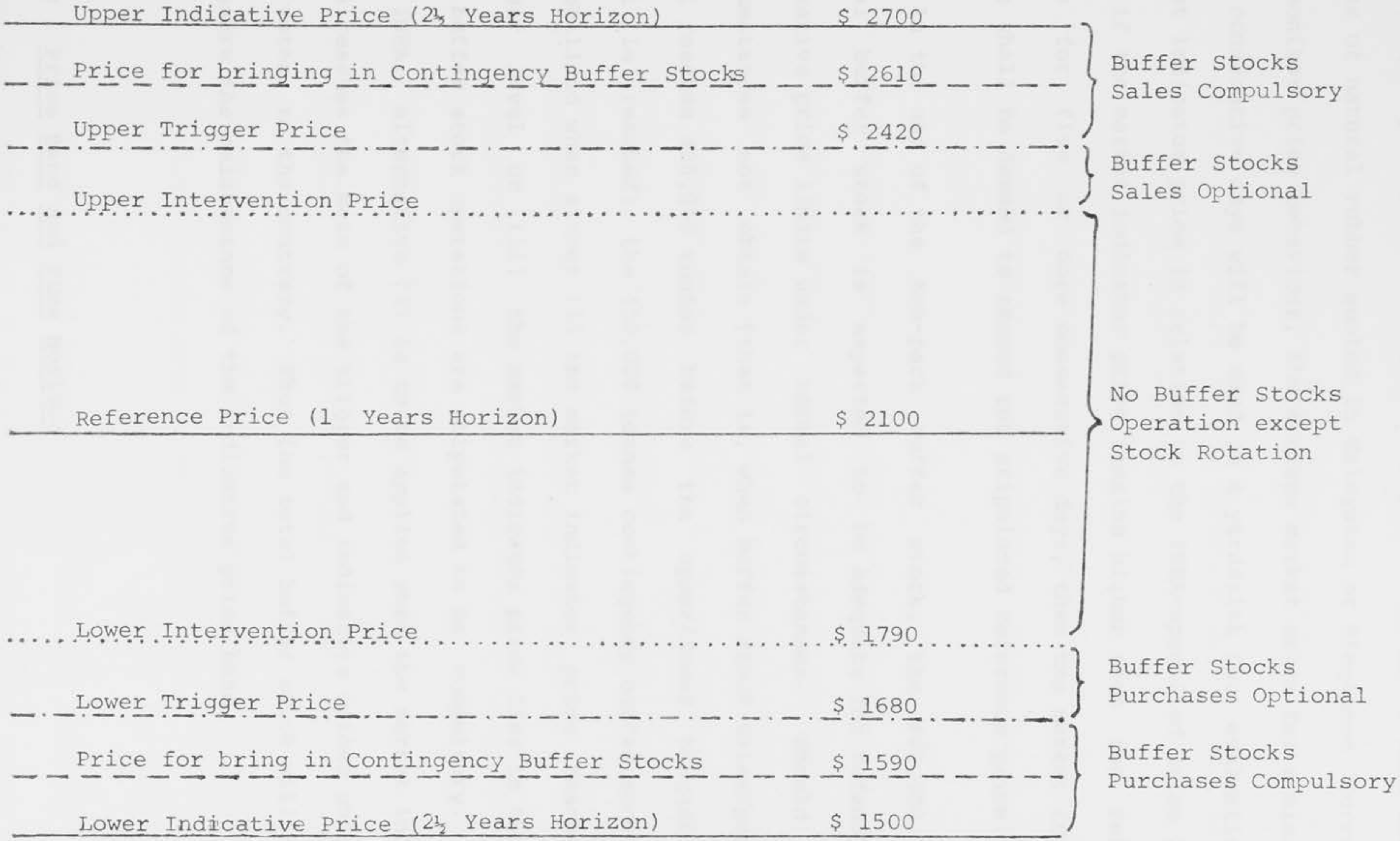


Figure 8.1: Price Ranges Specified for Buffer Stocks Operations Under the International Natural Rubber Agreement

be an equally-weighted average of the prices for RSS1, RSS3 and TSR20 grades of natural rubber quoted in Malaysian or Singapore currencies. To monitor price behaviour, the average market price for a minimum of five consecutive days will be used as a yardstick for evaluating the market indicator price in relation to the INRA-specified price levels. Thus if the market indicator price remains higher than the reference price for five or more consecutive days, then the market indicator price shall be deemed to exceed the stipulated reference price.

In the use of the two-part buffer stock, the 400,000 tonnes normal buffer stock is expected to be adequate for defending the indicative price limits under normal circumstances. Should normal circumstances not obtain (that is, when buffer stock sales/purchases level reaches 400,000 tonnes before the upper/lower trigger price level is reached), the 150,000 tonnes contingency buffer stock is to be mobilised when either (i) the market indicator price reaches the trigger level or (ii) the market indicator price lies in the range when buffer stock operations are stipulated to be compulsory. Under the INRA, alternative (i) is to be applied when the market indicator price reaches the mean of the trigger and indicative prices unless the IRC votes to the contrary. Thus the total buffer stock will be used to ensure the maintenance of the indicative price band.

8.4.2 Price Band and Time Horizon

Since the choice of the reference price level is influenced by the time horizon used, clauses providing for reference price revisions and the monitoring of buffer stock movements must be specified in relation to time. The time horizons for the INRA are:

(a) a five-year term once the INRA in enforced;

(b) one-and-a-half years for the reference price during which time it is to remain at $2100;

(c) two-and-a-half years for the indicative price during which time the indicative price band ($1500, $2700) is to remain unchanged;

(d) one-and-a-half years for buffer stock variations during which time the net change should not exceed 100,000 tonnes; that is, at any point in time, say at month t, the buffer stocks (BS) movement must satisfy $(BS_t - BS_{t-i}) \leq 100,000$ tonnes for i = 1, 2, ..., 18 months;

(e) constraints to clause (d) are that net total BS sales/purchases should not exceed 300,0000 tonnes since

(i) the enforcement of the INRA,

(ii) the last revision of the Reference Price, or

(iii) the last revision of BS net sales/purchases of (d), whichever is the most recent.

When any of the constraints become binding, then the Reference Price is to be lowered/raised by 3 percent of current level unless the IRC decides differently. These constraints therefore provide for changes in the Reference Price.

In the event of failure by the buffer stock operations to satisfy the time horizon constraints, the corresponding resolutions provided for each of constraints (b) to (e) above are:

(b') if the six-month average daily indicator price prior to the review date exceed the intervention price limits, then the reference price should be revised upwards or downwards by 5 percent as the situation demands;

(c') the indicative price band is to be reviewed when either

(i) within two-and-a-half-years, the reference price has been revised upwards(downwards) by more than 3 percent subsequent to a previous indicative price revision and in the 60 ensuing days the market indicator price continues to be above(below) the upper(lower) intervention price,[3] or

(ii) within one-and-a-half years the reference price has been revised upwards(downwards) by more than 5 percent subsequent to the previous indicative price revisions, and in the 60 ensuing days the market indicator price continues to be above(below) the upper(lower) intervention price. (The same implication as in footnote 2 applies here.)

(d') If the net change in buffer stocks exceeds 100,000 tonnes within one-and-a-half years, then the situation will be assessed and if necessary, one of the following measures will be adopted:

3 The implication here being that the buffer stock capabilities are exhausted and its effectiveness will be reinstated only if the indicative price band is revised.

(i) suspend the buffer stock operations;

(ii) change the rate of buffer stock operations (that is, by realigning the intervention and trigger price level for buffer stocks sales/purchases);

(iii) revise the reference price without modifying the indicative price band.

(e') Should net buffer stock sales/purchases exceed 300,000 tonnes (1) after the enforcement of the INRA or (2) after a revision of the reference price or (3) after the revision of the buffer stock net sales/purchases volumes permitted, whichever alternative is the most recent, then the reference price level shall be deemed inappropriate again and should be revised by plus or minus 3 percent of the existing level unless the IRC decides otherwise.

8.5 Towards a Viable Stabilisation Policy under the INRA

The first aspect of INRA to be considered is the question of feasibility. In using the econometric model presented in Chapter Six to simulate buffer stock operations for purpose of identifying a viable price stabilisation policy for the natural rubber market in the medium- to longer-term, the desirability of price stabilisation will be maintained. The simulation exercises attempt to "tell, if possible, what degree of stability can be realistically attained." (Klein, 1978:116) under a given forecast scenario, bearing in mind that the determination of the stabilisation price band depends critically on the capital resources available to the IRC as well as the conditions and constraints specified by the INRA for the buffer stock operations.

The INRA is intended for a 5-year term; however, the INRA price bands are specified for the shorter period of one-and-a-half years after which they are subject to review and revision. The problem here is that frequent price band revisions -- suggestive of a myopic approach -- not only involve time-consuming negotiations but more importantly, could mean the loss of longer-term price stabilisation. Consequently, successful longer-term stabilisation that avoids frequent renegotiations should be based on price bands relevant to longer-term market behaviour. Thus the key features of the INRA outlined in section 8.3 will here be used only as a guide to the choice of simulation exercises. The basic capital resources available are represented by the proposed 400,000 to 550,000 tonnes of natural rubber stocks. The relation between this capital and time are provided by the above clauses (a) to (e) which specify the operational conditions and constraints for longer-term buffer stocks stabilisation. It is through these clauses that the price band becomes integrated with the time horizon envisaged for the programme.

It will be recalled that the demand for natural rubber is derived in nature, and closely associated with business fluctuations of the industrialised countries. UNCTAD estimates show that during 1960-1974, natural rubber prices displayed complete cycles having a maximum length of 42 months (peak-to-peak) with downswings extending at most to 27 months from peak to trough (UNCTAD, 1975:11). With reference to the lengths of these historical cycles, the operation of a buffer stock programme on the basis of a possible five-year downswing (which is the interpretation adopted here of the UNCTAD clauses) would constitute a cautious stabilisation policy that allows considerable flexibility at the margin. This will be elaborated in the following discussion.

To illustrate how the buffer stocks will be initiated and operated on an annual basis, suppose that price forecasts for 1980 to 1990 lie within the price band delimited by the indicative f.o.b. Singapore prices \$1500 and \$2700. If the forecast price per tonne never falls below the nominal price of \$2100,[4] then no buffer stock simulations will be required. However, if the forecast price falls below \$2100 in any year t, then the INRA will be implemented via commencement of buffer stock operations. Support buying of natural rubber for buffer stocks will begin (with a one-year lag) in period (t+1); such buying is known as prospective buying since, strictly speaking, no buffer stocks operation is required until the trigger prices are reached. However, because of the dynamics (lagged effects) in the system, such prospective buying may be more efficient in stalling price falls instead of allowing the downward pressure on price to gather momentum. Although the total buffer stocks cannot exceed the sum of (normal and contingency) buffer stocks of 550,000 tonnes, the stringent condition of not exceeding the "normal" stock of 400,000 tonnes will be assumed. To satisfy clause (d) of net buffer stock variations not exceeeding 100,000 tonnes within any eighteen months, an acceptable strategy of gradual buffer stock build-up would

4 Since nominal prices are not necessarily the prices at which natural rubber are actually traded, the precise calculation of gains and losses requires knowledge of price actually paid for natural rubber deliveries. Since such detailed information are difficult to obtain, the simulation results based on nominal prices must be considered only as an indication of magnitudes.

be to buy not more than 80,000 tonnes in any year. This means that even should support buying be required throughout the five-year duration of the INRA, the buffer stocks accumulated at the end of the fifth year will not exceed 400,000 tonnes. By not utilising the 550,000 stocks fully, a financial margin is provided for operational and administrative costs that will be required for implementing the scheme, thus conveying a degree of flexibility for the scheme.

After the first buffer stock buying of 80,000 tonnes, the support (intervention) price $\hat{p}_{t+1}$ will be generated by the model. Similarly the price p_{t+2} in the following year (t+2) will also be generated by the model. If p_{t+2} falls below $2100 again, then another 80,000 tonnes will be bought in period (t+2), the second year of the support buying. The support price $\hat{p}_{t+2}$ and projected price p_{t+3} will again be determined from the model. Support buying at 80,000 tonnes annually will continue as described so long as the projected price in the next period remains below $2100.

After four years of buffer stock buying, the stock will stand at 320,000 tonnes. If by this time the projected price for the following period is still below $2100 per tonne, then the reference price could, according to clause (e'), be revised by minus 3 percent unless the IRC decides otherwise. If the IRC decides not to alter the reference price level, the support price in the next period will then be determined by the reduced support buying of only 50,000 tonnes. This is because the buffer stock operations are expected to caution and slow down as the buffer stock level tends towards its specified maximum. By now the buffer stocks will amount to 370,000 tonnes. Further support buying in future periods will be in smaller volumes, and it is expected that at this juncture the IRC will have to consider whether (a) to revise the stabilisation price band and/or increase capital outlay or (b) cease support buying when the buffer stock reaches 500,000 tonnes (or 550,000 tonnes, depending on financial constraints at that time) and thus allow market price to fall freely.

The suitability/viability of the ceiling price level depends on the speed of oscillations in the model. However, if the model oscillates at high speed (so that breaking the $2700 ceiling may be due to the support buying in previous periods), then buffer stock sales at $2700 may be premature and could set off another round of price declines. Depending on the model's behaviour, a revision of the upper indicative price may also be required; that is, the floor and ceiling prices need not be equidistant from the reference price.

8.6 Some Aspects of the INRA Stabilisation Scheme Which Need to be Considered

This section will discuss some of the aspects of INRA which need to be examined, assuming it is a feasible stabilisation scheme, in the context of its aspirations to stabilise price and increase export earnings simultaneously. Basically, the INRA can be viewed as a partial stabilisation/adjustment policy since it aims at reducing, rather than eliminating altogether, natural rubber price variability by a price band policy. For a given buffer stock size, the success of partial stabilisation then depends on (a) the choice of the reference price level as well as (b) the effective interaction between buffer stocks and market price.

Although partial stabilisation entails knowledge of the long-run equilibrium price about which prices are to be stabilised, this price need not be known to the degree of precision required for successful complete stabilisation. In this respect partial stabilisation is easier to operate than complete stabilisation since a higher margin of error is tolerable for the reference price chosen to proxy the equilibrium price. But with one caveat: the larger the error, the larger the buffer stocks required and the more one-sided the interventions will be. This leads to the question of whether the price bands employed have to be equidistant from the reference price.

While INRA specifies equidistant price bands about the $2100 reference price, no explanation is given for the choice of price level nor the economic rationale for the equidistant principle. Equidistant bands for a self-liquidating price are valid however, only when either (1) prices are symmetrically distributed about a stationary trend or (2) prices are distributed about a non-stationary trend and skewed to the left(right) in the lower(upper) price range. If these stringent conditions concerning price trends and distributions are not met, then a self-liquidating buffer stock might not lead to equidistant price bands. Hence the choice of equidistant/non-equidistant price bands cannot be determined independently of the expected trend behaviour of prices. In analysing natural rubber price patterns, Allen (1969) concluded that the behaviour of monthly prices during 1958-1969 approximated a normal distribution. However, it should be remembered that the 1958-1969 period coincides with the period of constant and low oil prices and continued steady growth of the synthetic rubber industry from 1956. As Figure 6.3 in Chapter Six of this study showed, the period used by Allen (1969) in his analysis is part of phase II. The normal distribution obtained by Allen may be explained by the gradual falling price trend and narrowing price fluctuations. From the behaviour of natural rubber prices during 1972-1980 (phase III in Figure 6.3), it is clear that uncertainties about rising oil and hence synthetic rubber prices lead to a sharp rising trend and wider fluctuations for natural rubber prices. Under such conditions, use of equidistant price bands would presuppose that the prices are distributed with certain skewness. Similarly, whether equidistant price bands are appropriate for the future period when prices are likely to behave in a similar way to those in 1972-1980 depends on the expected trend and distribution of prices. Regrettably, no explanation is given by INRA on how the reference price and equidistant price bands are determined.

Effective interaction between buffer stocks and market price involves, in addition, assumptions about how private stockholdings will behave in the presence of a buffer stock, an issue that is receiving due attention. In a recent paper, Siamwalla (1981) has shown that private stockholdings are not neutral to public storage programmes, viz. a buffer stock scheme. In general, the effect of public storage supply on private stockholdings depends on (1) the existing levels of public and private stockholdings, (2) the level of financial resources for the supply of public storage and (3) the size of (1) and (2) relative to the market fluctuations arising from random disturbances. Consequently, the supply of storage may shift between the two sources, with the scope for public displacement of private storage being proportional generally to the financial resources available for public storage. In the simulation exercises conducted in this study, it will be assumed that private stockholdings will nevertheless persist.

These considerations of long-run equilibrium price and private stockholdings highlight the reliance of the management of buffer stock operations on the judgement of the buffer stocks manager. This leads to the problems of the dynamics inherent in the system, the ability of the manager to distinguish reliable from false price signals and discretionary use of prospective buffer stock operations, problems which will be discussed again in the next section. The problems associated with the feasibility of operating and managing a buffer stock to attain these ends therefore cannot be overemphasised.

As mentioned, the INRA is aimed not only at price stabilisation but also at the steady growth of export incomes of the producing countries. Two ways by which steady growth of export incomes may be attained are (1) through obtaining a higher average price under stabilisation and (2) increased consumption (via input substitution) and production of natural rubber due to reduced fluctuations and uncertainty about price. In the first case, the growth in export incomes can be viewed as a transfer of incomes from consuming to producing countries. This raises the question of consumers' agreement to and participation in such price stabilisation, bearing in mind the availability of synthetic rubbers. In the second case, even with consumers' participation, the question is whether the two objectives of price stabilisation and income growth are compatible.

Several question concerning the stabilisation scheme need to be considered. On the indirect effects of stabilisation, a difficulty is in deriving a measure for evaluating the welfare effects of stabilisation on the participating countries.

8.7 Price Stabilisation Under Low Oil Price Scenario, 1982-1986: Preliminary Comments

Figures 8.2(a)-(c) present forecast time paths of natural rubber prices in the various primary and terminal markets under the low oil price scenario for 1980-1995 and without intervention à la INRA. A comparison of forecast New York prices with the World Bank forecast (using assumptions for the synthetic rubber sector which approximate those under the low oil price scenario) in Figure 8.2(b) shows the Bank's forecast to be the more optimistic. The corresponding time paths of world production and consumption of rubbers are presented in Figure 8.2(d). The forecasts give production of natural rubber in 1985, 1990 and 1995 to be 4.5, 5.6 and 6.9 million tonnes respectively, with the corresponding natural rubber consumption of 4.4, 5.3 and 6.6 million tonnes. For synthetic rubbers, the production volumes are 10.2, 12.3 and 18.1 million tonnes while consumption is expected to be 9.9, 13.0 and 17.2 million tonnes. Thus an excess demand for synthetic rubber will occur in 1990; this is due to the fact that while the business cycle begins an upswing in the second half of the eighties, expansion in synthetic rubber capacity is expected to remain restrained until 1990 when alternative energy, and hence feedstock supply, becomes available. The higher price of

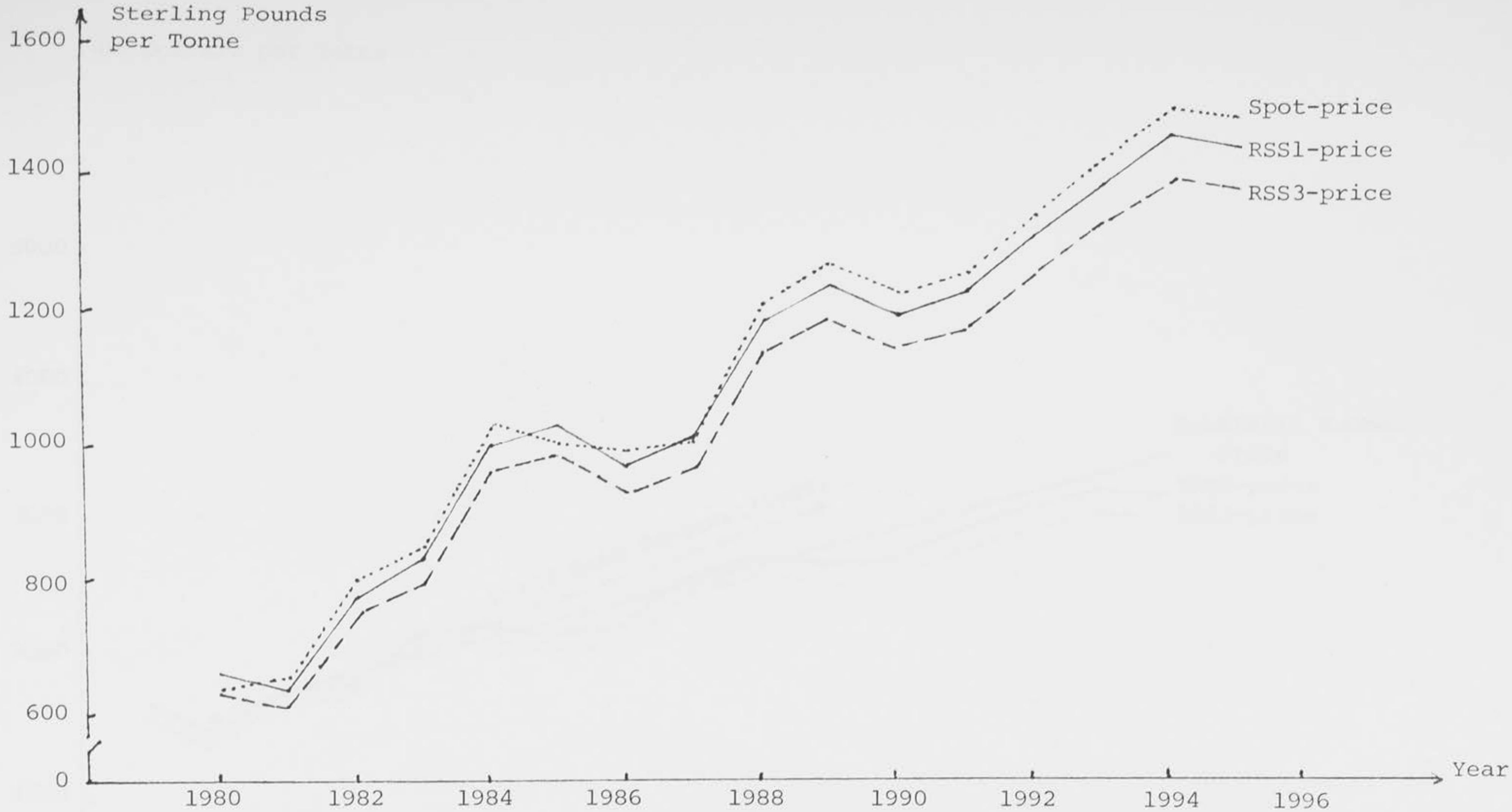


Figure 8.2(a): Forecasts of Natural Rubber Prices in London, 1981-1995 (Low Oil Price Scenario).

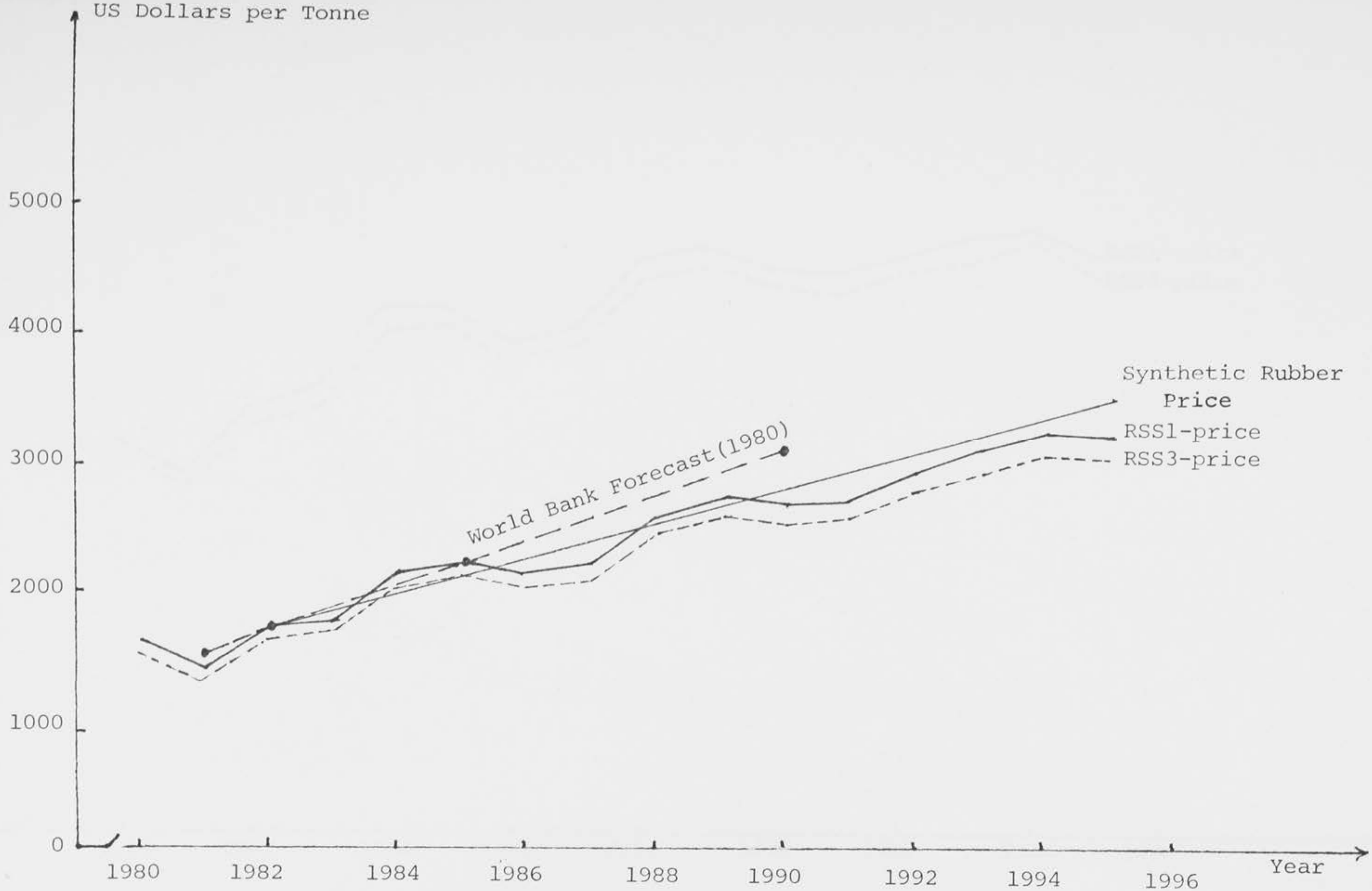


Figure 8.2(b): Forecasts of Average Synthetic Rubber Price and Natural Rubber Prices in New York, 1981-1995 (Low Oil Price Scenario)

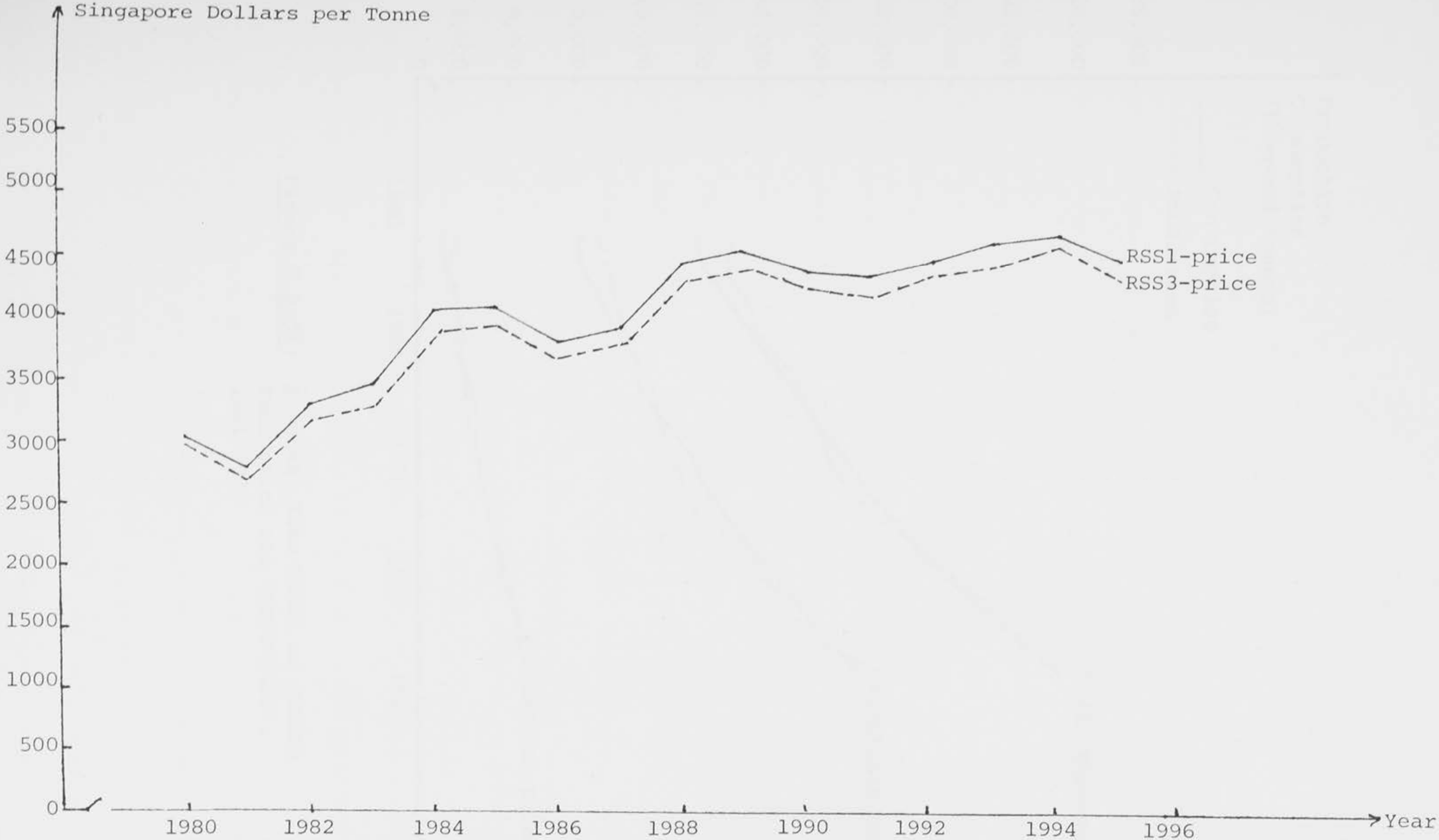


Figure 8.2(c); Forecasts of Natural Rubber Prices in Singapore, 1981-1995
(Low Oil Price Scenario)

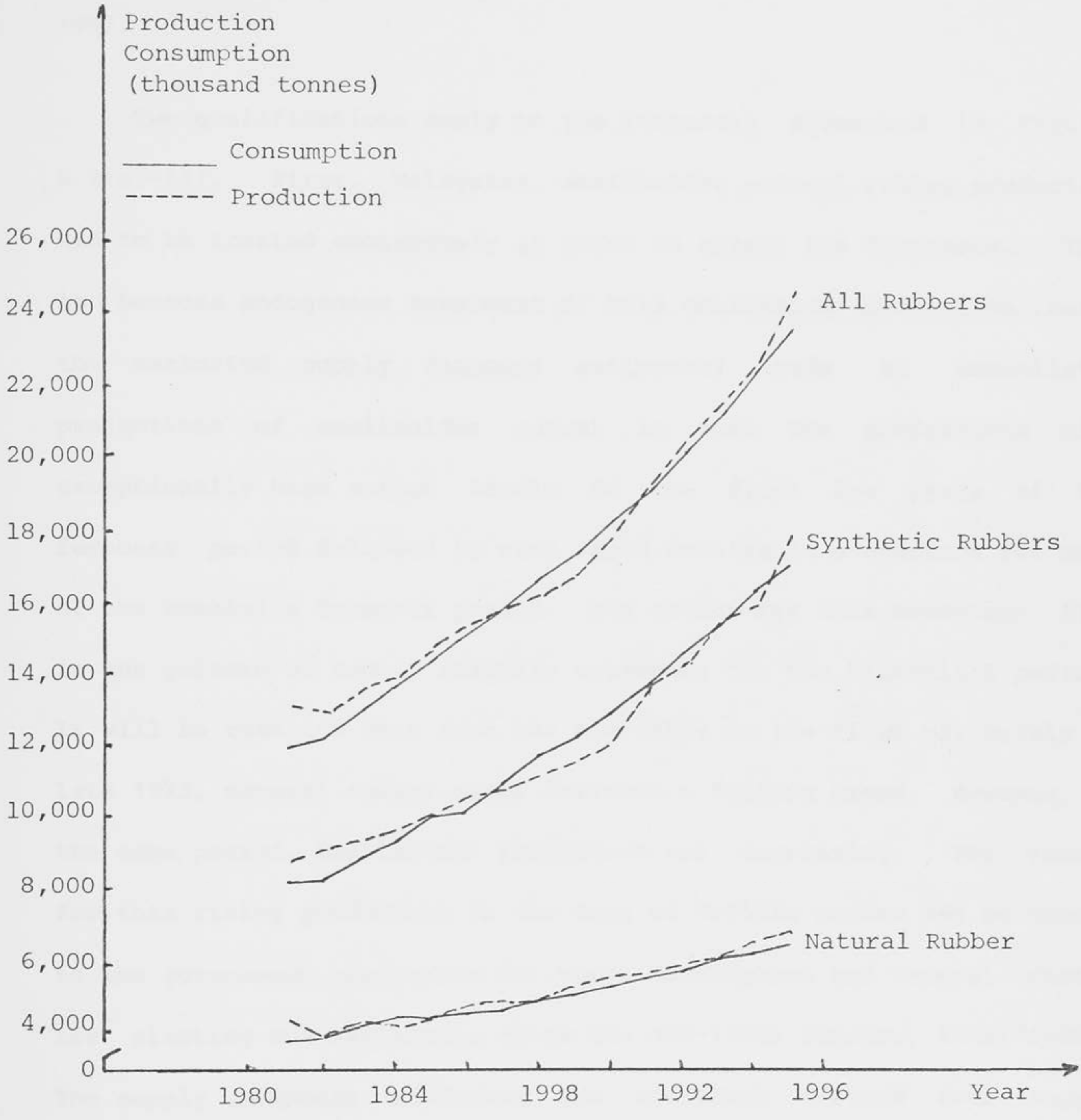


Figure 8.2(d): Forecast Time Paths of Rubber Production and Consumption, 1981-1995

synthetic rubbers relative to that for natural rubber from about 1989 then favours a shift towards natural rubber consumption so that a higher natural rubber consumption share of 38 percent is observed by 1995.

Two qualifications apply to the forecasts presented in Figures 8.2(a)-(d). First, Malaysian smallholder natural rubber production had to be treated exogenously in order to obtain the forecasts. This is because endogenous treatment of this smallholder production (using the estimated supply response estimates) leads to unrealistic projections of smallholder output in that the projections give exceptionally high output levels in the first few years of the forecast period followed by very rapid decline in production for most of the remaining forecast period. The reason for this behaviour lies in the pattern of supply response estimates for the historical period. It will be recalled that from the mid-1950s to the first oil crisis in late 1973, natural rubber price followed a falling trend. However, in the same period, smallholder production was increasing. The reason for this rising production in the face of falling prices can be traced to the government programmes for rural development and natural rubber new planting and replanting since the mid-1950s (Barlow, 1978:76-89). The supply response estimates are therefore derived from supply response that was significantly influenced by the government-funded programmes to rejuvenate the natural rubber industry in the postwar period, rather than solely by natural rubber prices. However, by the 1970s, the behaviour of natural rubber price was markedly different from that in the 1960s. The unrealistic projections for smallholder supply therefore arise from the application of historical supply response estimates to a period of very different behaviour in natural rubber price. This is reinforced by the long price lags used in the supply response equations, so that prices from 1967 are used in projecting supply from 1980 onwards. Second, because of the oil crisis and ensuing uncertainty about the price of feedstocks, expansion in new synthetic rubber production capacities is expected to be restrained until after 1990. If oil price should stabilise in the 1980s, and/or alternative sources of feedstock supply becomes available sooner, then more rapid investment in new synthetic rubber production capacities may be expected.

Several assumptions are involved in using the model to simulate buffer stock operations for price stabilisation. The key assumption is that the existing market structure (as represented by the model) will remain valid. In particular it is assumed that behaviour of private stockholdings of natural and synthetic rubbers will be unaffected by buffer stock operations. This assumption is favourable to the buffer stock operations since as already mentioned, private stockholdings will not be neutral in general to the implementation of public stockholding schemes. Another assumption concerns the natural rubber price formation process. During the historical period, the London spot market was found to play an important role; on this basis the equation for natural rubber price determination in the model refers to the London spot price formation. This situation may change in future since as Chapter Six showed, the rise in oil and hence synthetic rubber prices, has led to greater reliance on natural rubber supply through longer-term contracts. The potential shift of focus to other markets is also suggested by the fact that Singapore, an active centre for natural rubber trading, is not party to the INRA. Consequently, the reactions and speculative activities of Singapore traders to buffer stock operations remain to be seen. Finally, it is assumed that the buffer stock manager operates with sufficient financial reserves.

Throughout the following, all simulations for the future period are non-stochastic in nature. Although stochastic simulations are preferable for realism, such simulations entail more time resources because of the larger number of experiments involved. Another reason for the use of non-stochastic simulations is the annual nature of the model used here. Since an annual model is essentially a long-term model, it is considered more useful to employ non-stochastic simulations and concentrate on the dynamic effects (of market intervention) arising from the long lagged structure of the model. However, the INRA intervention is based on daily market prices and all the constraint clauses are tied to these prices. Since these daily price variations are assumed away in non-stochastic simulations, it is obvious that the problems of price stabilisation are understated. In this sense the non-stochastic approach may be seen to provide a most favourable test of the INRA proposals.

On the basis of the forecast time paths of prices, stabilisation of price within the price range specified by the INRA is not operative. This is because the f.o.b. Singapore price for RSS1-grade natural rubber for the 1981-1985 period is forecast to range from \$2810 to \$4100 per tonne. (Singapore dollar prices are used here for ease of comparison with the price ranges used by the INRA.) Thus in the following simulations of buffer stock operations, the stabilising price band will be determined from the forecast prices for 1981-1985. Instead of the INRA-specified reference price of \$2100, the reference price will be \$3455 (the average of the difference between the highest and lowest forecast prices) and the floor (upper indicative) and ceiling (lower indicative) prices will be \$2930 and \$3973 respectively.[5] The trigger prices will then be set at plus and minus 10 percent of the reference price; that is, \$3109 and \$3800 per tonne.

In order to understand the dynamics of the model, the simulated time paths of RSS1-grade natural rubber price under two types of buffer stock operations will be compared. In the first simulation, the INRA rules for buffer stock operations with respect to price levels for optional/compulsory intervention will be stringently applied. This means that prospective buying/selling are prohibited so that buffer stocks are strictly operational only after prices have fallen outside the \$3109-\$3800 trigger price band. In the second simulation prospective buying/selling will be allowed in order to determine the sequence of buffer stock operations necessary for price stabilisation.

Technically, the buffer stock operations are implemented by introducing a variable ΔBS for net change in buffer stocks into the balance equation for the natural rubber submodel. Thus equation (5.10) in Chapter Five for natural rubber stocks in consuming regions (SNC) now becomes:

5 This price band is plus and minus 15 percent (or plus and minus \$510) of the reference price. With respect to the INRA-specified \$600 difference between floor/ceiling and reference prices detailed in 8.2.1 above, this price band is therefore slightly narrower.

$$(8.1) \quad SNC = SNC_{-1} - \Delta(SNP+SNA) + \Delta SNG + QN - CN + \Delta BS$$

where all variables are as previously defined. In simulating the model with equation (8.1), a coefficient of 1.0 will be used for the ΔBS-variable; coefficients for all other variables will be as reported in Table 5.1 of Chapter Five. The constraint of net change in buffer stocks not exceeding 80,000 tonnes annually will be observed throughout.

8.8 Price Stabilisation Under Low Oil Price Scenario, 1982-1986: Results

Figure 8.3 presents the price forecasts under buffer stocks intervention without prospective buying/selling. Thus the first buffer stock purchase (positive net change) of 80,000 tonnes will occur in 1982 after the free market price ($2810) in 1981 had fallen below $2930.00, the lower indicative price. This buffer stock purchase raises the 1982 price from below to above the reference price. Since prices in 1982 and 1983 lie within the trigger price band, no intervention is permitted in these years. In 1984 the free market price exceeds the upper trigger price of $3930 thus necessitating buffer stock sales (negative net change) in 1985. Despite the disposal of all 80,000 tonnes stocks accumulated previously, the impact of this buffer stock is marginal with price in 1985 and 1986 remaining outside the stabilisation price range. The behaviour of price under market intervention revealed by this

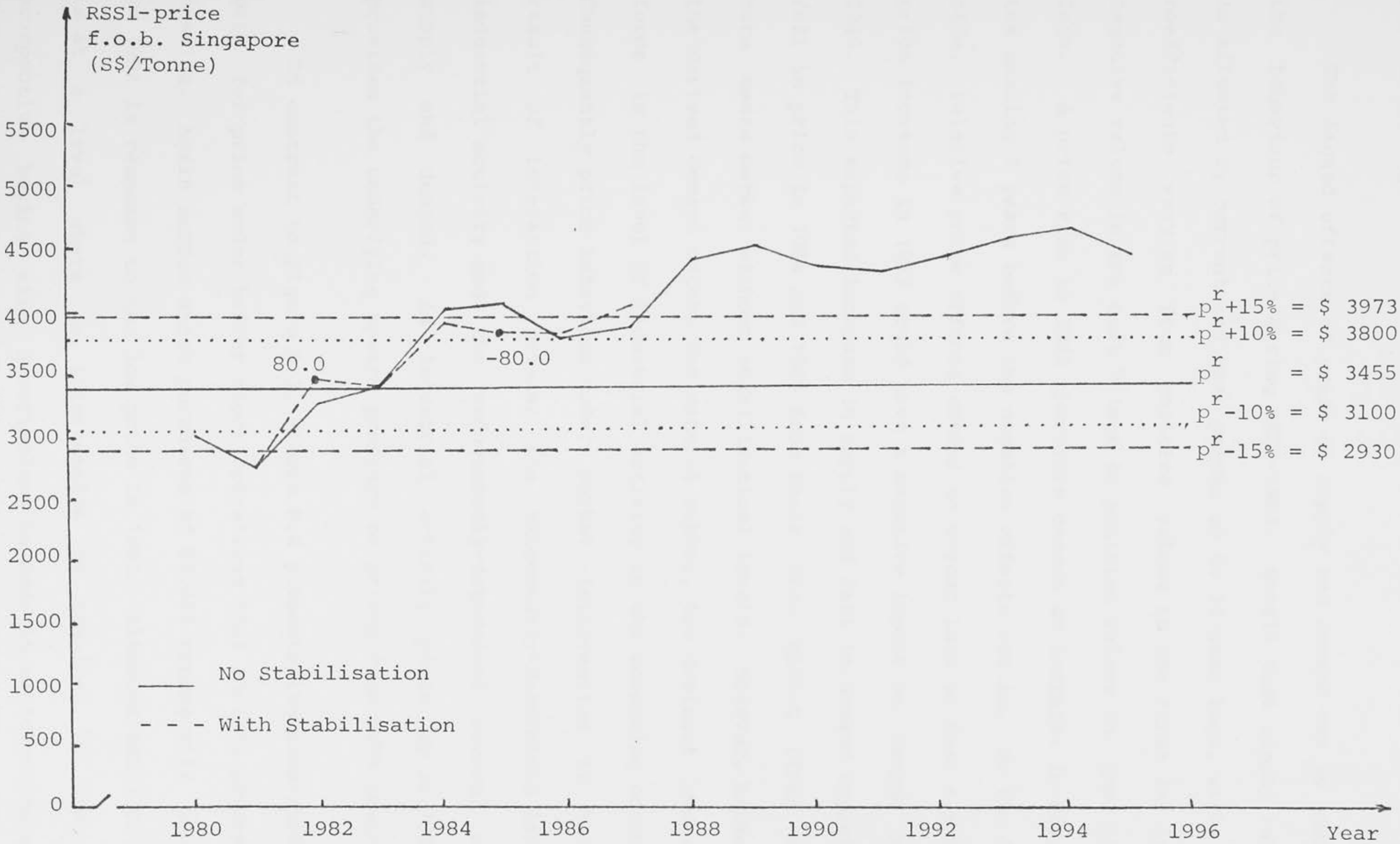


Figure 8.3: Time Paths of Natural Rubber Price in Singapore With and Without Market Intervention (No Prospective Buffer Stock Operations Allowed).

simulation emphasises the need to consider prospective buffer stock buying/selling.

The lagged effects of price on supply and demand can be seen from the behaviour of price during 1982-1984. Recall that supply response is affected by current and past prices up to 14-year lags, with price coefficients varying from positive values in the first 2-3 lags to negative values in the next 7 lags to positive values in the last 4 lags. A price rise in 1982 therefore causes an increase in supply in the ensuing 2 years before the negative effects set in. On the demand side, relative price effects extend to 4-year lags so that a relative price increase in 1982 could have a negative impact on demand up to 1986. This expected increase in supply and fall in demand explain the fall in price in 1984 and 1985 from their free market (free market here means market without stabilisation) levels. However, because of the derived demand nature for natural rubber, the dominant underlying force is the level of industrial activity in the consuming countries. Consequently price behaviour under market intervention is the net result of interaction between the exogenously-determined level of industrial activity and the endogenously-determined natural rubber supply and demand. As industrial activity picks up in 1983, it provides the underlying upward pressure on prices from 1983 onwards.

In contrast to Figure 8.3, Figure 8.4 presents the simulated time path for price under buffer stock operations that include prospective trading. Again buffer stock purchases of 80,000 tonnes will commence in 1982 in response to the low price in 1981. Although the 1983 price is at a level where no intervention is required by the INRA, prospective buying will nevertheless be made in anticipation of the

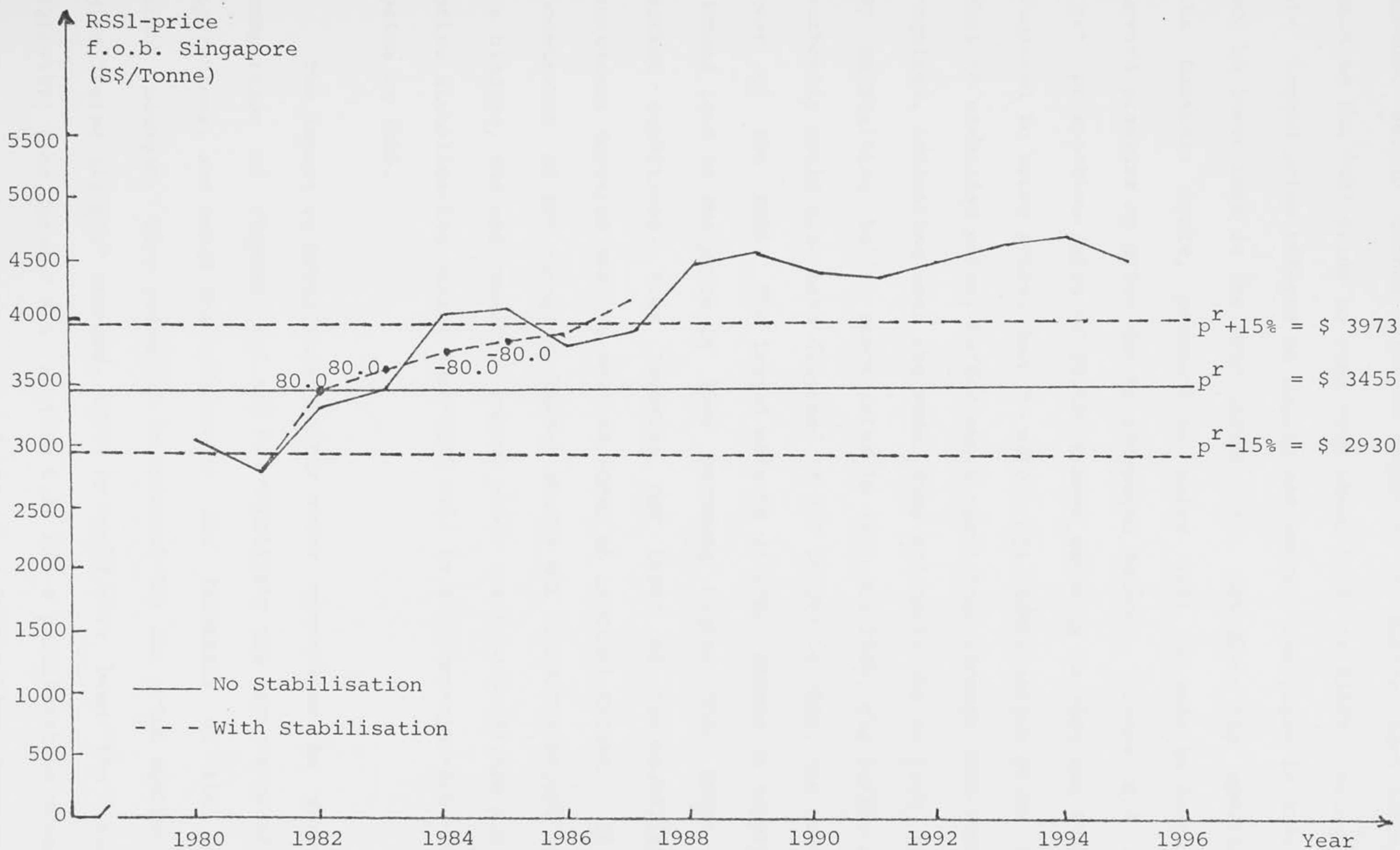


Figure 8.4: Time Paths of Natural Rubber Price in Singapore With and Without Market Intervention (Prospective Buffer Stock Operations Allowed).

subsequent increased industrial activity and hence demand. Thus another 80,000 tonnes will be bought by the buffer stock authority, causing the 1983 price to rise from about $3500 to $3600. Because of the lagged price effects on supply and demand, the price in 1984 will now be lower than in the free market case. But given the upswing in the business cycle, prospective sales will be made to dampen the upward pressure on price due to increased demand. Figure 8.4 shows that prospective sales of 80,000 tonnes annually in 1984 and 1985 are required to bring prices down to within the stabilisation price band. Thus to stabilise price, buffer stock operations through 1982-1985 are required, indicating that the model does not oscillate at high speed. By maintaining buffer stock sales in 1984 and 1985, the buffer stock authority would also have disposed of all stocks by 1986, the terminal year of the INRA. The lagged effects of lower prices on supply and demand lead to the price in 1986 becoming higher than under free market conditions, thus invoking the issue of the stabilisation agreement duration and the desired level of terminal stocks. If the constraint of net change in buffer stocks not exceeding 80,000 tonnes is binding, the end result of buffer stock operations (Figure 8.4) for price stabilisation during 1982-1986 will be a higher-than-free-market price in 1986.

The impact of prospective buffer stock operations as shown by comparison of Figures 8.3 and 8.4 highlights the importance of such operations, and hence the reliance on the judgement of the buffer stock manager. This judgement is critical for the price system could give "false signals" (Lerdau, 1959) as would have been the case in 1974-1976 (see Chapter Six, section 6.5) had a stabilisation programme been implemented then. Because of the close interaction between the natural and synthetic rubber markets, reliable judgement would entail tracking the production and stockholding behaviour in the synthetic rubber industry.[6]

Given the structure of the model used here, it should be indicated that an implicit assumption in the buffer stock operations is that stock adjustment occurs only in the consuming regions; this is because the buffer stock variable is introduced via the equation for stocks in consuming regions. Since it is stocks in consuming regions that enter the price formation equation, price stabilisation implies shifting some of the stock adjustment to the producing countries; this is verified by the 10 percent increase in stocks held in the producing regions and afloat under the stabilisation case. This qualification is important to the above findings since as discussed in Chapter Six, the increase in oil price has led to greater dependence on long-term contracts, thus reducing the role of the London spot market. It is possible that the role of the London spot market may be reduced further when buffer stock operations are introduced, in which case the price formation aspect of the present model will need modification.

[6] Although this requirement of monitoring the development in the synthetic rubber industry is not explicitly stated in the INRA, it may be interpreted as being implicit in Article 38 of the draft INRA which mentions the need for "reliable data on production, consumption, stocks, trade and prices of natural rubber and other factors that influence demand and supply of natural rubber." (UNCTAD, 1979:44).

8.9 Distribution of Gains from Price Stabilisation

Assuming that the 5-year INRA is implemented from 1982 (subsequent to the low price in 1981) and terminated in 1986, the effects of INRA-price stabilisation on producers and consumers can now be discussed. Figures 8.5(a) and (b) present time paths of world natural rubber output and consumption volumes and their corresponding values (in current US dollars) under a free market and under market intervention.[7] The global effects of price stabilisation during 1982-1986 are summarised in Table 8.1. A comparison of world supply and demand under the free market and under price stabilisation shows the main effect of stabilisation to be a fall in the levels of supply and demand; however, Table 8.1 shows the impact of price stabilisation on average supply and demand volumes during 1982-1986 to be small. Average production during the period falls by a marginal 0.42 percent while average consumption falls by an even smaller value of 0.22 percent. The variations in supply and demand as measured by their coefficients of variation are found to be unaffected. However, the stabilising effects become significant when the dollar values of natural rubber production and consumption are considered. For natural rubber export earnings, the trade-off for reduced fluctuations (from a coefficient of variation of 0.16 to 0.10) is a fall in average earnings of US$105 million. Price stabilisation therefore benefit consumers since a negligible (0.22 percent) reduction in consumption volume will bring about an average savings in consumption expenditure of US$81.0 million.

7 In this discussion of stabilisation effects, the US dollar will be used as the unit of measurement.

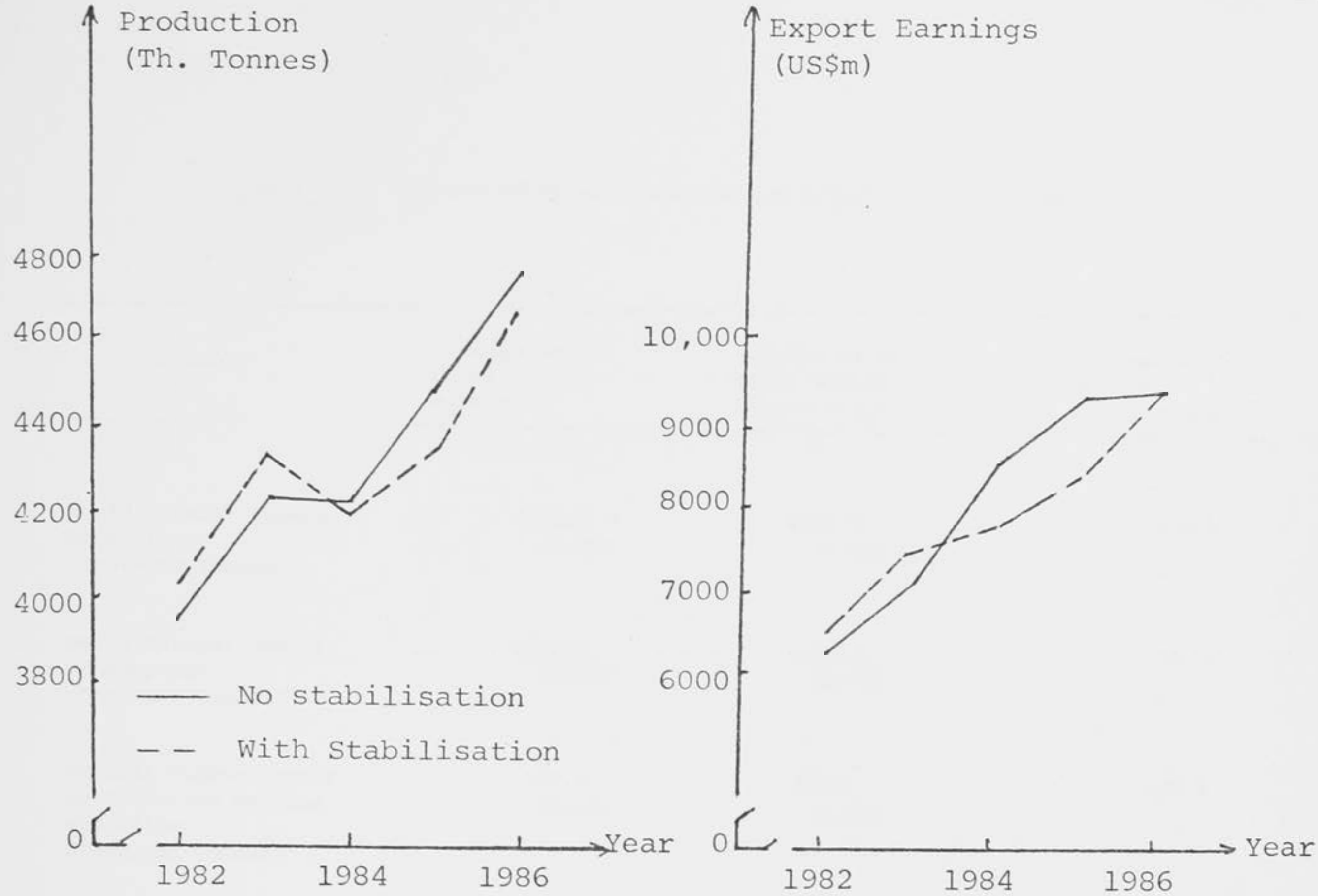


Figure 8.5(a): Time Paths of World Natural Rubber Supply

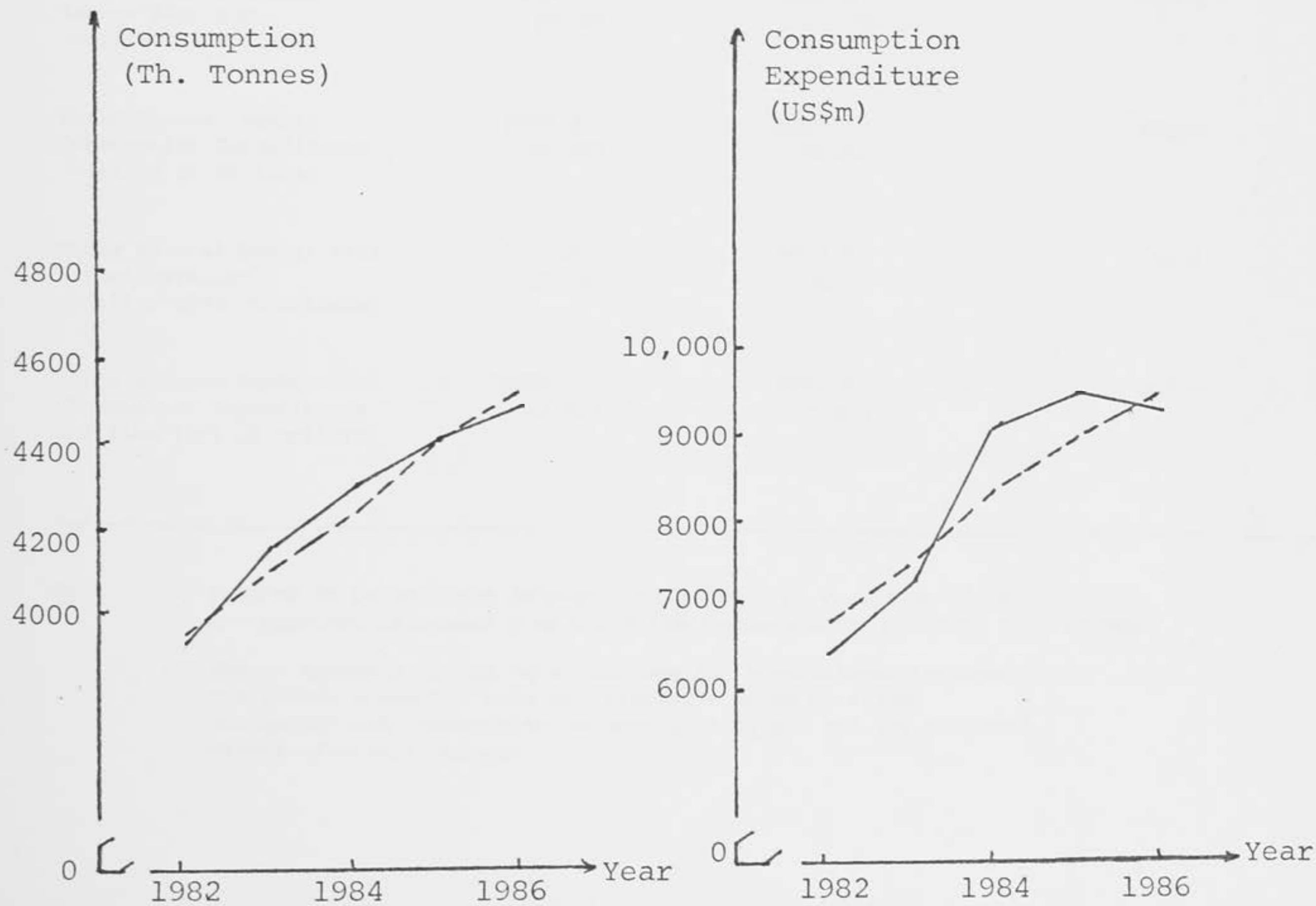


Figure 8.5(b): Time Paths of World Natural Rubber Demand.

Table 8.1: Summary of Price Stabilisation Effects, 1982 - 1986

Variable	Average Value Under Free Market	Average Value Under Market Intervention	Change due to Market Intervention
World Natural Rubber Production (Thousand Tonnes)	4331.0 (0.06)	4313.0 (0.05)	-18.0
World Natural Rubber Consumption (Thousand Tonnes)	4270.0 (0.05)	4260.0 (0.05)	-10.0
Natural Rubber Stocks in Producing Regions and Afloat (Thousand Tonnes)	749.4 (0.02)	824.7 (0.19)	+75.3
Natural Rubber Stocks in Consuming Regions (Thousand Tonnes)	1047.5 (0.07)	1046.0 (0.07)	-1.5
World Natural Rubber Export Earnings (Million US Dollars)	8134.2 (0.16)	8028.6 (0.12)	-105.6
World Natural Rubber Consumption Expenditures (Million US Dollars)	8354.3 (0.15)	8273.3 (0.12)	-81.0
World Natural Rubber Real Export Earnings (Million 1981 US Dollars)	6536.9 (0.07)	6477.9 (0.02)	-59.0
World Natural Rubber Real Consumption Expenditures (Million 1981 US Dollars)	6839.1 (0.07)	6671.8 (0.02)	-167.3

Note : (1) Figures in parentheses denotes coefficients of variation of the distribution of values from which the corresponding averages are derived.

(2) Export earnings do not equal consumption expenditures because the values presented here are estimates based on actual production and consumption volumes (not equal) and the relevant market (fob/cif) prices.

The effects of price stabilisation on individual countries will now be discussed, beginning with those on producing countries. Table 8.2 summarises the effects of price stabilisation on the major natural rubber producing countries of Africa, Brazil, Indonesia, Malaysia, Sri Lanka and Thailand. The analysis concentrates on total production and export earnings (in current and constant dollars) effects; the corresponding coefficients of variation for the distribution of production and export earnings are also presented. Time paths of production and export earnings in markets with and without intervention are given in Figures A8.1-A8.6 in Appendix 8A.

The effects of stabilisation on production volumes in the main producing countries are small, both in output level and degree of instability. More importantly, Table 8.2 shows that stabilisation does not affect the producing countries systematically; for example, the average Indonesian output falls by 11,000 tonnes while the fall in average output for Sri Lanka is less than 1000 tonnes. Of the smaller producers, the output of Africa is shown to fall while that for Brazil rises.

The effects of stabilisation on export earnings are more significant, with reduced export instability being accompanied by reduced average export earnings which can amount to 5 percent as in the case of Africa. The uneven effects of stabilisation also apply to average export earnings; for example, the average export earnings for Malaysian estates falls by US$6.82 million while that for Indonesia falls by S$42.06 million. Of the countries examined, only Brazil will benefit from price stabilisation in terms of an increase in output and average export earnings. But this increase in earnings is accompanied

Table 8.2: Summary of Price Stabilisation Effects on Major Producers, 1982 - 1986

	Average Natural Rubber Output (Thousand Tonnes)			Average Natural Rubber Export Earnings (US $ million)		
Country	(a)	(b)	Change due to Intervention	(a)	(b)	Change due to Intervention
Africa	74.14 (0.29)	71.07 (0.25)	-3.07	139.43 (0.33)	132.28 (0.27)	-7.15
Brazil	35.73 (0.05)	36.52 (0.06)	+0.79	66.81 (0.12)	68.06 (0.13)	+1.25
Indonesia	1108.78 (0.07)	1049.66 (0.05)	-11.12	2084.50 (0.17)	2042.44 (0.12)	-42.06
Malaysia Estates	649.50 (0.10)	649.26 (0.07)	-0.24	1248.44 (0.16)	1241.62 (0.14)	-6.82
Smallholders	897.20 (0.01)	897.20 (0.01)	0.00	1718.92 (0.14)	1666.46 (0.08)	-52.46
Sri lanka	172.16 (0.15)	171.28 (0.12)	-0.88	325.84 (0.36)	320.12 (0.18)	-5.72
Thailand	435.00 (0.00)	431.02 (0.09)	-3.98	808.92 (0.08)	790.86 (0.03)	-18.06

Notes: (1) The constancy in Malaysian smallholder production is due to treating this variable exogenously.

(2) Figures in parentheses denote coefficients of variation of the distributions of the values from which the corresponding averages are derived.

(3) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

by increased instability.

In summary, the effects of price stabilisation differ among producing countries, both in extent and direction. The effects of price stabilisation on export earnings, volumes and instability tends to be offsetting, so that whether the overall effect of stabilisation is a gain or loss is a moot point. Moreover, the change in instability and total (and hence average) earnings move in different directions for different countries and have important implications for members of the INRA.

Table 8.3 summarises the effects of price stabilisation on total natural rubber consumption volumes and expenditures of the major consuming countries of France, West Germany, Italy, Japan, UK and USA. As for production, the analysis concentrates on comparing total consumption volumes and values in markets with and without intervention and their differing degrees of instability. The distribution of consumption volumes and values over time under the different market situations are presented in Figures A8.7 - A8.12.

For the main consuming countries, gains from price stabilisation in terms of lower natural rubber expenditures are partially due to slight reductions in their levels of consumption. Except for Japan, the levels of savings are correlated with the volume of consumption; thus bigger savings are achieved by the major consuming countries of Italy, West Germany and USA. As for producing countries, whether the overall effect of stabilisation on consumers is a gain or loss is again a moot point.

Table 8.3: Summary of Price Stabilisation Effects on Major Consumers, 1982-1986

Country	Average Natural Rubber Consumption Volume (Thousand Tonnes)			Average Natural Rubber Consumption Expenditure (US $million)		
	(a)	(b)	Changes due to Intervention	(a)	(b)	Changes due to Intervention
France	192.42 (0.03)	192.24 (0.03)	-0.18	375.74 (0.13)	372.74 (0.10)	-3.00
West Germany	228.14 (0.05)	225.44 (0.04)	-2.70	445.88 (0.14)	437.12 (0.10)	-8.76
Italy	166.00 (0.05)	165.66 (0.06)	-0.34	325.08 (0.15)	321.84 (0.13)	-3.24
Japan	469.74 (0.02)	468.48 (0.02)	-1.26	875.60 (0.13)	870.60 (0.09)	-5.00
United Kingdom	126.82 (0.02)	126.76 (0.01)	-0.06	246.60 (0.09)	245.08 (0.06)	-1.52
United States	836.04 (0.02)	835.04 (0.02)	-1.00	1622.80 (0.12)	1600.36 (0.08)	-22.40

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

Finally operation of a buffer stock scheme also incurs operational (carrying and rotation) and administrative costs. These costs must be considered in an overall evaluation of the net result of buffer stock price stabilisation. Based on UNCTAD estimates of handling and storage costs of natural rubber (Reynolds, 1978:81) and more recent (1981) estimates obtained from traders in the Singapore market, the estimates of operational costs relevant to the 1982-1986 period are presented in Table 8.4. Assuming that the buffer stock will consist of equal shares of RSS1- and RSS3-grades natural rubber bought on the primary markets on the basis of f.o.b. Singapore prices, the value of the buffer stock purchases and sales in each period can be calculated from the support (intervention) prices determined by the model. Since according to traders in Malaysia, it is viable to keep stocks in the primary markets for periods up to a year without rotation (Brown, 1974: footnote 11), it will be assumed that stocks are rotated annually. The total net buffer stock outlay in each period is then the sum of the value of the buffer stocks and the operational costs. The total buffer stock outlay required in each period is presented in the first column of Table 8.5; assuming an interest rate of 10 percent per annum for financing this outlay, the total buffer stock debt up to each current period is given by Table 8.5; thus the total debt incurred by operating a buffer stock over the 1982-1986 period is US$152.1 million (current dollars). In constant 1981 US dollars, this is equivalent to US$181 million.

Table 8.4: Estimates of Buffer Stock Operational Costs by Item, 1981-1986

Year	Carrying Costs (US$/tonne)	Rotation Costs (US$/tonne)	Administrative and Overhead Costs (US$ million/year)
1981	228.60	7.14	0.5714
1982	252.90	7.90	0.6341
1983	280.00	8.80	0.7000
1984	310.00	9.70	0.7692
1985	344.00	10.70	0.8421
1986	377.00	11.80	0.9625

Notes: (1) Carrying Costs consist of warehousing and insurance costs of storing the buffer stocks in licensed warehouses.

(2) Rotation Costs consist of brokerage, transportation, handling and internal haulage costs.

(3) Administrative and Overhead Costs consist of salaries of personnel serving the Buffer stock organisation, home leave provisions, insurance, auditor's remuneration, expenses of International Rubber Council, recruitment expenses, rental, utilities, fixtures and fittings, postage and telecommunications, etc.

Table 8.5: Buffer Stock Outlay and Cumulative Buffer Stock Debt in each period, 1982-1986

Year	Buffer Stock Outlay		Cumulative Buffer Stock Debt	
	Current US$m	Constant US$m	Current US$m	Constant US$m
1982	155.1666	146.9380	155.1656	146.9380
1983	188.2572	165.4281	358.9404	315.4133
1984	-126.5230	-102.7806	268.3102	217.9611
1985	-157.7747	-118.6275	137.3665	103.2830
1986	0.9625	0.6702	152.0656	105.8952

Notes: (1) Buffer Stock Outlay refers to the sum of bufferstock purchases/sales and the operational and administrative costs of bufferstock operations in each period. Positive(negative) values denote expenditure(revenue) due to net change in buffer stock volumes.

(2) Cumulative Buffer Stock Debt in each period is the sum of debt and 10 percent interest costs incurred by the buffer stocks authority up to that period.

8.10 Conclusion

The results of price stabilisation for 1982-1986 may now be summarised. A comparison of the supply and demand coefficients of variation for the main producing and consuming countries show that instability is higher for natural rubber supply than for demand, despite the fact that natural rubber is a perennial crop. Thus buffer stock operations to stabilise price are essentially focussed on smoothing out the cycles in rubber demand and fluctuations in supply. However, as the stabilisation results indicate, other effects of pure price stabilisation have to be considered. This chapter has shown that a number of problems exist with the INRA price stabilisation scheme, in particular those of feasibility and management.

As the analysis of stabilisation effects have shown, the two aims of the INRA of price stabilisation with steady growth of export earnings need not be compatible. The results of simulating buffer stock stabilisation for 1982-1986 about equidistant price bands indicate a fall in export earnings both at the world and individual country levels. In particular, the changes in totals and instability of a variable for a country are offsetting, while changes in totals and instability vary in sign and magnitude among variables. These offsetting effects therefore makes it difficult to assess the benefits of stabilisation. Furthermore, for a given variable, the effects vary across countries. Both these aspects show that stabilisation has complex effects which are very different from the naive view that price stabilisation solves the problem of instability due to demand and supply shifts.

APPENDIX 8.A

GRAPHIC PRESENTATION OF PRICE STABILISATION EFFECTS, 1982-1986

The appendix presents Figures A8.1 - A8.12 giving time paths of production, export earnings, consumption volumes and values for individual countries in markets with and without intervention during the period 1982-1986.

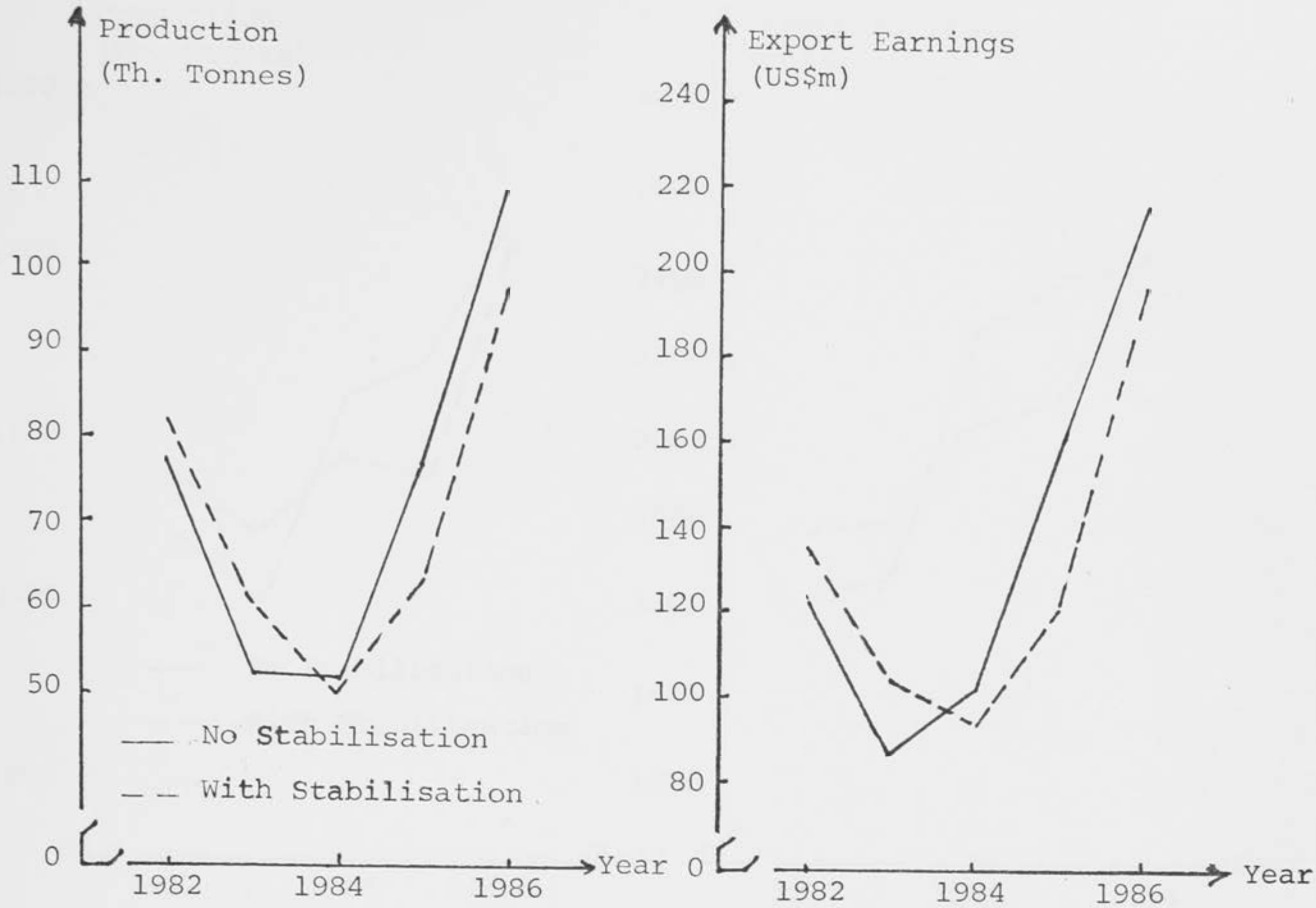


Figure A8.1: Time Paths of Natural Rubber Supply and Export Earnings, Africa.

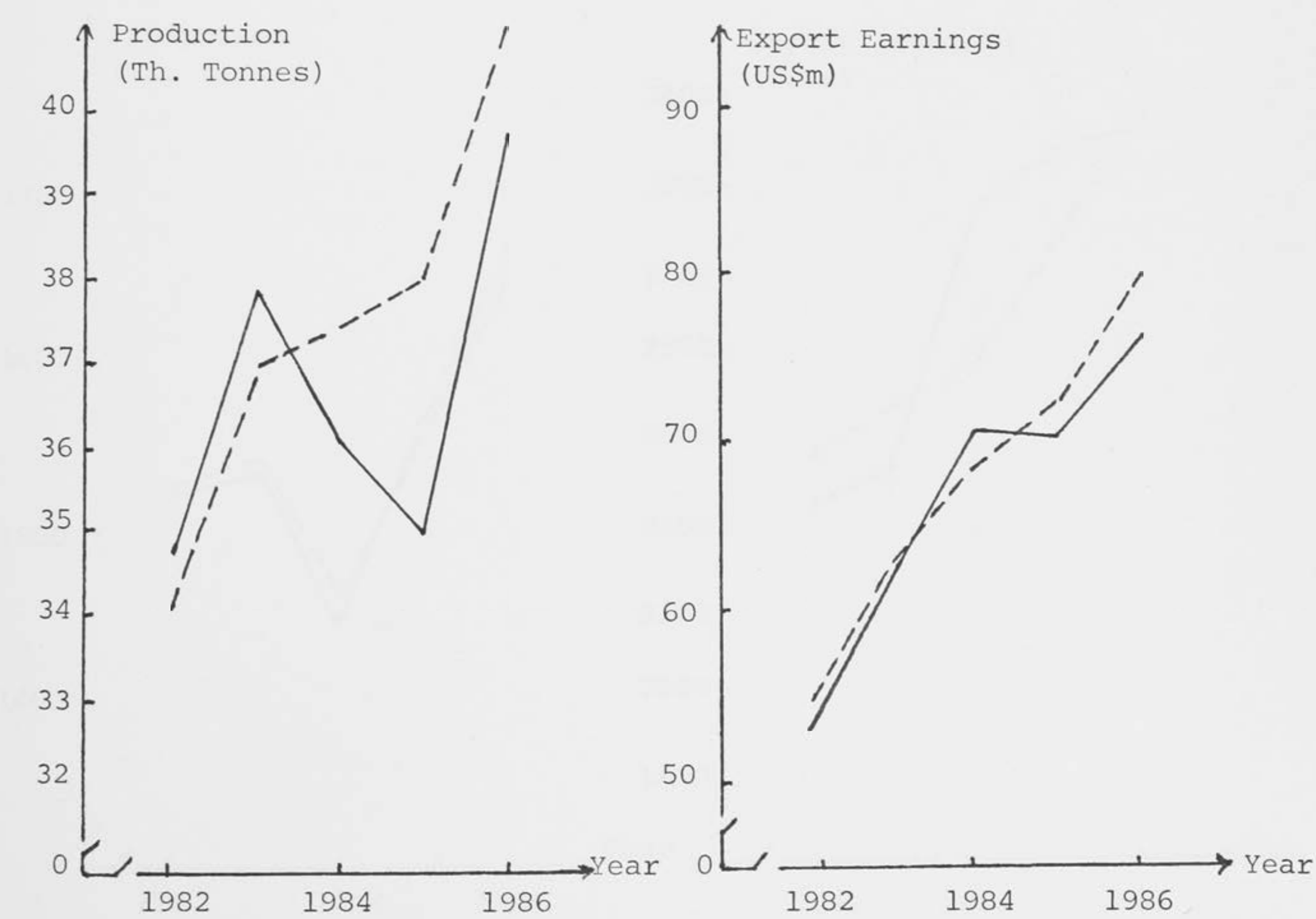


Figure A8.2: Time Paths of Natural Rubber Supply and Export Earnings, Brazil.

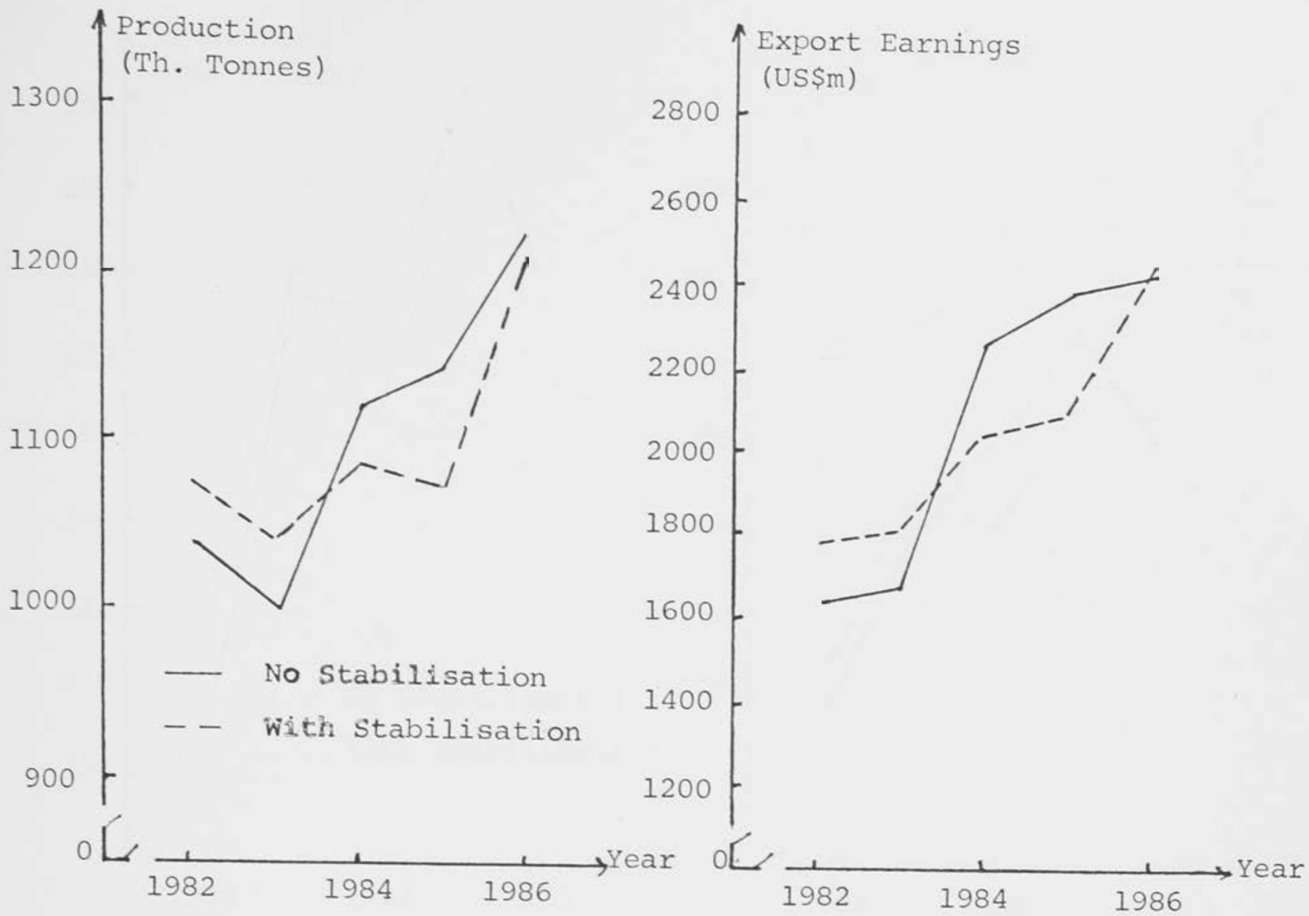


Figure A8.3: Time Paths of Natural Rubber Supply and Export Earnings, Indonesia.

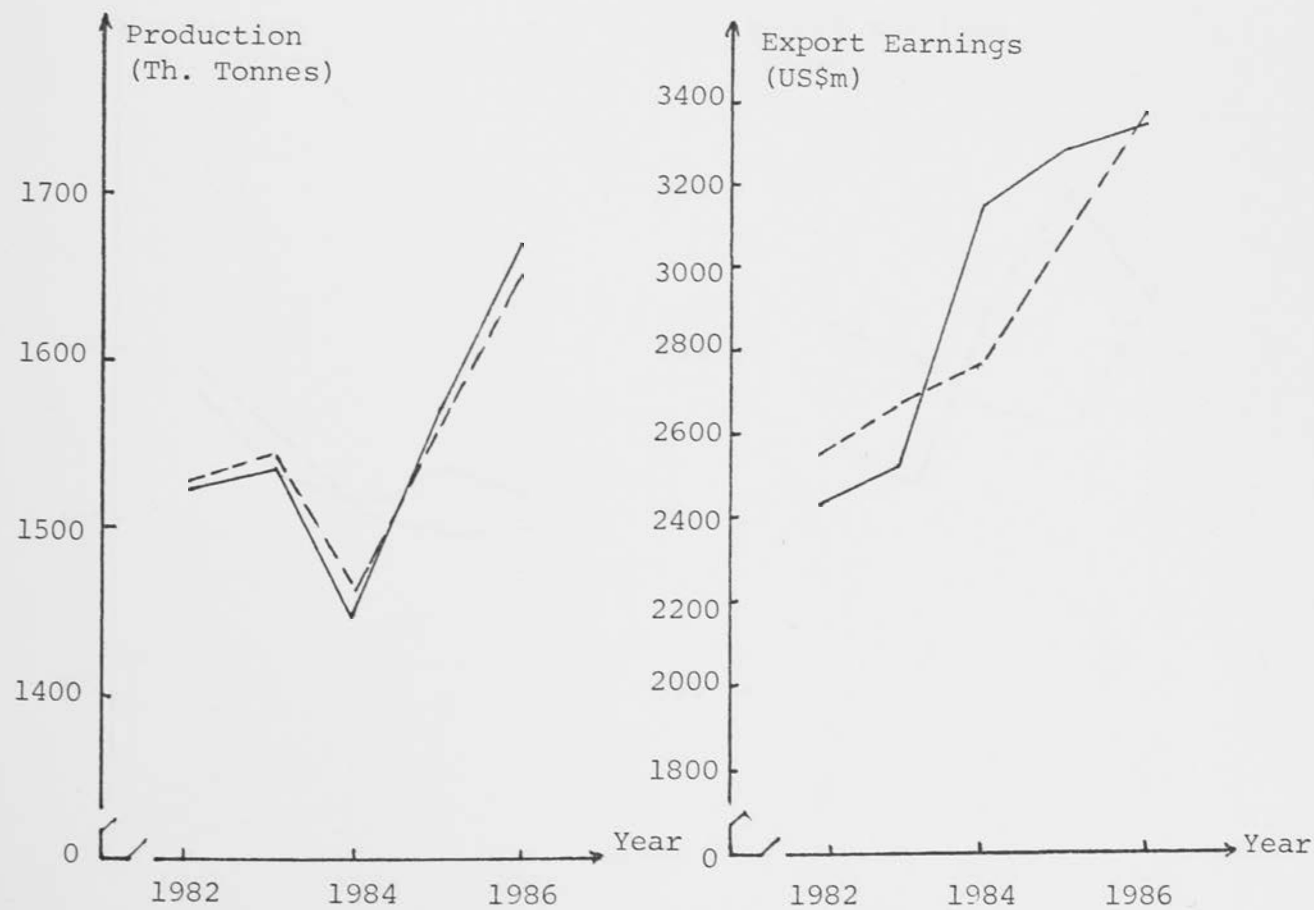


Figure A8.4: Time Paths of Natural Rubber Supply and Export Earnings, Malaysia.

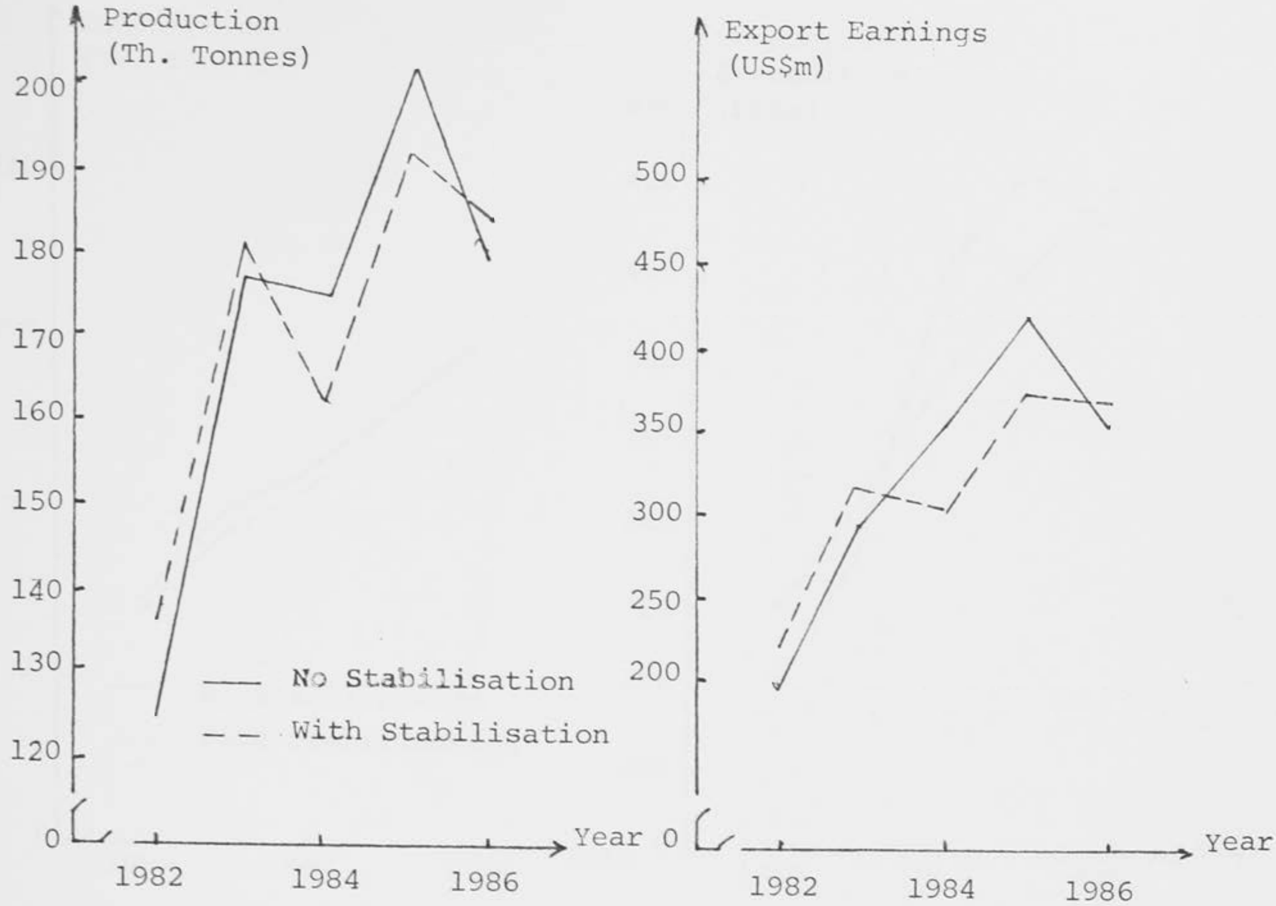


Figure A8.5: Time Paths of Natural Rubber Supply and Export Earnings, Sri Lanka.

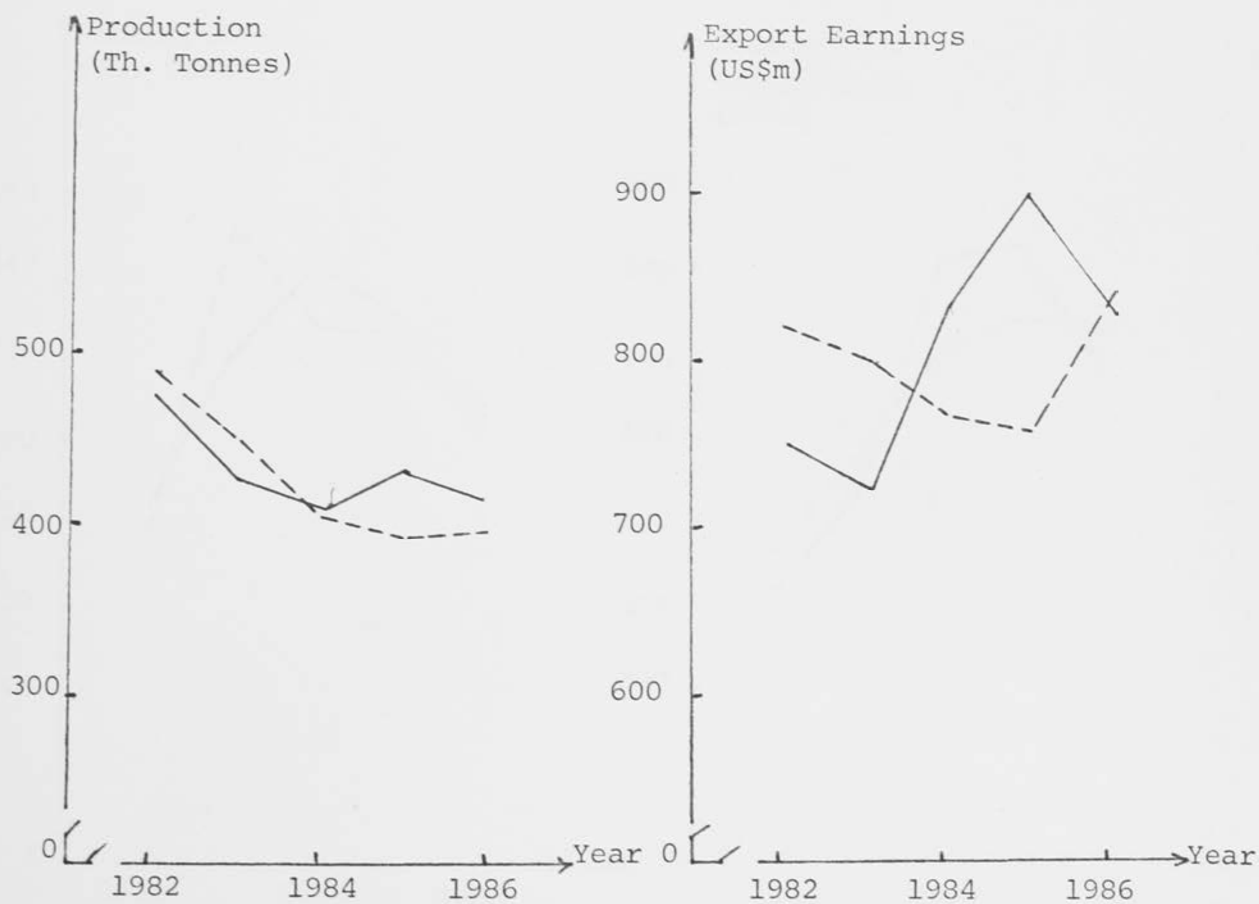


Figure A8.6: Time Paths of Natural Rubber Supply and Export Earnings, Thailand.

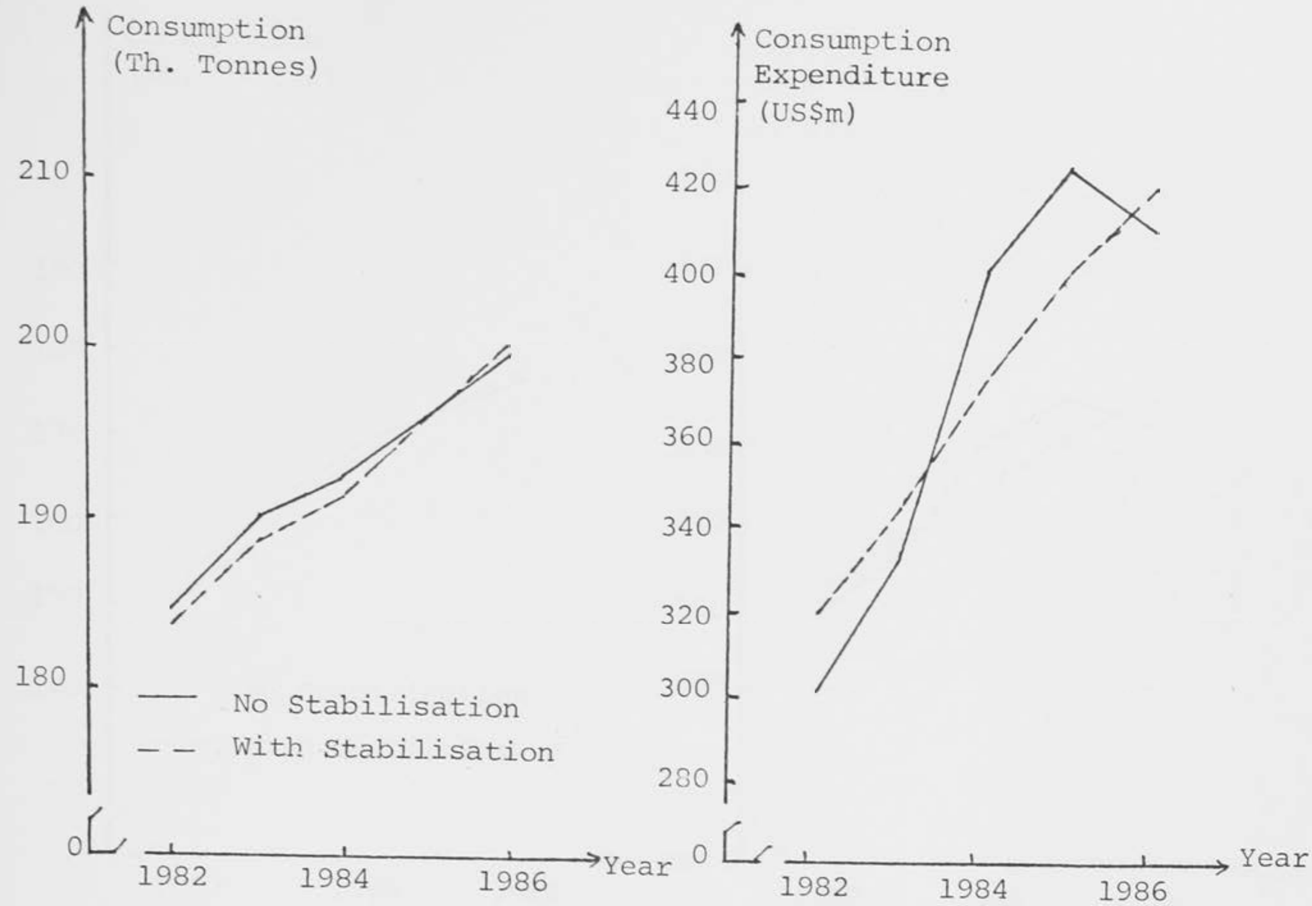


Figure A8.7: Time Paths of Natural Rubber Consumption, France.

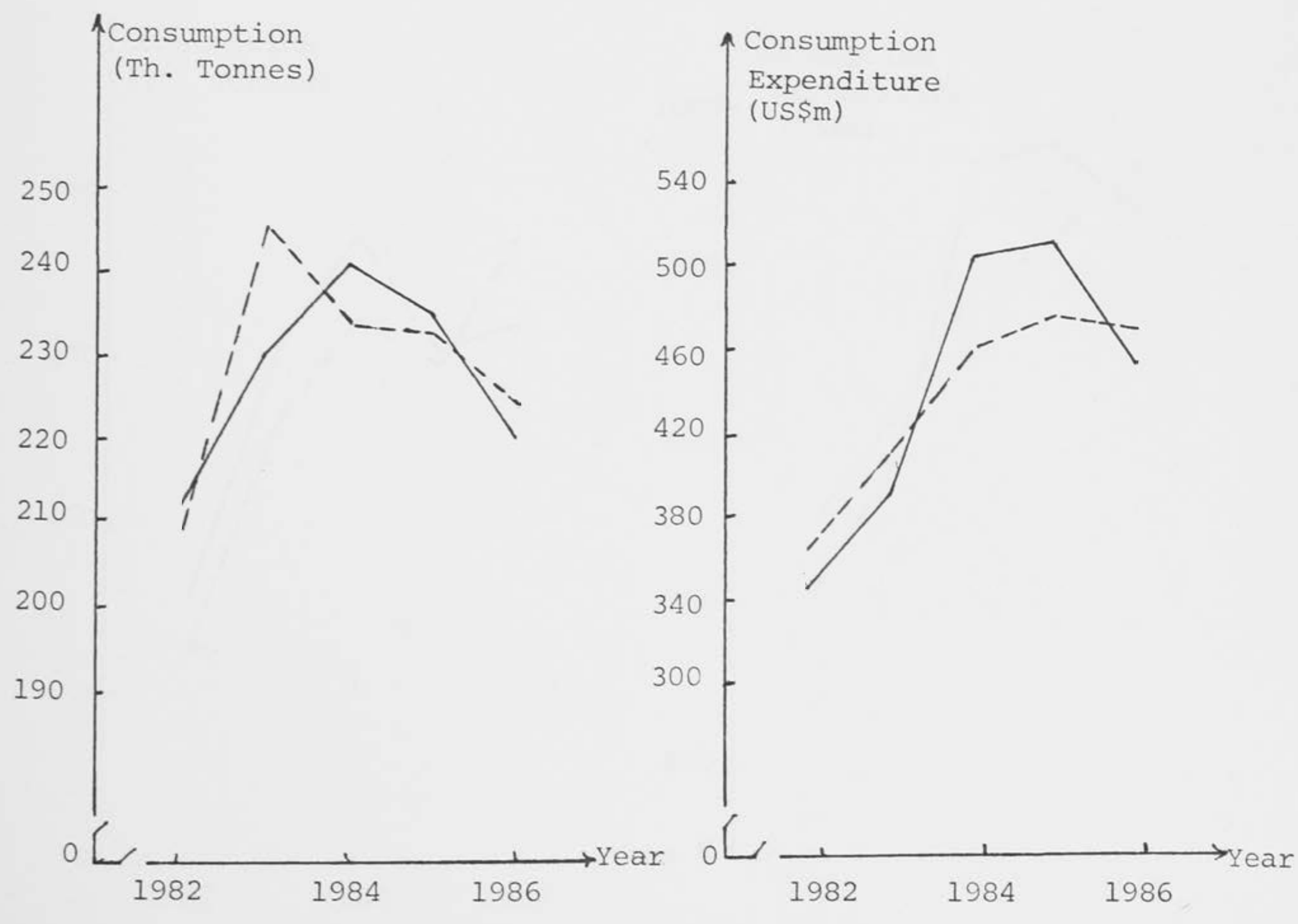


Figure A8.8: Time Paths of Natural Rubber Consumption, West Germany.

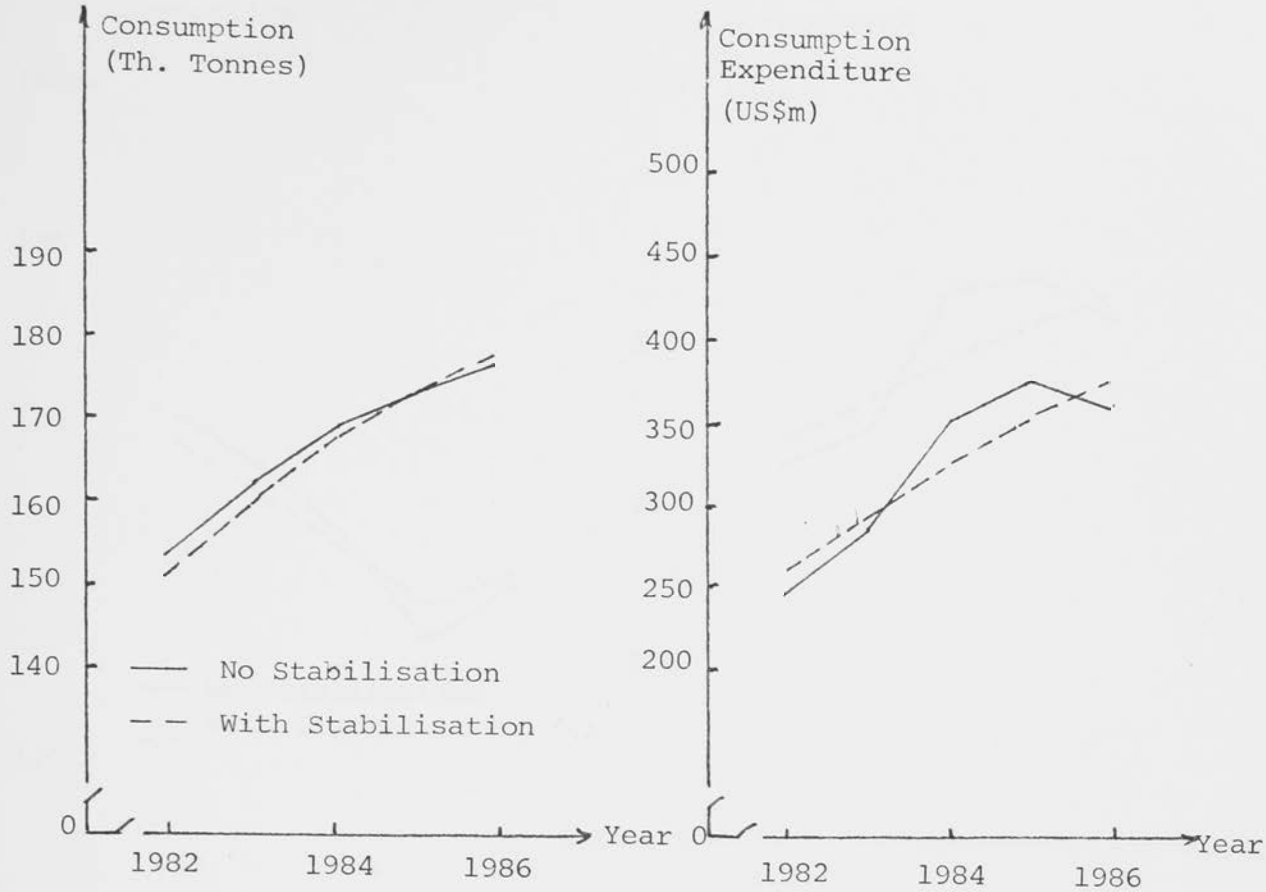


Figure A8.9: Time Paths of Natural Rubber Consumption, Italy.

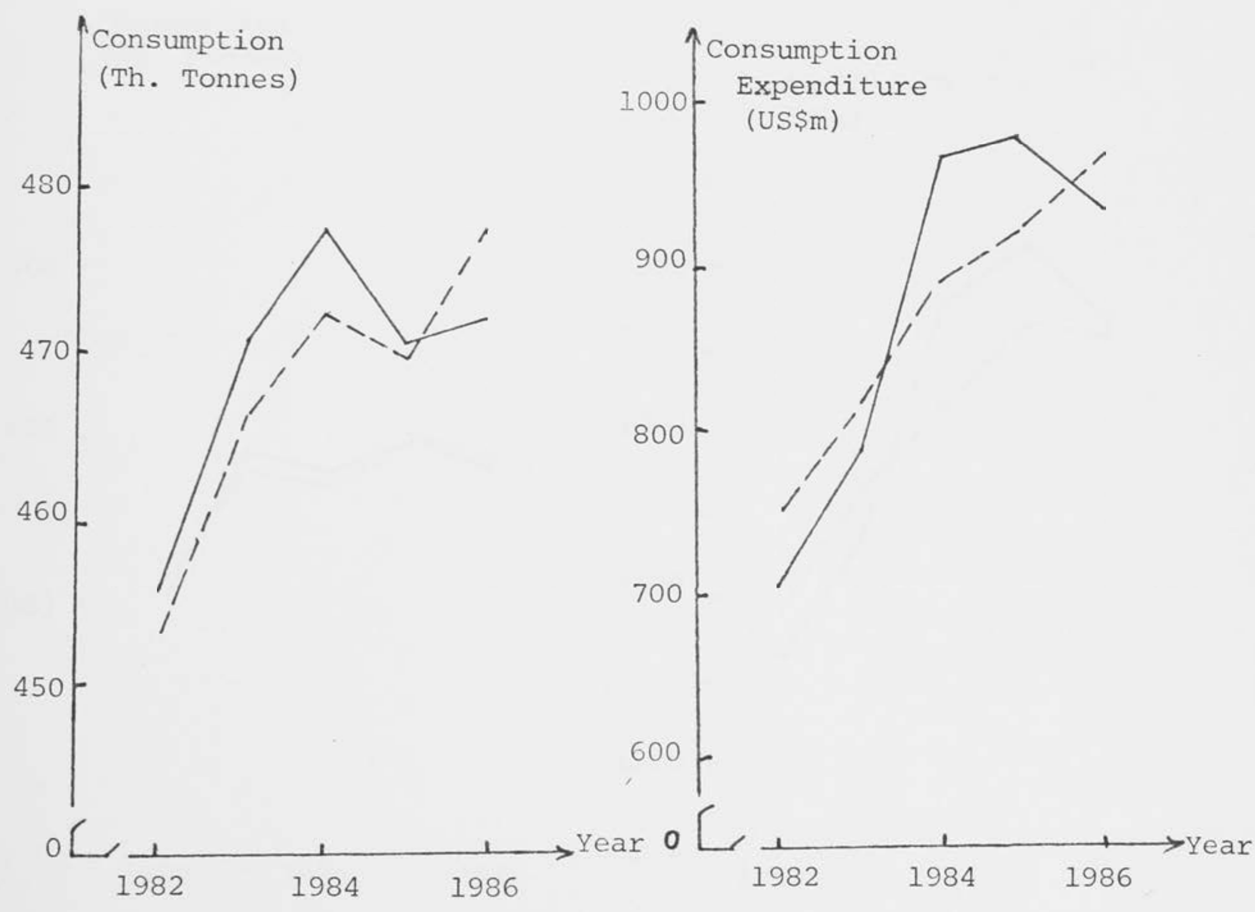


Figure A8.10: Time Paths of Natural Rubber Consumption, Japan.

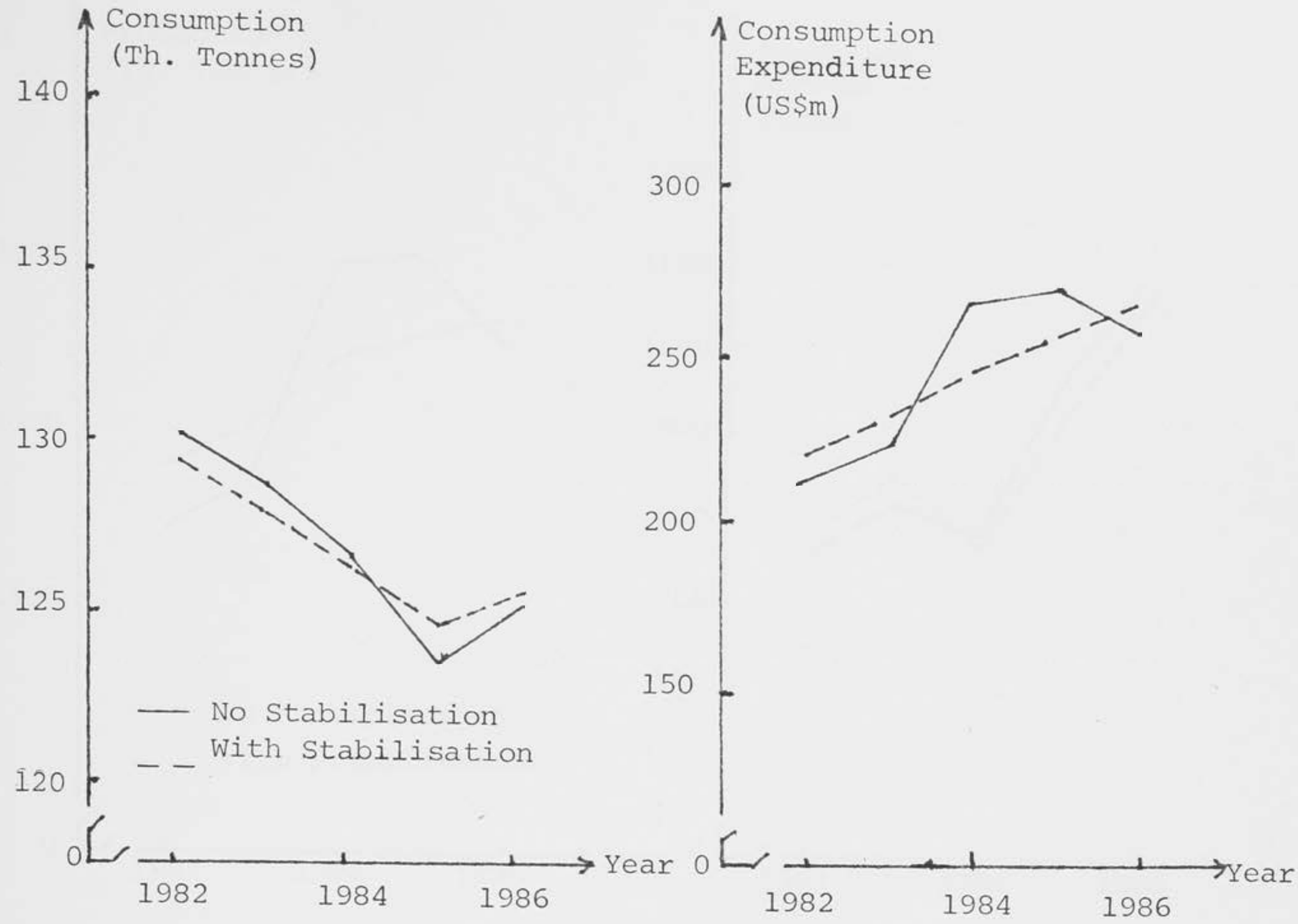


Figure A8.11: Time Paths of Natural Rubber Consumption, UK.

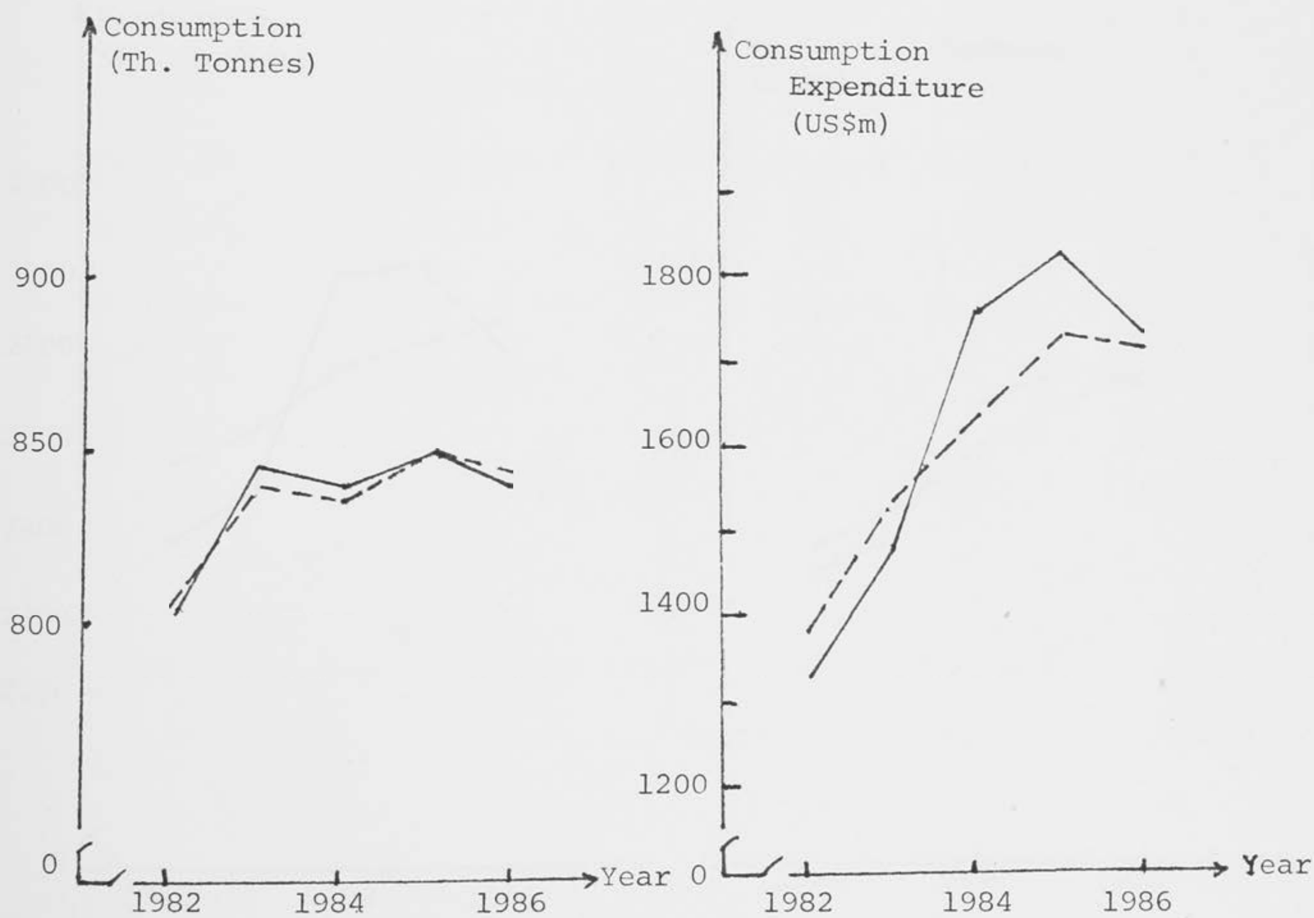


Figure A8.12: Time Paths of Natural Rubber Consumption, USA.

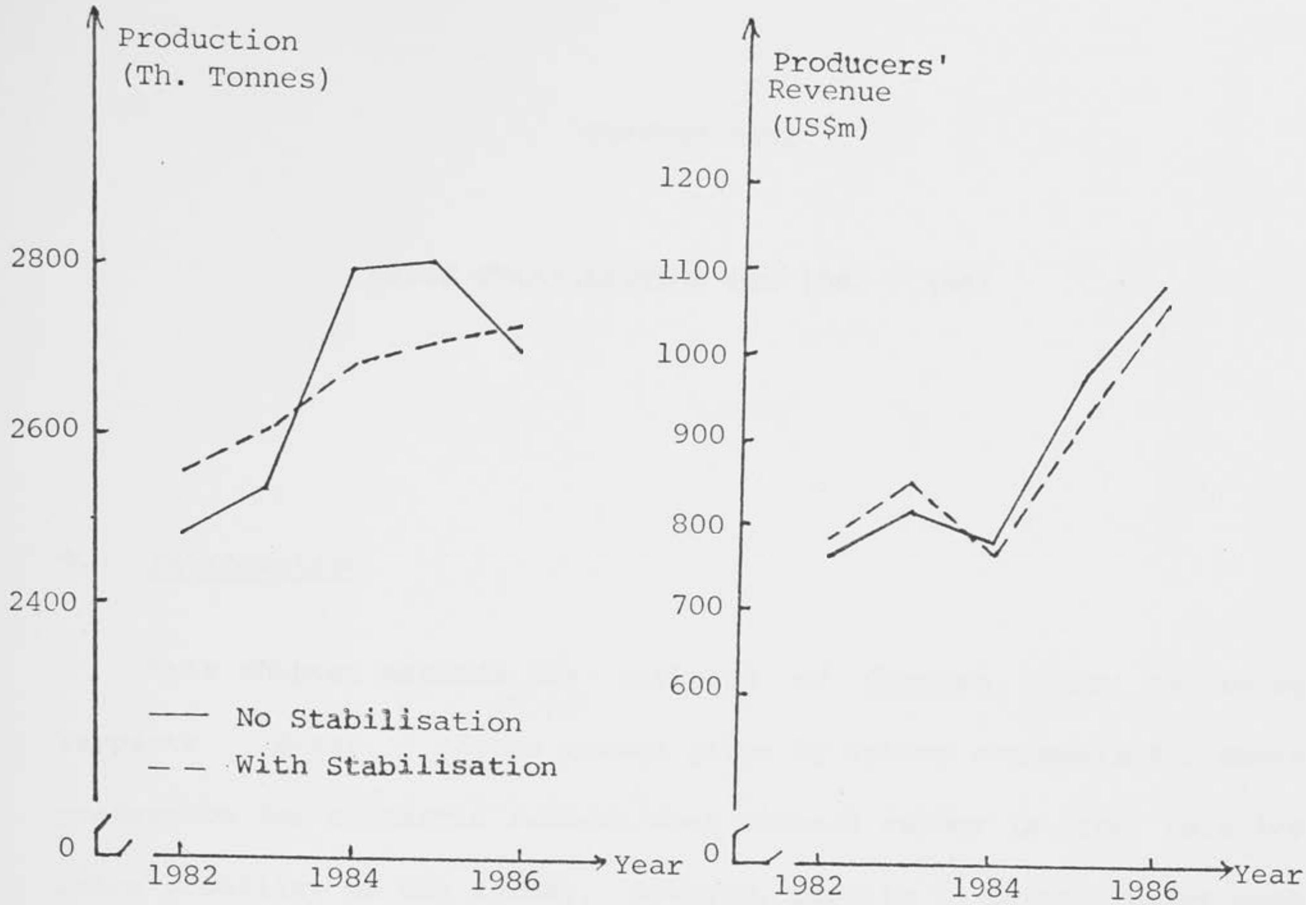


Figure A8.13: Time Paths of Natural Rubber Supply and Producers' Revenue, Malaysian Estates.

Figure A8.14: Time Paths of Natural Rubber Supply and Producers' Revenue, Malaysian Smallholders.

CHAPTER NINE

PRICE STABILISATION FOR 1982 - 1991

9.1 Introduction

This chapter extends the analysis of Chapter Eight in three respects. First, a common reason given by rubber consumers for their preference for synthetic rubbers over natural rubber is the relative price stability of the former. However, results in Chapter Eight show that with a 5-year stabilisation programme, the increase in world consumption of natural rubber was 0.22 percent only. Given the lagged price effects on consumption, it may be that longer-term stabilisation is necessary to establish any significant shift towards natural rubber consumption. The first part of this chapter therefore focus on longer-term stabilisation by assuming that the 5-year INRA will be extended for a second term from 1986 so that the stabilisation period now extends from 1982 to 1991.

Second, this chapter also considers the effect of introducing non-equidistant price bands.

Third, it will be recalled from Chapter Seven that political uncertainties in the Middle-Eastern oil producing region provides a basis for a high oil price scenario. Hence it is useful also to forecast natural rubber prices under the high oil price scenario since the forecast time paths of natural rubber price under the low and high oil price scenarios will delineate the price range within which the natural rubber price is likely to fall. This focus on delineating the probable forecast price range under alternative scenarios reinforces the basis for using non-stochastic instead of stochastic simulations in this study. The final section presents forecast time paths of natural rubber price under a high oil price scenario during 1980-1995.

9.2 Stabilisation for 10 Years About Equidistant Price Bands

As in Chapter Eight, the simulation results of buffer stock operations with and without prospective buying/selling will be presented to highlight the importance of prospective buffer stock operations. If price is to be stabilised at the average of the price range observed for 1982-1991, then the reference price is $3650. The trigger price bands, given by plus and minus 15 percent of the reference price, are delineated by $3102 and $4197. The indicative price bands which are plus and minus 20 percent of the reference price are then given by $2920 and $4380 respectively. In line with the INRA stipulations, it will be assumed that buffer stock operations are compulsory only when price falls outside the trigger price bands. Thus without prospective buying/selling, the buffer stock will be operated on (other than stock rotation) only when price lies outside the trigger price bands.

From Figure 9.1 it can be seen that without prospective buying/selling, buffer stock operations are required only in 1982 (when 80,000 tonnes will be bought) and 1989 (when 80,000 tonnes will be sold). During 1983-1988 no market intervention is required.

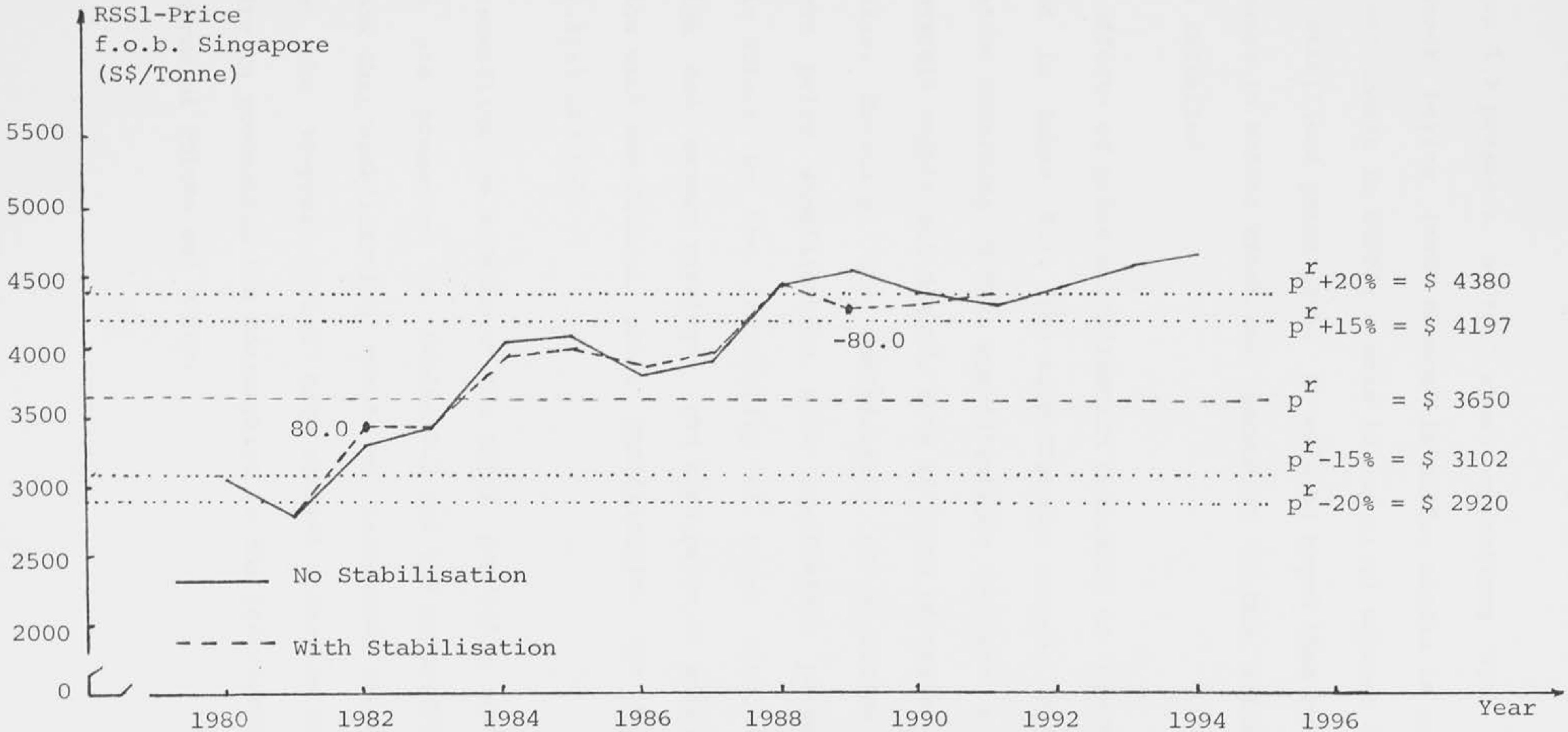


Figure 9.1: Price Stabilisation Without Prospective Buffer Stocks Purchases/Sales, 1982-1991.

However, as the time path of price under such buffer stock operations shows, the degree of price stabilisation is minimal.

Figure 9.2 presents buffer stock operations with prospective buffer stock buying (net change in buffer stocks is positive) and selling (net change in buffer stocks is negative) volumes as indicated along the stabilised price path. It will be noted that the constraint of net change in buffer stock not exceeding 80,000 tonnes in each period is satisfied.

The effects of price stabilisation according to Figure 9.2 are summarised in Table 9.1. Two main features emerge. Firstly, price stabilisation according to INRA specifications does not significantly affect overall supply and demand, both in terms of volume and current dollar value. Secondly, the coefficients of variation show that longer-term price stabilisation with equidistant price bands has negligible effect on the instability of total world production, consumption and export earnings. The time paths of world supply and consumption with and without price stabilisation are presented in Figures 9.3(a) and (b).

The stabilisation effects on the major producing and consuming countries are presented in Tables 9.2 and 9.3 respectively. These tables show that stabilisation about an unchanged reference price throughout the 10-year period have minimal effect on the degree of instability in production and consumption in the individual countries both in terms of volume and value.

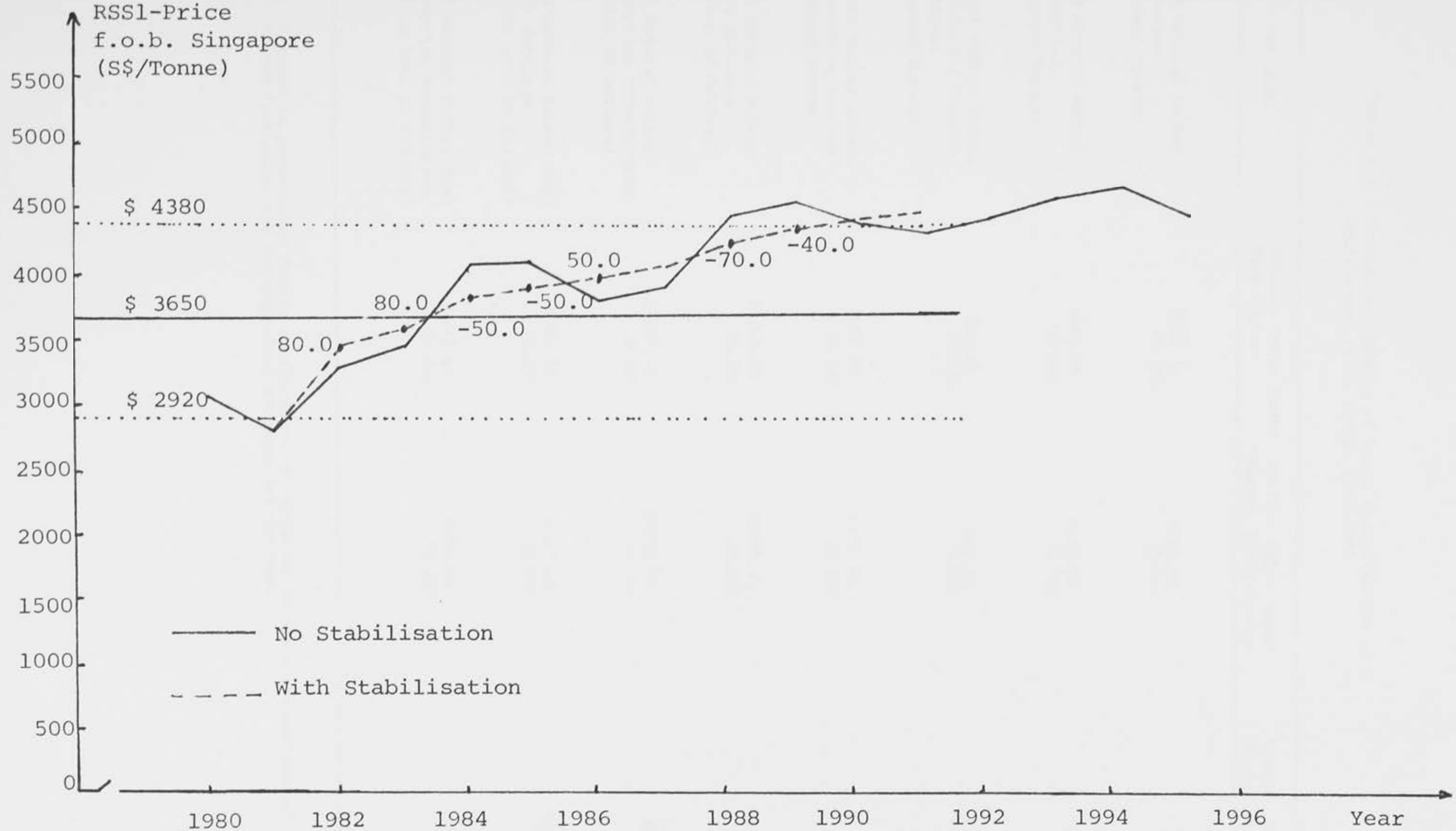


Figure 9.2: Price Stabilisation With Prospective Buffer Stocks Purchases/Sales, 1982-1991(Equidistant Price Bands).

Table 9.1: Summary of Effects of Price Stabilisation with Equidistant Price Bands, 1982-1991

Variable	Average Value Under Free Market	Average Value Under Market Intervention	Change Due to Market Intervention
World Natural Rubber Production (Thousand Tonnes)	4789.34 (0.12)	4781.84 (0.11)	-7.50
World Natural Rubber Consumption (Thousand Tonnes)	4684.56 (0.10)	4683.19 (0.11)	-3.37
Natural Rubber Stocks in Producing Regions and Afloat (Thousand Tonnes)	828.85 (0.03)	840.33 (0.02)	+11.48
Natural Rubber Stocks in Consuming Regions (Thousand Tonnes)	1183.00 (0.14)	1179.56 (0.14)	-3.44
World Natural Rubber Export Earnings (Million US Dollars)	10408.80 (0.26)	10376.71 (0.25)	-32.09
World Natural Rubber Consumption Expenditures (Million US Dollars)	10595.15 (0.25)	10600.34 (0.25)	+5.19
World Natural Rubber Real Export Earnings (Million 1981 US Dollars)	6746.80 (0.07)	6737.62 (0.04)	-10.18
World Natural Rubber Real Consumption Expenditures (Million 1981 US Dollars)	6943.47 (0.06)	6890.55 (0.03)	-52.92

Note: Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding averages are derived.

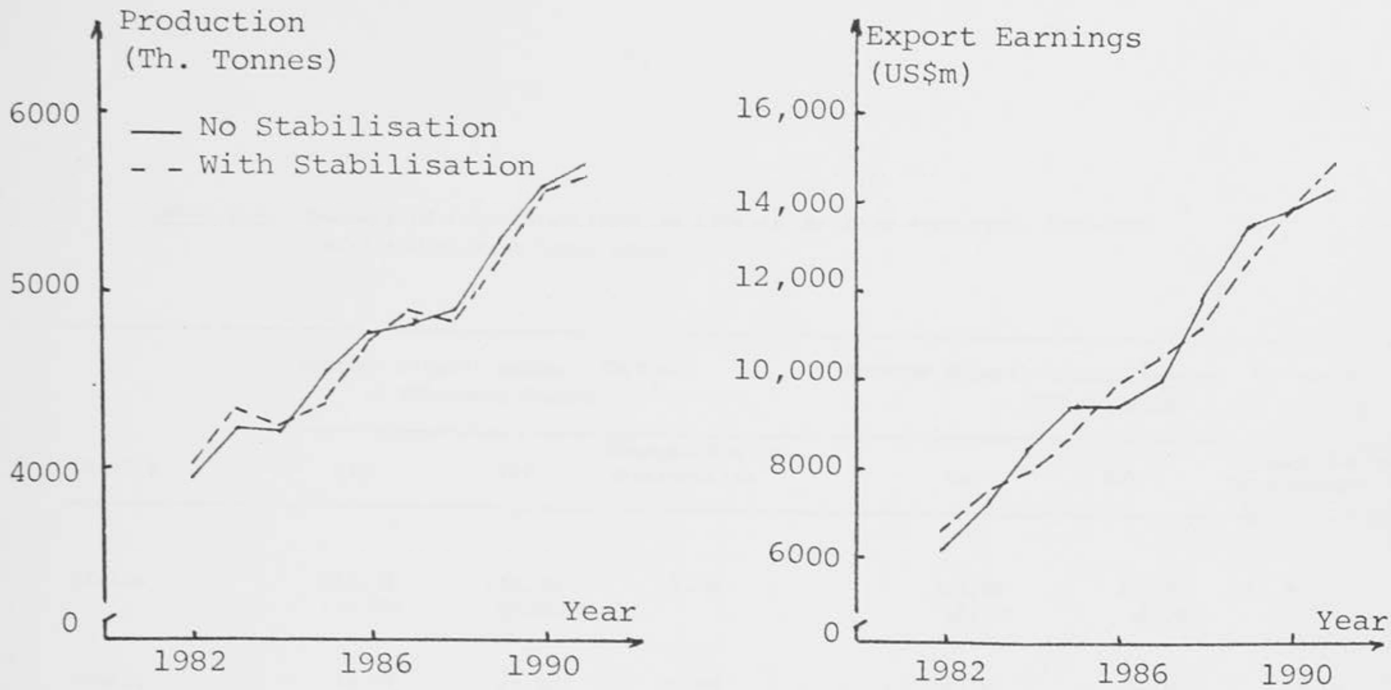


Figure 9.3(a): Time Paths of World Natural Rubber Supply.
(Equidistant Price Bands)

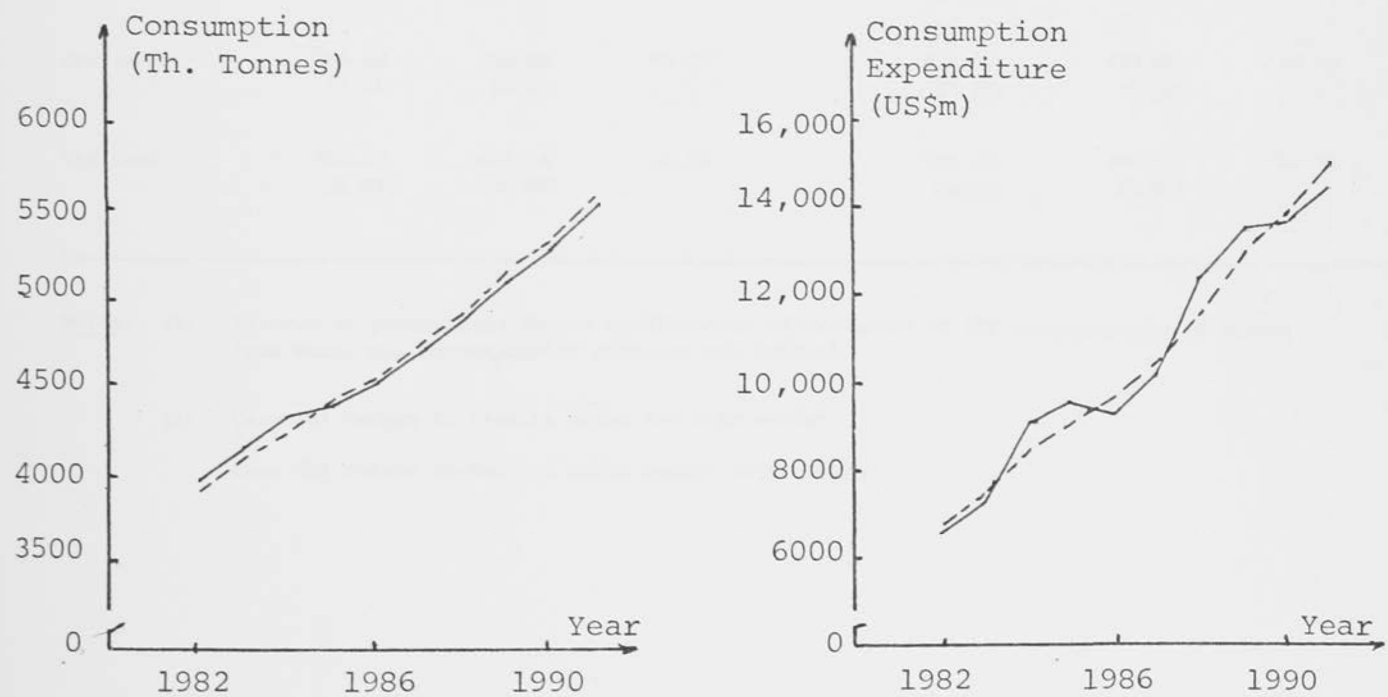


Figure 9.3(b): Time Paths of World Natural Rubber Demand.
(Equidistant Price Bands)

Table 9.2: Summary of Price Stabilisation Effects on Major Producers, 1982-1991 (With Equidistant Price Bands)

	Average Natural Rubber Output (Thousand Tonnes)			Average Natural Rubber Export Earnings (US $million)		
Country	(a)	(b)	Changes Due to Intervention	(a)	(b)	Changes Due to Intervention
Africa	152.31 (0.59)	150.73 (0.60)	-1.58	351.49 (0.70)	352.66 (0.70)	+1.17
Brazil	41.57 (0.15)	41.49 (0.14)	-0.08	90.61 (0.29)	90.56 (0.28)	-0.05
Indonesia	1270.04 (0.16)	1275.80 (0.15)	+5.76	2776.79 (0.30)	2779.24 (0.29)	+2.45
Malaysia Estates	675.46 (0.10)	674.09 (0.09)	-1.37	1488.23 (0.20)	1581.67 (0.27)	+93.44
Smallholders	926.70 (0.04)	926.70 (0.04)	0.00	2012.58 (0.18)	1984.87 (0.18)	-27.71
Sri Lanka	206.42 (0.21)	206.46 (0.20)	+0.04	454.82 (0.35)	453.08 (0.34)	-1.74
Thailand	430.23 (0.07)	426.14 (0.09)	-4.09	918.35 (0.17)	907.57 (0.16)	-10.78

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

Table 9.3: Summary of Price Stabilisation Effects on Major Consumers, 1982-1991 (Case of Equidistant Price Bands)

	Average Natural Rubber Consumption Volume (Thousand Tonnes)			Average Natural Rubber Consumption Expenditures (US $million)		
Country	(a)	(b)	Changes Due to Intervention	(a)	(b)	Changes Due to Intervention
France	203.75	203.86	+0.11	458.08	457.88	-0.80
	(0.07)	(0.07)		(0.21)	(0.21)	
West Germany	238.63	237.64	-0.99	536.44	538.67	+2.23
	(0.07)	(0.08)		(0.22)	(0.21)	
Italy	181.71	181.56	-0.15	410.79	410.84	+0.05
	(0.10)	(0.10)		(0.25)	(0.21)	
Japan	492.46	492.13	-0.33	1059.74	1061.56	+1.82
	(0.06)	(0.06)		(0.21)	(0.21)	
United Kingdom	128.57	128.50	-0.07	286.82	287.15	+0.33
	(0.02)	(0.02)		(0.17)	(0.16)	
United States	867.83	867.55	-0.32	1927.29	1893.01	-34.28
	(0.04)	(0.05)		(0.19)	(0.22)	

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

The shares of export earnings of the main producers tend to correspond to their production shares. Except for Malaysian estate production, the gains/losses of producing countries because of price stabilisation are small in magnitude. However, longer-term price stabilisation benefits Malaysian estates significantly, as verified by the 6.3 percent increase in their export earnings.[1]

From Table 9.3 it can be seen that longer-term price stabilisation affects individual consuming countries unevenly. While consumption in France increases (although only by 0.05 percent), the remaining main consuming countries are shown to reduce their natural rubber consumption. The effects of price stabilisation in terms of consumption expenditures also vary between countries. Except for France and USA, all other countries are shown to expend more on their reduced consumption. Significantly, the USA -- which is the largest single consumer -- is seen to save nearly 2 percent in consumption expenditure from a reduction in consumption of 0.03 percent. Time paths for natural rubber production and consumption of individual countries under markets with and without stabilisation are presented in Appendix 9A.

The effects of stabilisation on Malaysian producers' revenues are presented in Table 9.4 while the time paths of Malaysian estate and smallholder production and producers' revenues are presented in Figures A9.13 and A9.14 respectively in Appendix 9A.

1 The constancy in average production of the smallholder sector is due to the exogenous treatment of this variable in the <u>ex ante</u> simulations.

Table 9.4: Effects of Stabilisation With Equidistant Price Bands on Malaysian Average Producers' Revenues, 1982-1991 (Million US Dollars)

Producer	Free Market	Market Intervention	Gains/Loss Due to Intervention (%)
Estates	1019.60 (0.17)	1014.33 (0.16)	-0.52
Smallholders	1353.83 (0.15)	1355.11 (0.10)	+0.10

Table 9.5 gives the estimates of buffer stock operational costs by item while Table 9.6 presents the net buffer stock outlay and cumulative buffer stock debt in each period. In constant 1981 US dollars, the total debt incurred by the buffer stock authority in 1991 after a 10-year stabilisation programme is US$243 million.

Table 9.7 presents the natural rubber shares with and without price stabilisation. Under the given technology, it is seen that extending the stabilisation period to 10 years will have no positive effect on natural rubber consumption shares.

9.3 Stabilisation for 10 Years About Non-Equidistant Price Bands

A problem with stabilising price for 10 years from 1982 to 1991 about the single reference price $3650 is that prices in 8 out of 10 years lie above this reference price. The interaction between the strong upward price trend in the latter half of the 1980s and the lagged price effects of stabilisation in the early period causes the 1991 price to exceed the ceiling price. This reiterates the question raised in Chapter Eight about the relationship between the reference price, self-liquidating buffer stocks and the associated problem of equidistant/non-equidistant price bands. What the longer-term stabilisation has highlighted is the need to take into account the influence of lagged price effects on the price formation in subsequent periods, and hence on the overall distribution of prices.

Table 9.5: Estimates of Buffer Stocks Operational Costs by Item, 1981-1991

Year	Carrying Costs (US$/tonne)	Rotation Costs (US$/tonne)	Administrative & Overhead Costs (US $million/year)
1981	228.60	7.14	0.5714
1982	252.90	7.90	0.6341
1983	280.00	8.80	0.7000
1984	310.00	9.70	0.7692
1985	344.00	10.70	0.8421
1986	377.00	11.80	0.9625
1987	411.70	12.85	1.0291
1988	457.00	14.30	1.1423
1989	505.40	15.90	1.2689
1990	557.80	17.44	1.3943
1991	616.80	19.30	1.5416

Note: Components of the various cost items are as for Table 8.2 in Chapter Eight.

Table 9.6: Buffer Stocks Outlay and Cumulative Buffer Stocks Debt in each period, 1982-1991 (Stabilisation with Equidistant Price Bands)

Year	Buffer Stocks Outlay		Cumulative Buffer Stocks Debt	
	Current US$m	Constant US$m	Current US$m	Constant US$m
1982	156.1666	146.4380	156.1666	146.4380
1983	188.2572	165.4281	358.9404	315.4133
1984	-61.0674	-49.6079	333.7670	271.1348
1985	-78.4570	-58.9902	288.6867	217.0576
1986	148.5445	79.4355	466.0998	324.5820
1987	47.7345	25.8024	560.4442	361.3437
1988	-144.5359	-86.2386	471.9527	281.5946
1989	-98.0189	-54.2139	421.1290	232.9253
1990	1.3943	0.7135	464.6362	237.7872
1991	1.5416	0.7299	512.6414	242.7279

Note: Definitions of Buffer Stocks Outlay and Debt as in Chapter 8, Table 8.3.

Table 9.7: Natural Rubber Consumption Shares With and Without Price Stabilisation with Equidistant Price Bands, 1982-1991 (Percentages)

Year	Case A	Case B	Case C
1982	32.3 (12242.4)	32.2 (12251.1)	32.2 (12251.1)
1983	32.2 (12942.3)	31.9 (12955.8)	31.9 (12955.8)
1984	31.7 (13593.9)	31.5 (13592.9)	31.4 (13595.4)
1985	30.8 (14311.8)	30.9 (14303.2)	30.8 (14307.6)
1986	30.0 (15014.3)	30.3 (15005.0)	30.1 (15016.5)
1987	29.8 (15820.0)	30.0 (15811.7)	29.8 (15819.9)
1988	29.5 (16596.8)		29.5 (16588.7)
1989	29.3 (17419.0)		29.3 (17415.3)
1990	28.9 (18305.7)		29.0 (18303.8)
1991	28.6 (19309.8)		28.7 (19304.7)

Notes: (1) Case A refers to market without stabilisation
Cases B and C refer to market with stabilisation and for the periods 1982-1986 and 1982-1991 respectively.

(2) Figures within parentheses denote total volume of rubber (natural and synthetic) consumption in thousand tonnes.

Supposing the buffer stock authority gives due consideration to the role of lagged price effects in price formation and knows, _a priori_, how the distribution of prices will be affected after the buffer stock operations have begun. Then the determination/choice of reference price may be made in one of the following ways:

(1) on the basis of moving averages, viz. 3-year moving average;

(2) on the basis of 5-year intervals so that the reference price is adjusted after 5 years;

(3) on the basis of the arithmetic mean of forecast prices for the full 10-year period.

Each of the above methods of selecting the reference price raises problems of feasibility and management for the buffer stock scheme. The problems associated with methods (1) and (2) stem from the increased frequency in negotiating new reference prices, a procedure which is time-consuming in general. Furthermore, frequent revisions of reference price could negate the pure price stabilisation objective. Method (3) raises different problems and warrants a separate discussion.

If the lagged price effects subsequent to buffer stock operations in the initial years of a 10-year stabilisation programme are recognised, then the buffer stock authority may choose to incorporate the lagged effects by lifting the ceiling price. The extent of increase for the ceiling price may be so as to retain the INRA principle of equidistant price bands. However, this would widen the stabilisation price band. Moreover, the feasibility of lifting the ceiling price is contingent upon the agreement of the consumer countries. If the willingness of the consumer countries to participate in INRA stems mainly from their interest in securing a known ceiling price for their future natural rubber consumption, then their approval for lifting the ceiling price may not be obtained easily. Alternatively, a higher reference price may be chosen on the basis of the expected distribution of prices and the dynamic lagged price effects. Using the original floor and ceiling prices, this means that stabilisation will now be about non-equidistant price bands. For the period 1982-1991, a reason for the use of non-equidistant price bands is the sharply rising price trend and the skewed distribution of the forecast prices towards the ceiling level. This upward pressure on price is due primarily to increased demand during the upswing in business cycles.

Figure 9.4 presents time paths of natural rubber price under the non-stabilised market and under buffer stock stabilisation about the higher reference price of $3900, but retaining the original floor and ceiling prices. This means that price stabilisation is now about non-equidistant price bands. The effects of stabilisation with prospective buffer stock operations on world production and consumption are summarised in Table 9.8, and their time paths given in Figures 9.5(a) and (b). A comparison of Table 9.8 with Table 9.1 shows stabilisation gains/losses to be the same qualitatively, but differing in magnitude. In terms of volume, stabilisation about different reference prices do not lead to marked difference in global production and consumption. However, because of the higher reference price and non-equidistant price bands, producers gain since they now receive the same export earnings for less output. In contrast, consumers lose because they now consume less at approximately the same

Figure 9.4: Price Stabilisation with Prospective Buffer Stocks Purchases/Sales, 1982-1991 (Non-Equidistant Price Bands).

Table 9.8: Summary of Effects of Price Stabilisation with Non-Equidistant Price Bands, 1982-1991

Variable	Average Value Under Free Market	Average Value Under Market Intervention	Change Due to Market Intervention
World Natural Rubber Production (Thousand Tonnes)	4798.34 (0.12)	4775.04 (0.11)	-23.30
World Natural Rubber Consumption (Thousand Tonnes)	4686.54 (0.10)	4678.89 (0.11)	-7.65
Natural Rubber Stocks in Producing Regions and Afloat (Thousand Tonnes)	828.85 (0.03)	844.44 (0.15)	+15.59
Natural Rubber Stocks in Consuming Regions (Thousand Tonnes)	1183.00 (0.14)	1178.89 (0.14)	-4.12
World Natural Rubber Export Earnings (Million US Dollars)	10408.80 (0.26)	10377.76 (0.24)	-31.04
World Natural Rubber Consumption Expenditures (Million US Dollars)	10595.15 (0.25)	10596.18 (0.24)	+1.33
World Natural Rubber Real Export Earnings (Million 1981 US Dollars)	6746.80 (0.07)	6751.87 (0.03)	+5.07
World Natural Rubber Real Consumption Expenditures (Million 1981 US Dollars)	6943.47 (0.06)	6892.18 (0.03)	-51.29

Note: (1) Figures in parentheses denotes coefficients of variation of the distributions of the values from which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

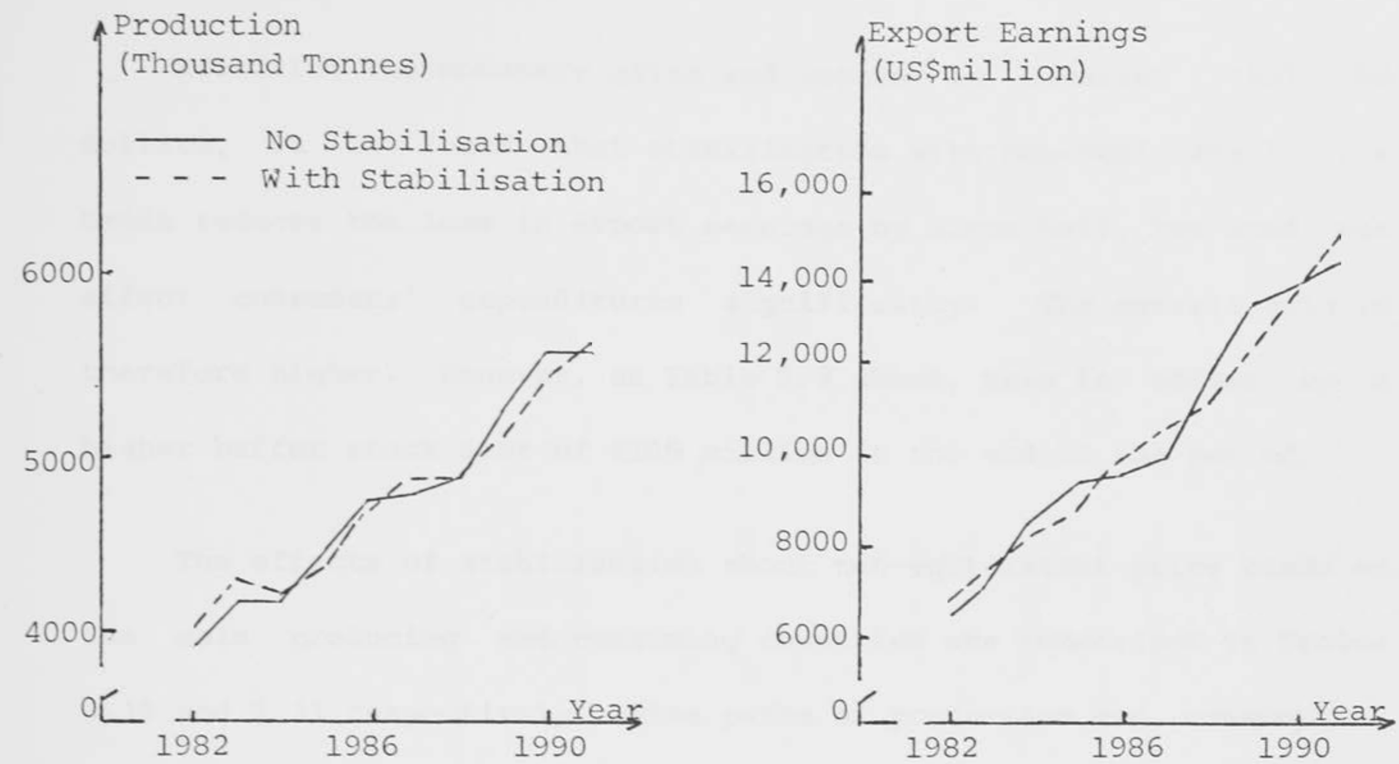


Figure 9.5(a): Time Paths of World Natural Rubber Supply, (Non-Equidistant Price Bands).

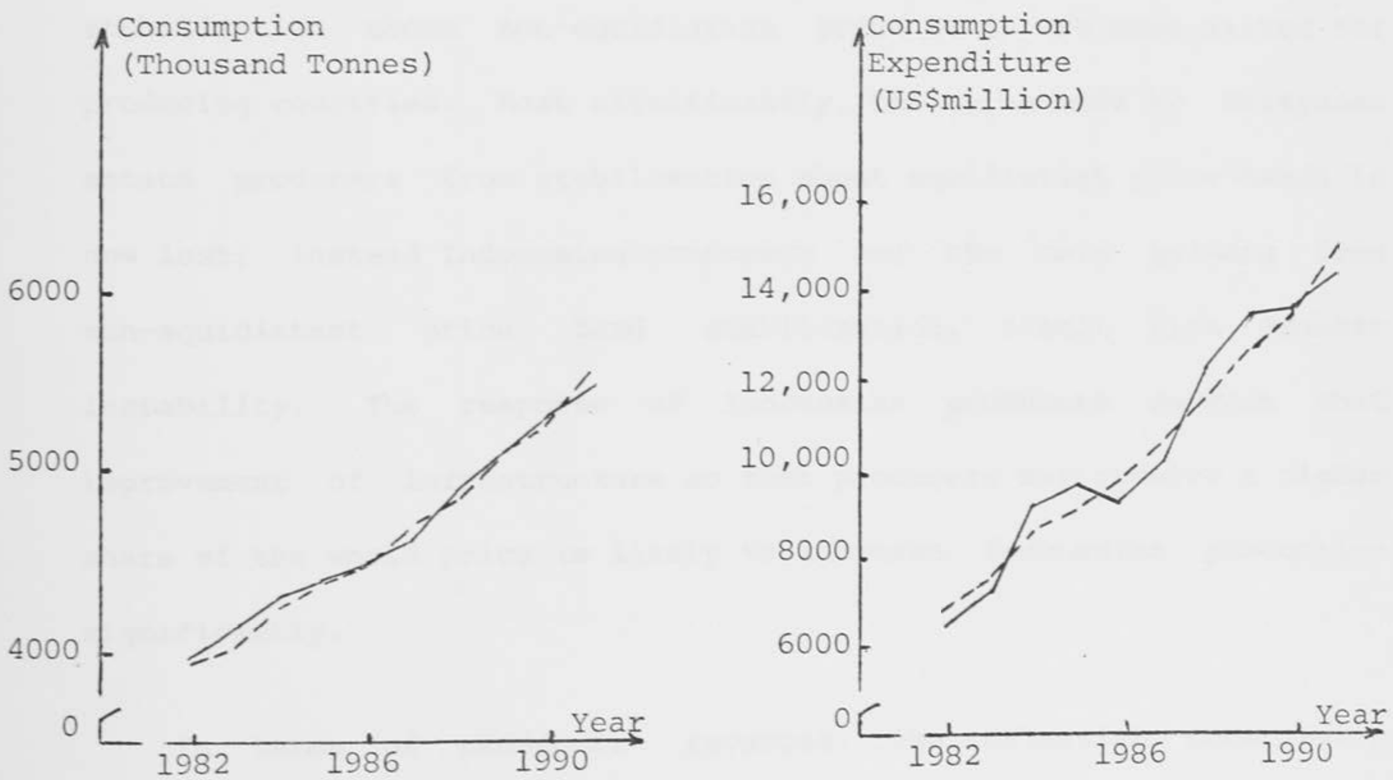


Figure 9.5(b): Time Paths of World Natural Rubber Demand (Non-Equidistant Price Bands).

cost.

Measuring the monetary gains and losses in constant (1981) US dollars, it is found that stabilisation with non-equidistant price bands reduces the loss in export earnings by about half, but does not affect consumers' expenditures significantly. The overall gain is therefore higher. However, as Table 9.9 shows, this is offset by a higher buffer stock debt of $365 million at the end of the period.

The effects of stabilisation about non-equidistant price bands on the main producing and consuming countries are summarised in Tables 9.10 and 9.11 respectively. Time paths of production and consumption of the main countries under the free market and market with non-equidistant price bands stabilisation as well as for Malaysian producers' revenues are given in Figures A9.15 - A9.28 in Appendix 9A. A comparison of the Tables 9.10 and 9.11 shows that the effects of stabilisation about non-equidistant price bands are more marked for producing countries. Most significantly, the gains made by Malaysian estate producers from stabilisation about equidistant price bands is now lost; instead Indonesian producers are the main gainers from non-equidistant price band stabilisation, albeit with greater instability. The response of Indonesian producers suggest that improvement of infrastructure so that producers may receive a higher share of the world price is likely to increase Indonesian production significantly.

In terms of producers' revenues, the Malaysian case again reiterates the uneven effects of stabilisation. From Table 9.12 it can be seen that the effect of non-equidistant price band stabilisation brings about an increase of 0.23 percent in smallholders

Table 9.9: Buffer Stock Outlay and Cumulative Buffer Stock Debt in Each Period, 1982-1991 (Stabilisation with Non-Equidistant Price Bands)

Year	Buffer Stock Outlay		Cumulative Buffer Stock Debt	
	Current US$m	Constant US$m	Current US$m	Constant US$m
1982	155.1666	146.4380	155.1666	146.4380
1983	188.2572	165.4281	358.9404	315.4133
1984	-16.7726	-13.6251	378.0618	307.1176
1985	-24.4458	-18.3803	391.4221	294.3023
1986	214.1135	149.1041	644.6778	448.9399
1987	151.9016	97.9378	861.0471	555.1560
1988	-129.6010	-77.3275	817.5508	487.7988
1989	-172.3512	-95.3269	726.9546	402.0766
1990	-98.9891	-50.6597	700.6609	358.5777
1991	1.5416	0.7299	772.2685	365.6574

Note: Definitions of Buffer Stock Outlay and Debt as in Chapter 8, Table 8.3.

Table 9.10: Summary of Price Stabilisation Effects on Major Producers, 1982-1991 (With Non-Equidistant Price Bands)

	Average Natural Rubber Output (Thousand Tonnes)			Average Natural Rubber Export Earnings (US $million)		
Country	(a)	(b)	Changes due to Intervention	(a)	(b)	Changes due to Intervention
Africa	152.31 (0.59)	148.69 (0.58)	-3.62	351.49 (0.70)	342.36 (0.69)	-9.13
Brazil	41.57 (0.15)	41.92 (0.15)	+0.35	90.61 (0.29)	91.15 (0.30)	+0.54
Indonesia	1270.04 (0.16)	1286.83 (0.18)	+16.79	2776.79 (0.30)	2819.97 (0.32)	+43.18
Malaysia Estates	675.46 (0.10)	673.98 (0.09)	-1.48	1488.23 (0.20)	1488.88 (0.19)	+0.65
Smallholders	926.70 (0.04)	926.70 (0.04)	0.00	2012.58 (0.18)	1995.27 (0.18)	-17.31
Sri Lanka	206.42 (0.21)	206.13 (0.20)	-1.77	454.82 (0.35)	453.38 (0.33)	-1.44
Thailand	430.23 (0.07)	424.73 (0.09)	-5.50	918.35 (0.17)	905.01 (0.14)	-13.34

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

Table 9.11: Summary of Price Stabilisation Effects on Major Consumers, 1982-1991
(With Non-Equidistant Price Bands)

	Average Natural Rubber Consumption Volume (Thousand Tonnes)			Average Natural Rubber Consumption Expenditures (US $million)		
Country	(a)	(b)	Changes due to Intervention	(a)	(b)	Changes due to Intervention
France	203.75 (0.07)	203.56 (0.07)	-0.19	458.08 (0.21)	458.47 (0.20)	+0.39
West Germany	238.63 (0.07)	236.52 (0.08)	-2.11	536.44 (0.22)	531.36 (0.22)	-5.08
Italy	181.71 (0.10)	181.42 (0.10)	-0.29	410.79 (0.25)	410.71 (0.24)	-0.08
Japan	492.46 (0.06)	491.64 (0.06)	-0.82	1059.74 (0.21)	1061.59 (0.20)	+1.85
United Kingdom	128.57 (0.02)	128.43	-0.14	286.82 (0.17)	287.43 (0.16)	+0.41
United States	867.83 (0.04)	867.09 (0.05)	-0.74	1927.29 (0.19)	1929.27 (0.18)	-0.02

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

Table 9.12: Effects of Stabilisation with Non-Equidistant Price Bands on Average Malaysian Producers' Revenues, 1982-1991
(Million US Dollars)

Producer	Free Market	Market Intervention	Gains/Loss Due to Intervention (%)
Estates	1019.60 (0.17)	1020.03 (0.16)	+0.04
Smallholders	1353.83 (0.15)	1357.04 (0.14)	+0.24

producers' revenue, but only 0.04 percent for estate producers' revenues. It should be pointed out that this result is biased against the smallholders because their production was held constant as a result of exogeneity.

In conclusion, the results reiterate the uneven effects of price stabilisation on individual countries. Furthermore, whether equidistant or non-equidistant price bands are used also lead to different results. These findings raise in particular the question of distributing the financial burden between producing and consuming countries in their joint funding and operations of a buffer stocks scheme.

9.4 Ex Post Stabilisation for 1970-1980

The stabilisation results presented thus far are derived from non-stochastic simulations with exogenous treatment of the Malaysian smallholder supply. In order to check for the possibility that the qualitative stabilisation outcomes discussed so far are due to the non-stochastic and exogenous features mentioned above, *ex post* stabilisation for 1970-1980 was simulated.

Figure 9.6 presents the actual and stabilised price paths for 1970-1980 while the stabilisation effects on world production and consumption are summarised in Table 9.13. From Table 9.13 it is found that the *qualitative* effects of stabilisation during 1970-1980 are similar to those under non-stochastic simulation of price stabilisation for 1982-1991. As before, price stabilisation leads to

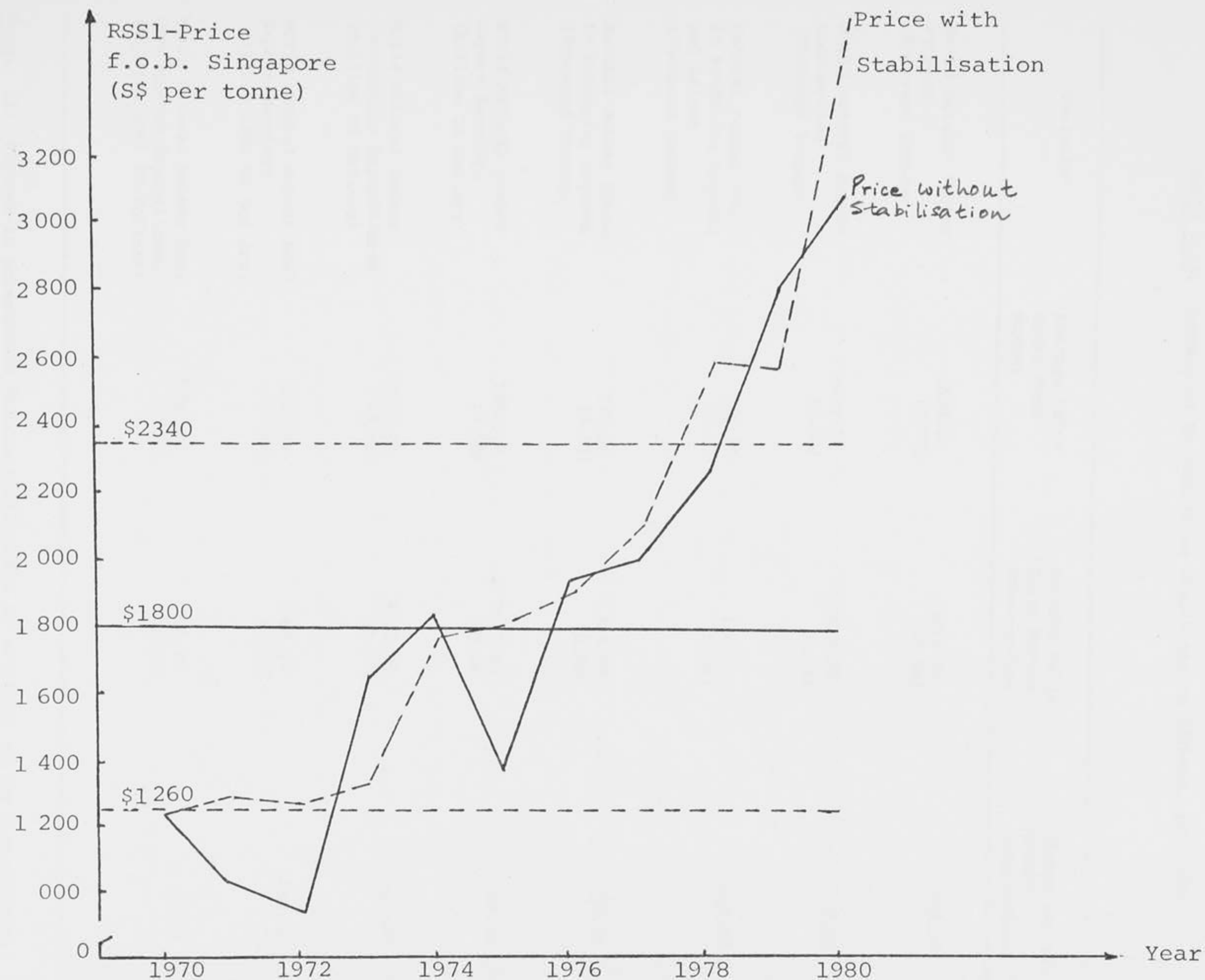


Figure 9.6: Time Paths of Natural Rubber Price With and Without Buffer Stocks Stabilisation, 1970-1980.

Table 9.13: Summary of Ex Post Price Stabilisation Effects, 1971-1980

Variable	Average Value Under Free Market	Average Value Under Market Intervention	Change due to Market Intervention
World Natural Rubber Production (Thousand Tonnes)	3509.50 (0.07)	3418.30 (0.06)	-91.20
World Natural Rubber Consumption (Thousand Tonnes)	3423.10 (0.08)	3422.20 (0.08)	-0.90
Natural Rubber Stocks In Producing Regions and Afloat (Thousand Tonnes)	761.30 (0.05)	746.50 (0.08)	-14.80
Natural Rubber Stocks in Consuming Regions (Thousand Tonnes)	776.50 (0.05)	765.77 (0.09)	-10.73
World Natural Rubber Export Earnings (Million US Dollars)	2772.70 (0.50)	2817.50 (0.46)	+44.80
World Natural Rubber Consumption Expenditures (Million US Dollars)	3045.40 (0.50)	3058.00 (0.50)	+12.60
World Natural Rubber Real Export Earnings (Million 1981 US Dollars)	1630.60 (0.28)	1668.30 (0.19)	+37.70
World Natural Rubber Real Consumption Expenditures (Million 1981 US Dollars)	1788.20 (0.22)	1797.20 (0.22)	+9.00

Note: (1) Figures in parentheses denotes coefficients of variation of the distributions of values from which the corresponding averages are derived.

(2) Export earnings do not equal consumption expenditures because the values presented here are estimates based on actual production and consumption volumes (not equal) and the relevant market (fob/cif) prices.

a fall in world production and consumption in volume terms. However, when production and consumption are measured in monetary terms, stabilisation leads to an increase in export earnings and a marginal increase in consumption expenditures. A 10-year stabilisation programme will benefit producing countries by increasing their natural rubber export earnings by S$44.8 million (US$37.7 million in constant 1970 dollars).

The effects of price stabilisation (for the historical period 1971-1980) on the main producing countries are presented in Table 9.14; comparing Table 9.14 with Table 9.2 it can be seen that <u>qualitatively</u>, the stabilisation effects are neutral to stochastic or non-stochastic simulations. But the stochastic simulation for the historical period leads to more marked <u>quantitative</u> effects, thus suggesting that the gains to producing countries indicated by the non-stochastic simulations earlier tends to be under-estimated. This vindicates the argument in Chapter Eight that non-stochastic simulation provides a most favourable test of the INRA scheme. Table 9.14 also provides an evaluation of the impact of price stabilisation on Malaysian smallholder production. For the historical period, it is seen that price stabilisation would have led to a slight reduction in Malaysian smallholder production but an increase in export earnings. Table 9.14 also shows that stabilisation in the presence of random disturbances leads to more significant gains for Indonesian producers. For 1971-1980, price stabilisation would have benefitted Indonesian producers by an increase in export earnings of US$115.6 million.

Table 9.14: Summary of Ex Post Price Stabilisation Effects on Major Producers, 1971-1980

	Average Natural Rubber Output (Thousand Tonnes)			Average Natural Rubber Export Earnings (US $ million)		
Country	(a)	(b)	Change due to Intervention	(a)	(b)	Change due to Intervention
Africa	207.33 (0.07)	205.47 (0.08)	-1.86	155.44 (0.38)	162.15 (0.35)	+6.71
Brazil	23.08 (0.12)	21.33 (0.09)	-1.75	18.05 (0.54)	17.21 (0.44)	-0.84
Indonesia	857.41 (0.05)	920.55 (0.09)	+63.14	673.88 (0.49)	789.49 (0.55)	+115.61
Malaysia Estates	637.93 (0.64)	643.09 (0.08)	+5.16	505.04 (0.42)	535.58 (0.37)	+30.54
Smallholders	814.13 (0.14)	808.74 (0.07)	-5.39	600.78 (0.54)	675.70 (0.46)	+74.92
Sri Lanka	145.71 (0.06)	156.75 (0.10)	+11.04	111.86 (0.44)	133.53 (0.54)	+21.67
Thailand	413.61 (0.17)	422.79 (0.12)	+9.18	399.92 (0.60)	365.84 (0.56)	-34.08

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding average are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

The effects of stabilisation on Malaysian producers' revenues are given in Table 9.15; as before, stabilisation will result not only in higher export earnings but also higher producers' revenues.

The effects of price stabilisation during 1971-1980 on the main consuming countries will now be discussed.

Table 9.16 presents the effects of stabilisation on consumption volumes and expenditures. Comparing Table 9.16 with Table 9.3, it can be seen that the qualitative effects of stabilisation are also neutral to stochastic or non-stochastic simulations. Most importantly, the results in Table 9.16 substantiate the earlier finding that price stabilisation affects the consuming countries unevenly.

9.5 Forecasts for Rubber Market under High Oil Price Scenario

Figures 9.7(a) and 9.7(b) present the forecasts of natural rubber prices in Singapore and New York under alternative oil price scenarios. In order to reflect supply response due to higher natural rubber prices, the Malaysian smallholder supply is assumed to grow at 2 percent per annum from the 1981 production level.[2] The price forecasts show that natural rubber prices are expected to be $4151, $4750 and $5500 by 1985, 1990 and 1995 respectively. Natural rubber production is forecast to reach 4680, 5870 and 7700 thousand tonnes respectively for the three benchmark years while consumption is forecast to reach 4500, 5600 and 7300 thousand tonnes respectively.

2 The 2 percent annual rate of growth is based on the rate of new planting observed in the 1970s.

Table 9.15: Effects of Ex Post Price Stabilisation on Malaysian Average Producers' Revenues, 1971-1980 (Million US dollars)

Producer	Free Market	Market Intervention	Gains Due to Intervention (%)
Estates	398.40 (0.30)	436.93 (0.29)	+9.67
Smallholders	481.60 (0.42)	523.82 (0.35)	+8.77

Table 9.16: Summary of Ex Post Price Stabilisation Effects on Major Consumers, 1971-1980

	Average Natural Rubber Consumption Volume (Thousand Tonnes)			Average Natural Rubber Consumption Expenditures (US $ million)		
	(a)	(b)	Change due to Intervention	(a)	(b)	Change due to Intervention
France	164.98 (0.04)	164.50 (0.04)	-0.48	137.76 (0.46)	144.40 (0.46)	-6.64
West Germany	191.62 (0.04)	156.00 (0.07)	-35.62	184.20 (0.39)	134.60 (0.41)	-49.60
Italy	124.50 (0.06)	127.70 (0.07)	+3.20	103.52 (0.44)	113.90 (0.50)	+10.38
Japan	331.32 (0.13)	290.30 (0.04)	-41.02	265.96 (0.58)	241.70 (0.46)	-24.26
United Kingdom	162.23 (0.12)	156.05 (0.11)	-5.18	127.68 (0.31)	130.30 (0.31)	+2.62
United States	717.57 (0.10)	706.10 (0.10)	-11.47	644.94 (0.49)	650.40 (0.48)	+5.46

Notes: (1) Figures in parentheses denote coefficients of variation of the distributions of values from which the corresponding averages are derived.

(2) Case (a) refers to results under the free market.

Case (b) refers to results under market intervention.

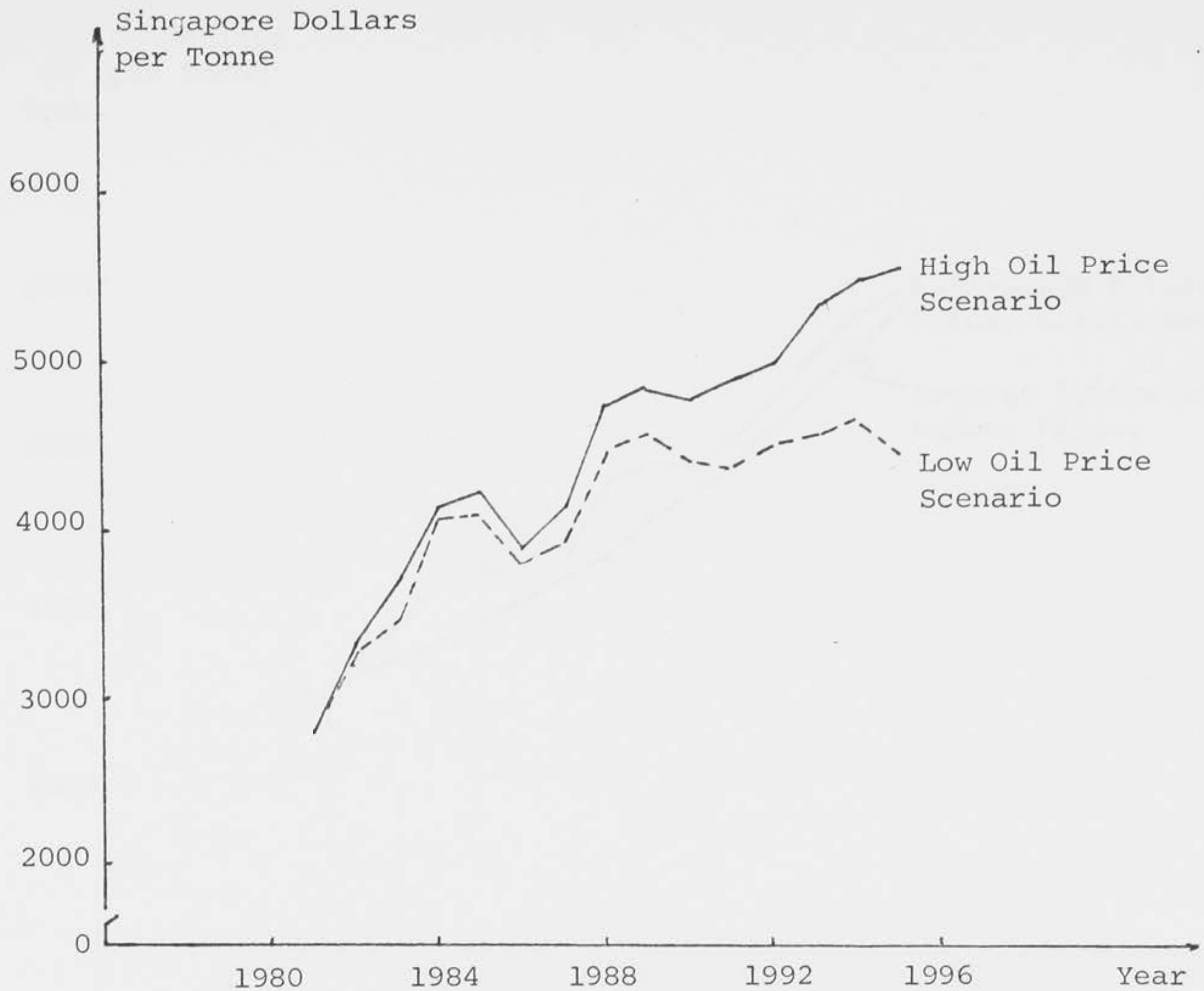


Figure 9.7(a): Forecasts of RSS1-grade Natural Rubber Prices in Singapore Under Different Oil Price Scenarios, 1981-1995.

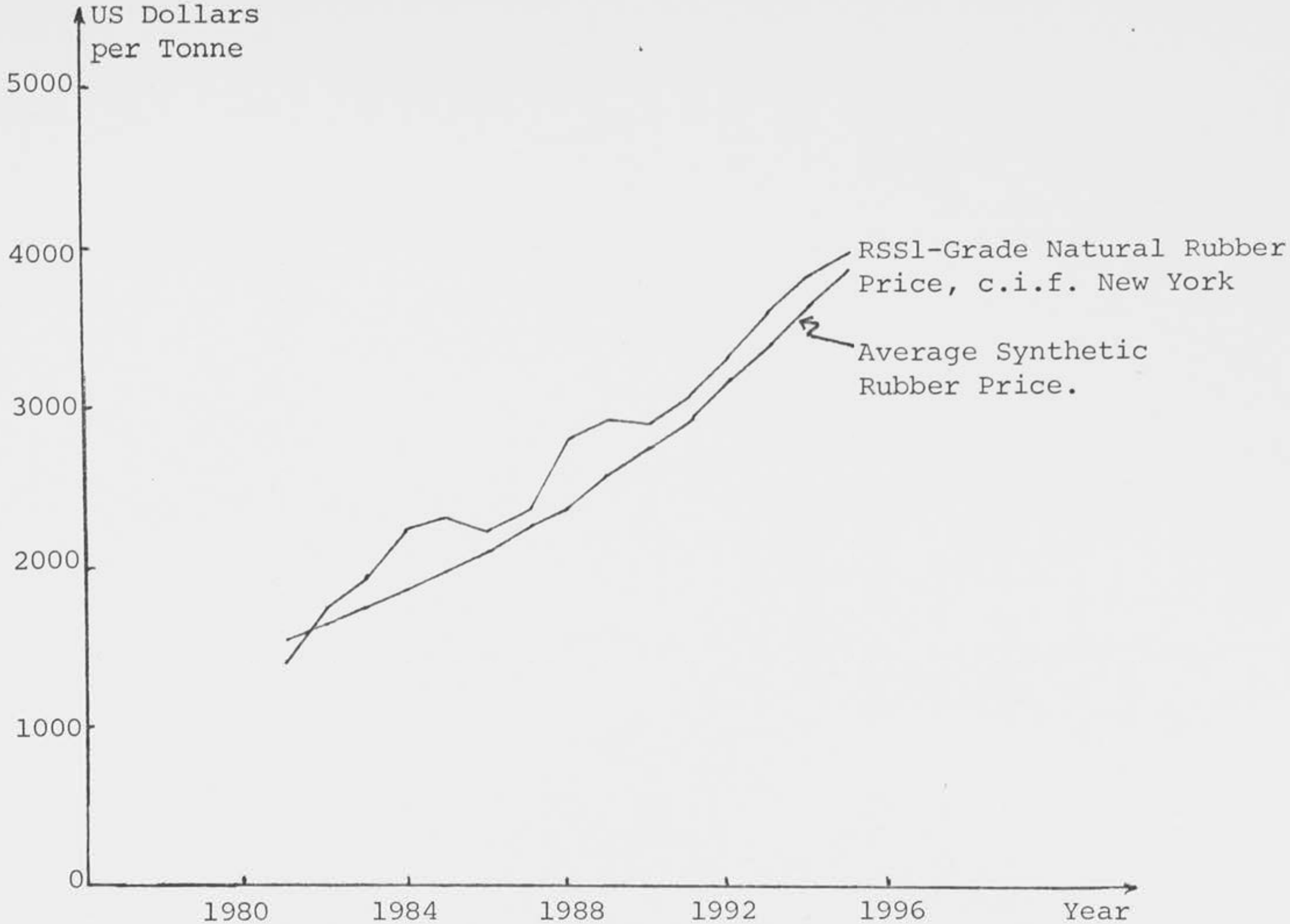


Figure 9.7(b): Forecasts of Average Synthetic Rubbers Price and Natural Rubber Price in New York, 1981-1995 (High Oil Price Scenario).

Consequently the tight natural rubber market situation observed in the early part of the 1980s will be eased in the later 1980s when new investment in synthetic rubber capacities are expected.

APPENDIX 9.A

GRAPHIC PRESENTATION OF PRICE STABILISATION EFFECTS, 1982 - 1991

This appendix presents the time paths of production, export earnings, consumption volumes and values for individual countries in markets with and without price stabilisation during 1982-1991. It also presents time paths for Malaysian estate and smallholder production and producers' revenues separately.

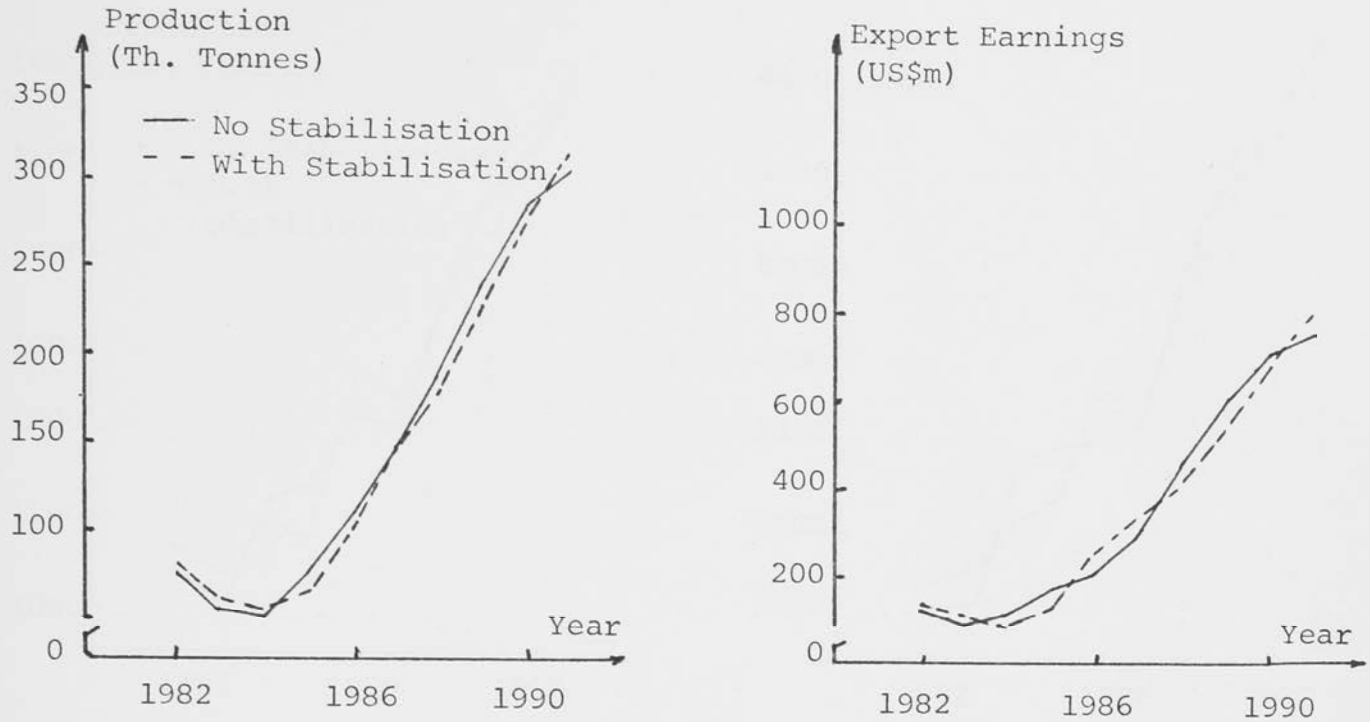


Figure A9.1: Time Paths of Natural Rubber Supply and Export Earnings, Africa. (Equidistant Price Bands)

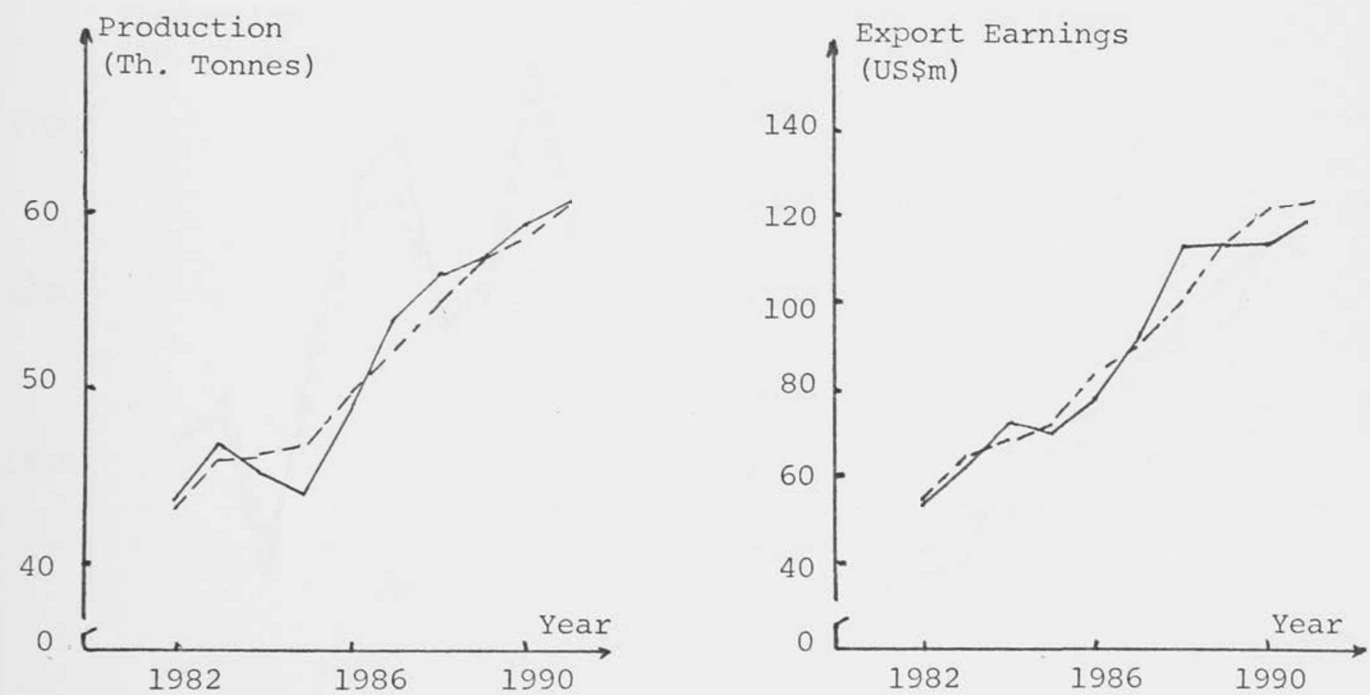


Figure A9.2: Time Paths of Natural Rubber Supply and Export Earnings, Brazil (Equidistant Price Bands)

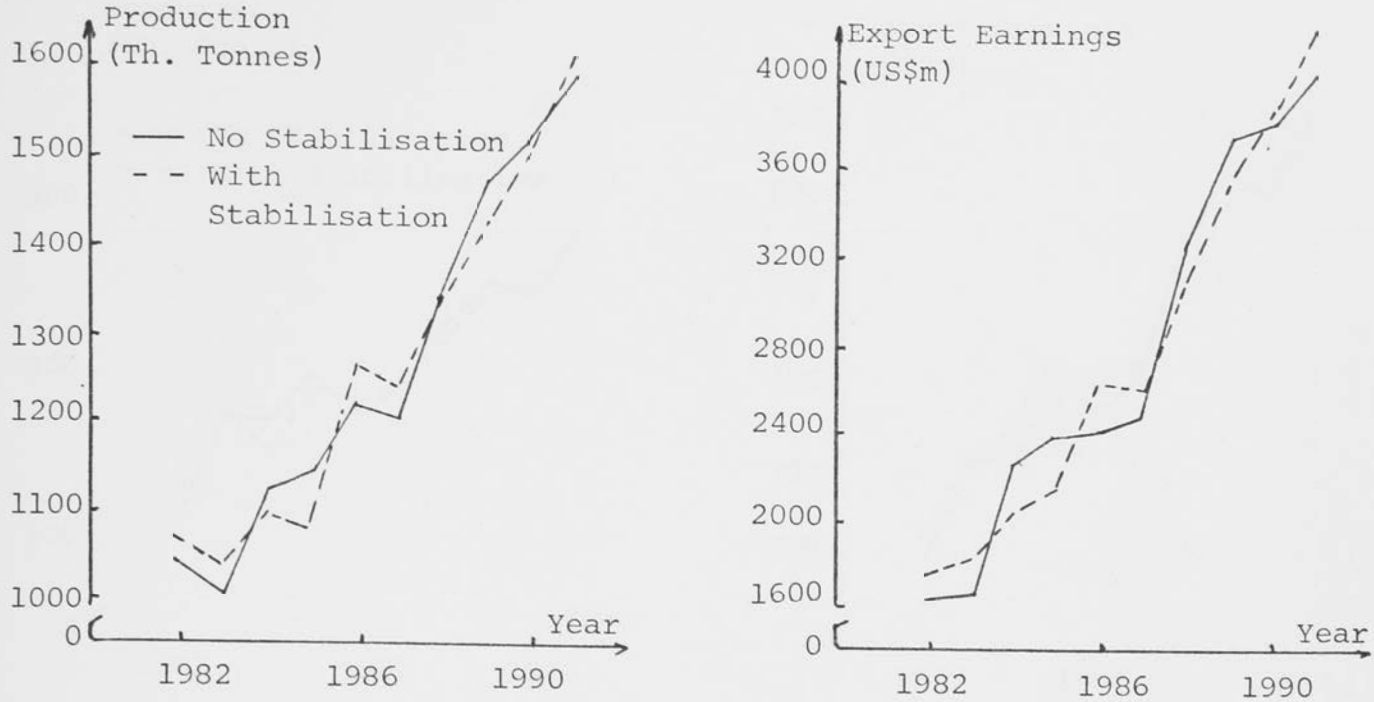


Figure A9.3: Time Paths of Natural Rubber Supply and Export Earnings, Indonesia. (Equidistant Price Bands)

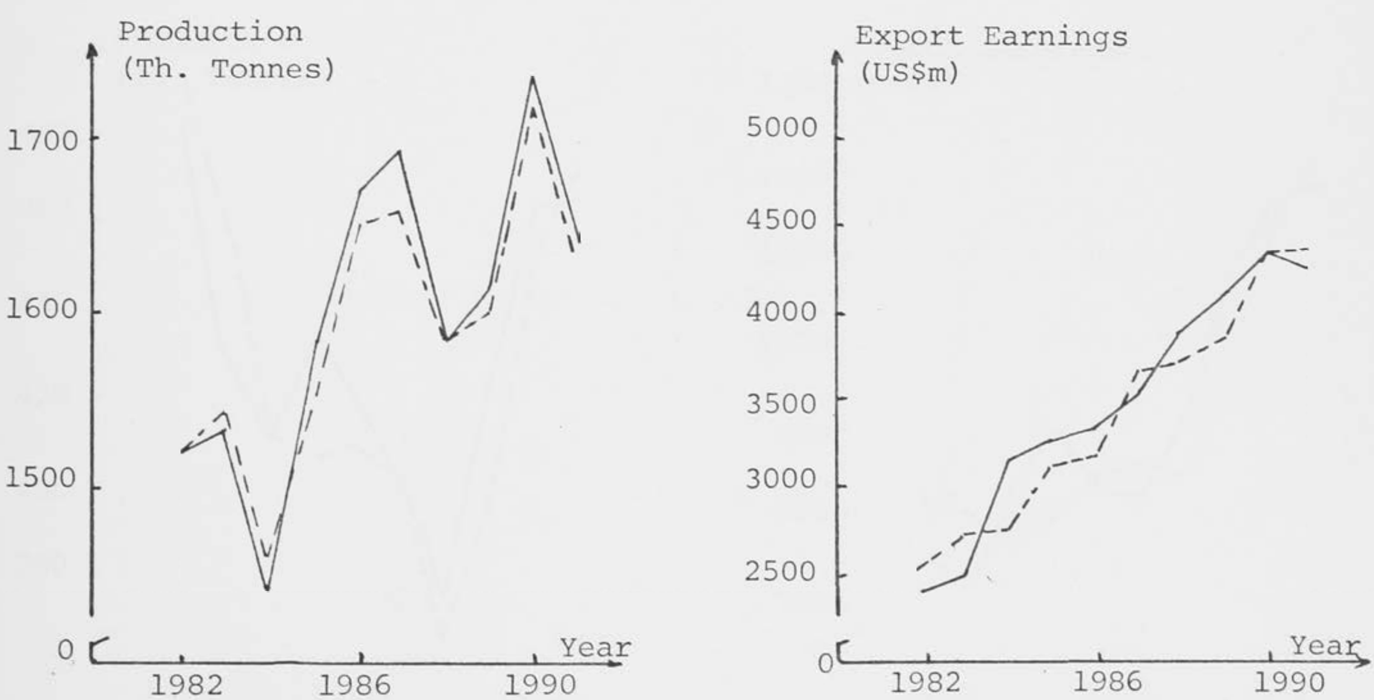


Figure A9.4: Time Paths of Natural Rubber Supply and Export Earnings, Malaysia. (Equidistant Price Bands)

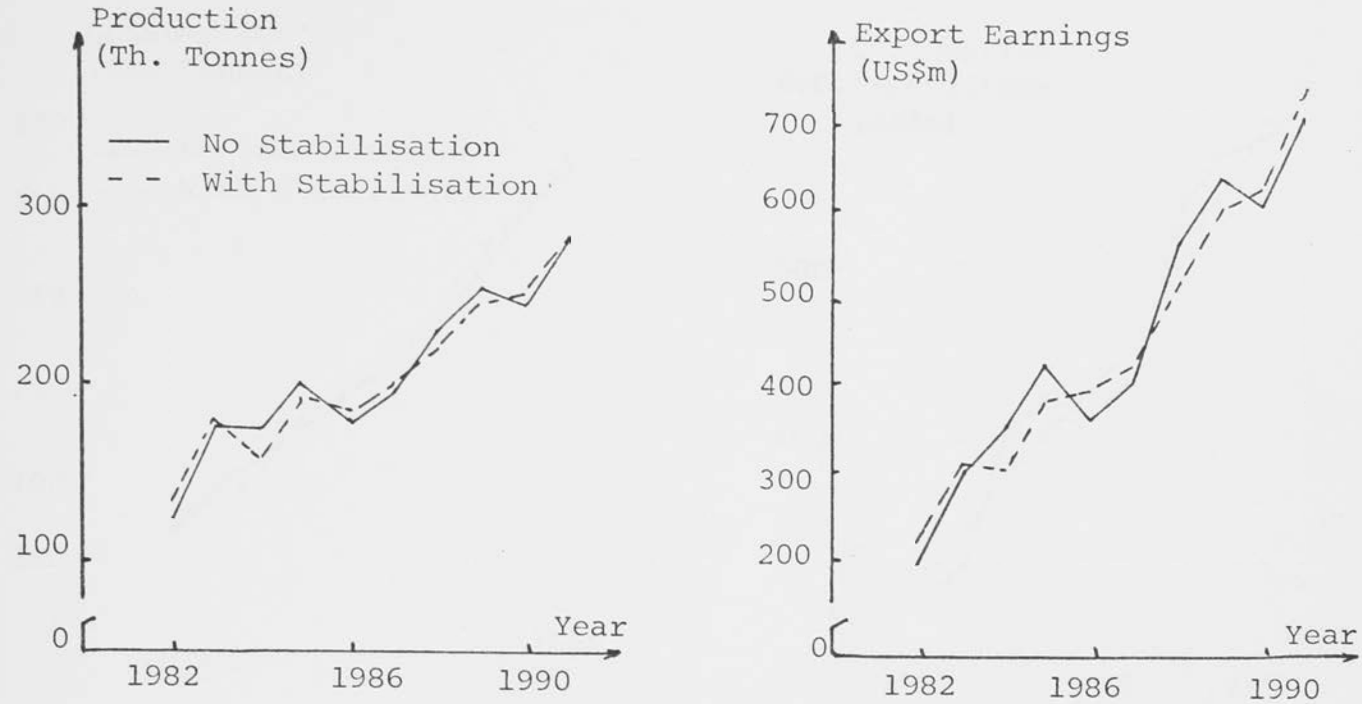


Figure A9.5: Time Paths of Natural Rubber Supply and Export Earnings, Sri Lanka. (Equidistant Price Bands)

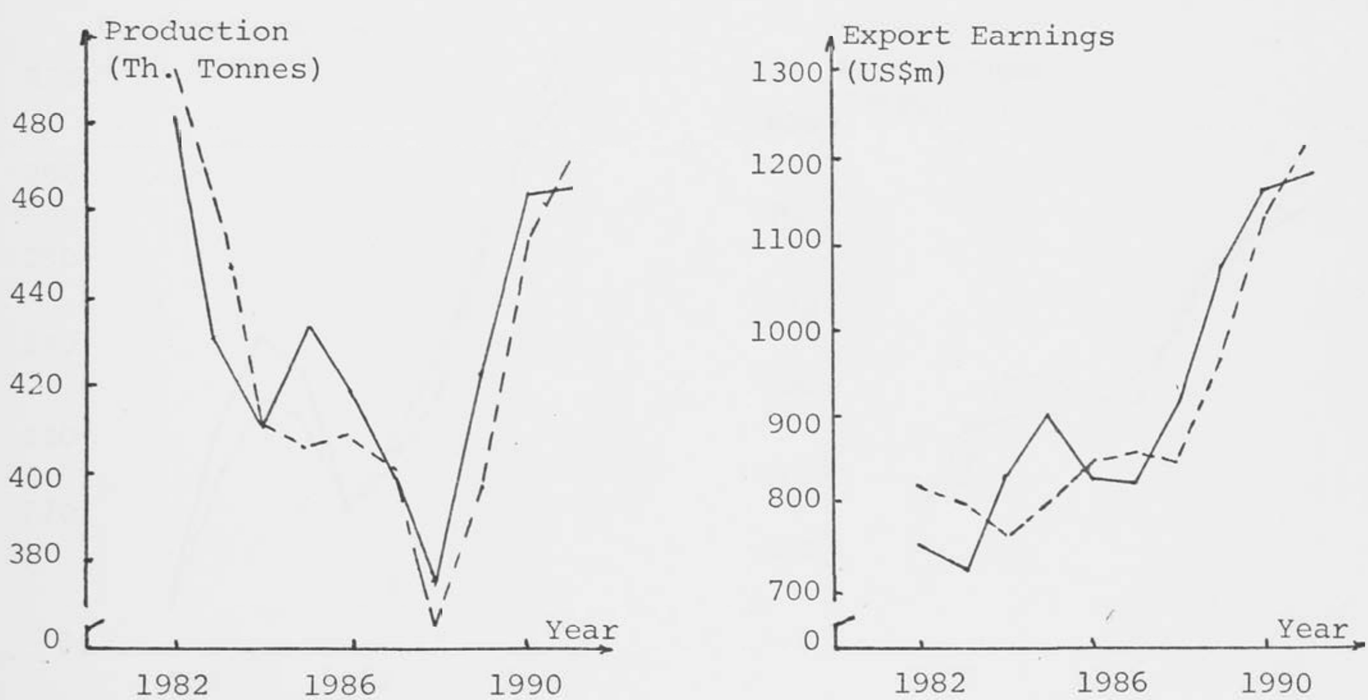


Figure A9.6: Time Paths of Natural Rubber Supply and Export Earnings, Thailand. (Equidistant Price Bands)

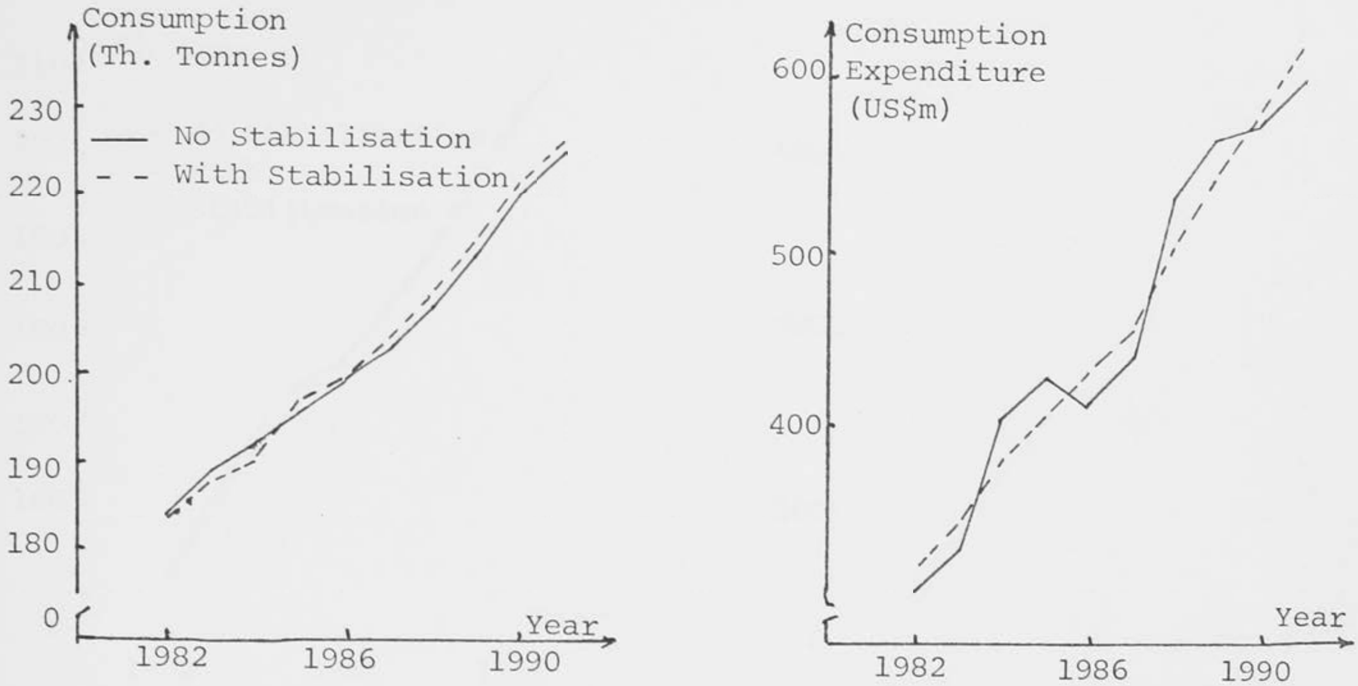


Figure A9.7: Time Paths of Natural Rubber Consumption, France. (Equidistant Price Bands)

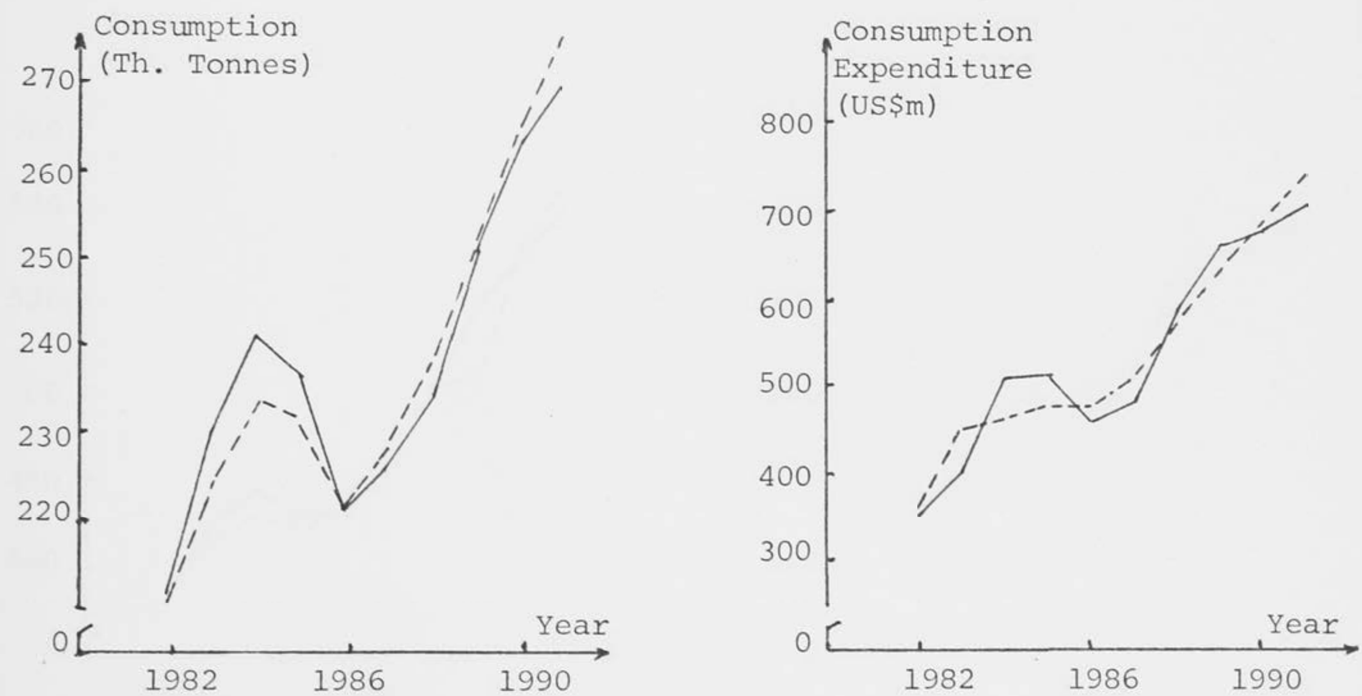


Figure A9.8: Time Paths of Natural Rubber Consumption, West Germany. (Equidistant Price Bands)

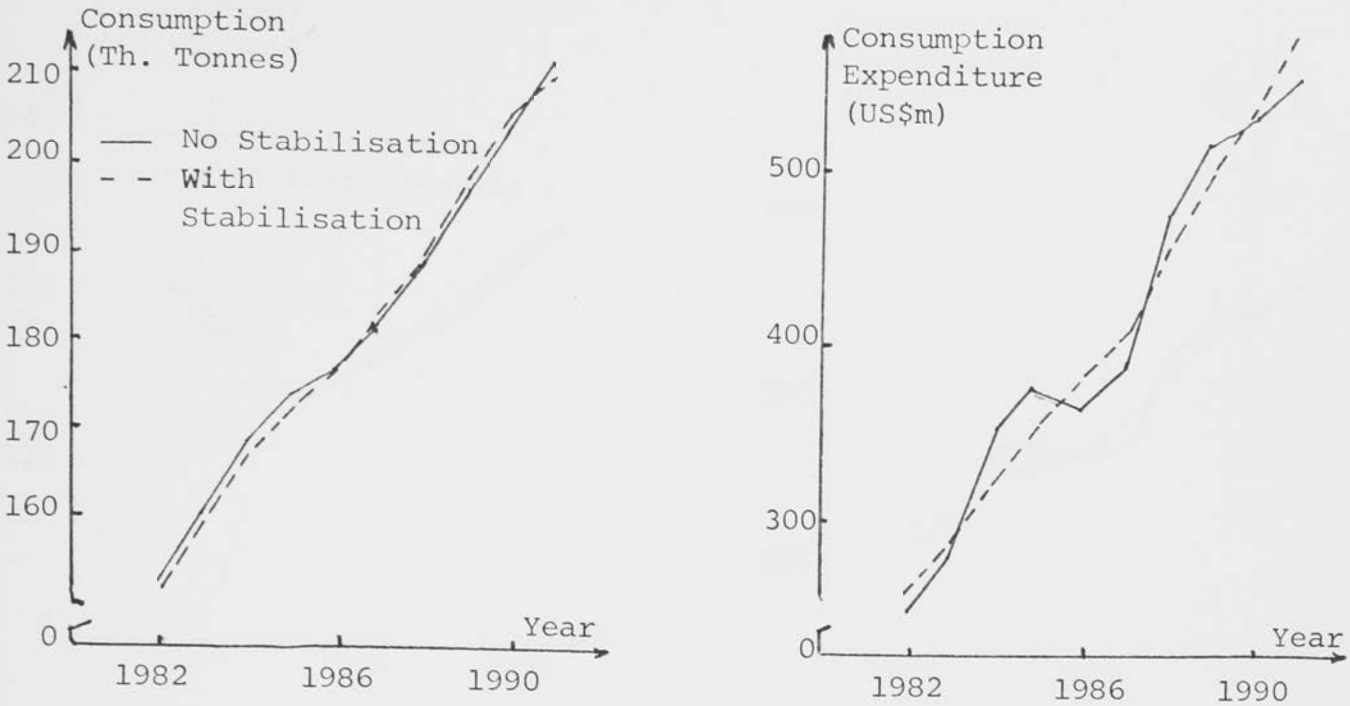


Figure A9.9: Time Paths of Natural Rubber Consumption, Italy. (Equidistant Price Bands)

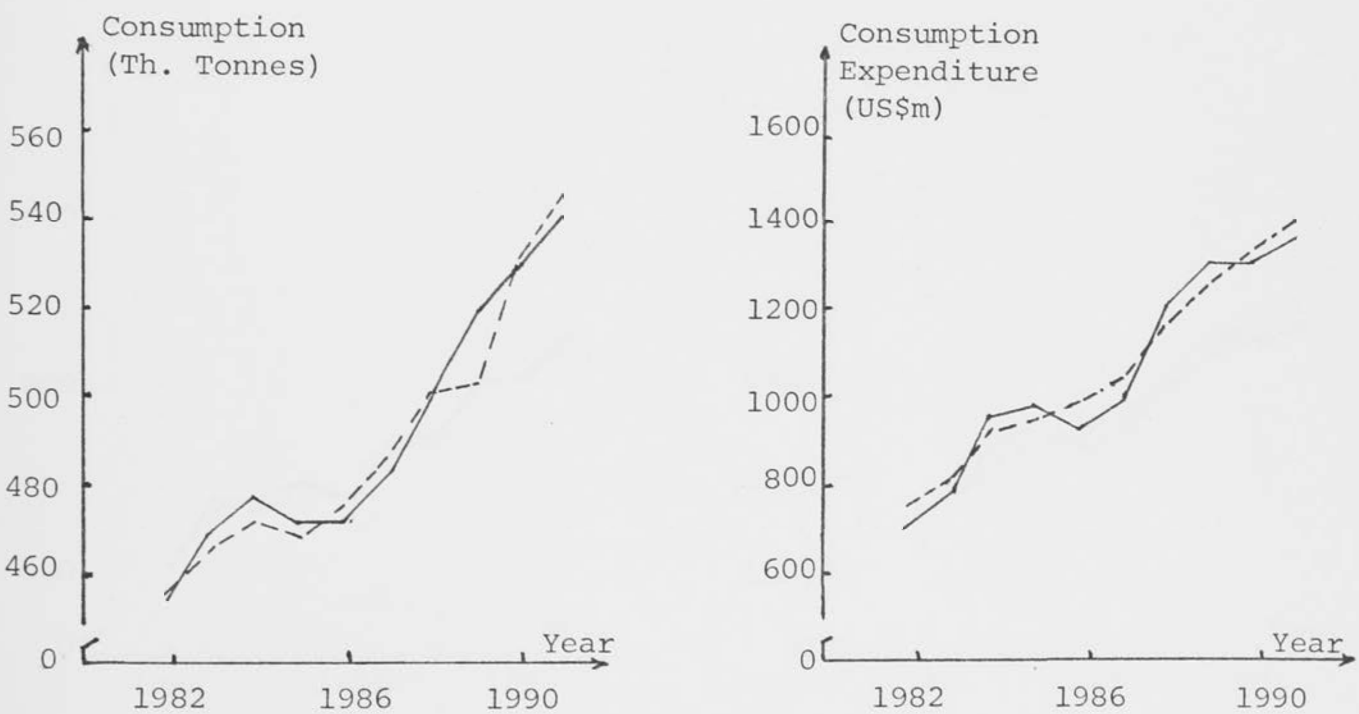


Figure A9.10: Time Paths of Natural Rubber Consumption, Japan. (Equidistant Price Bands)

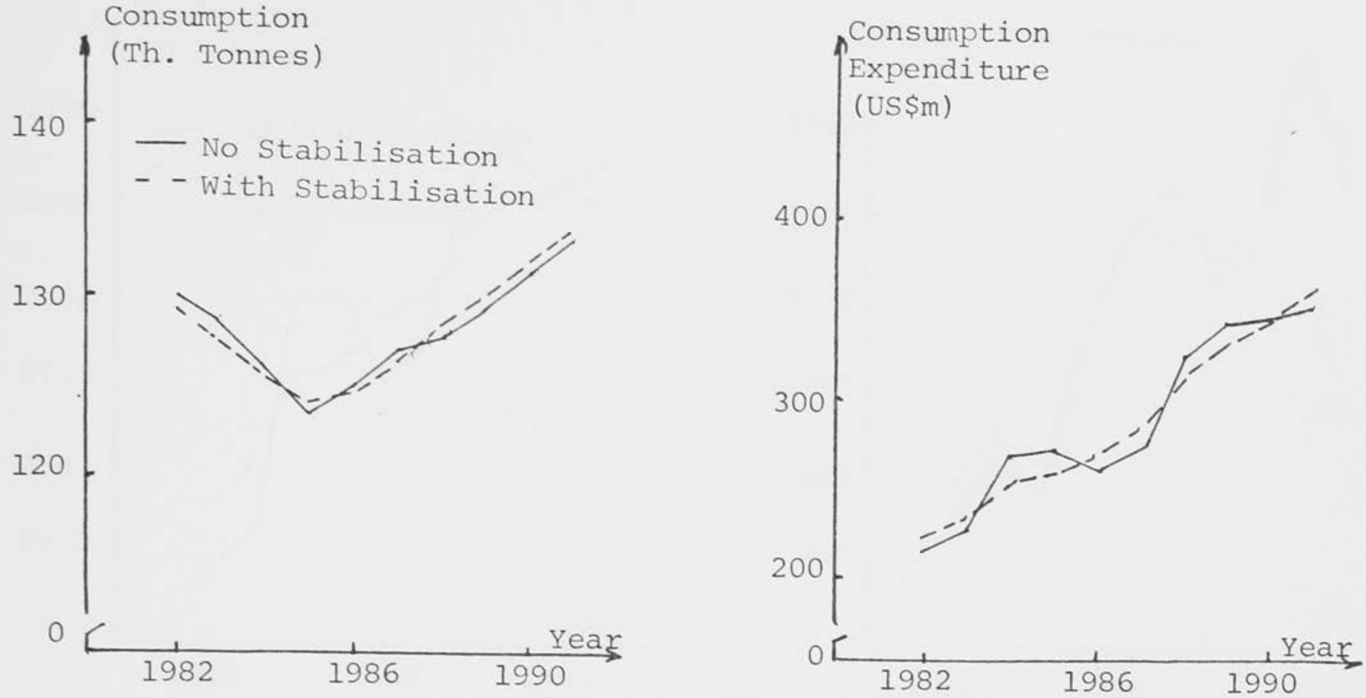


Figure A9.11: Time Paths of Natural Rubber Consumption, UK. (Equidistant Price Bands)

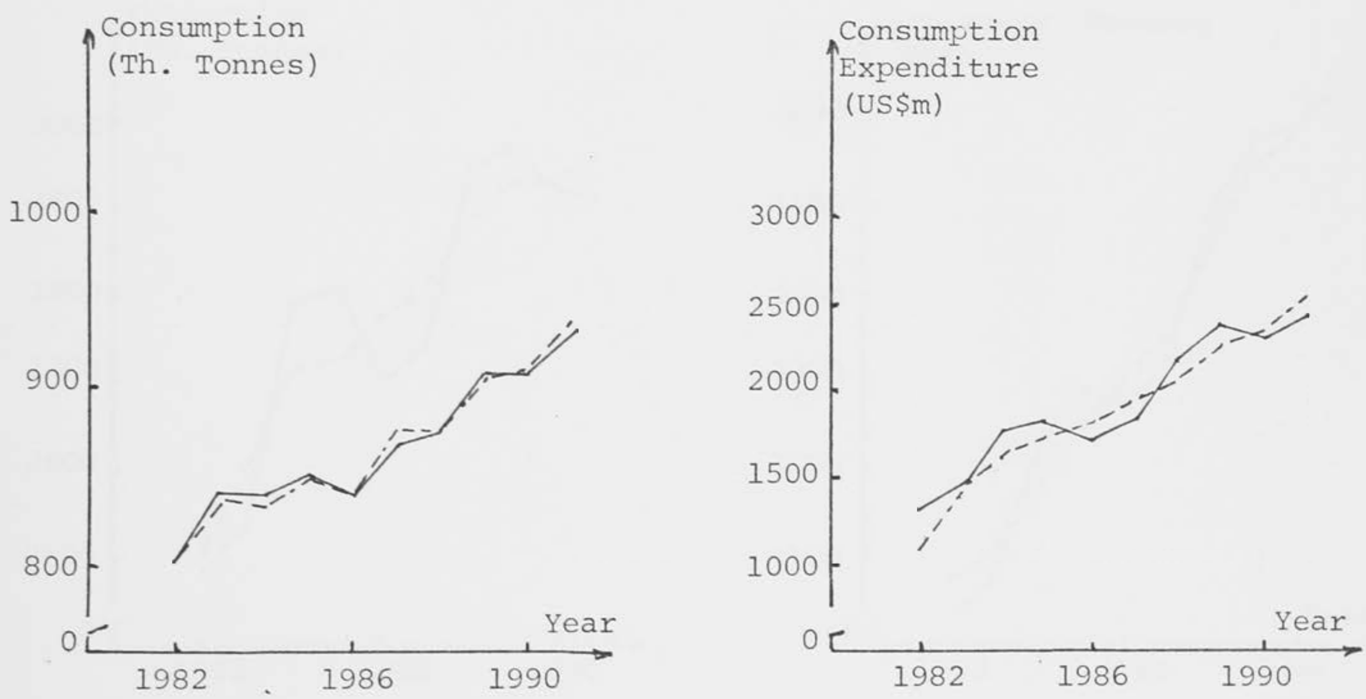


Figure A9.12: Time Paths of Natural Rubber Consumption, USA. (Equidistant Price Bands)

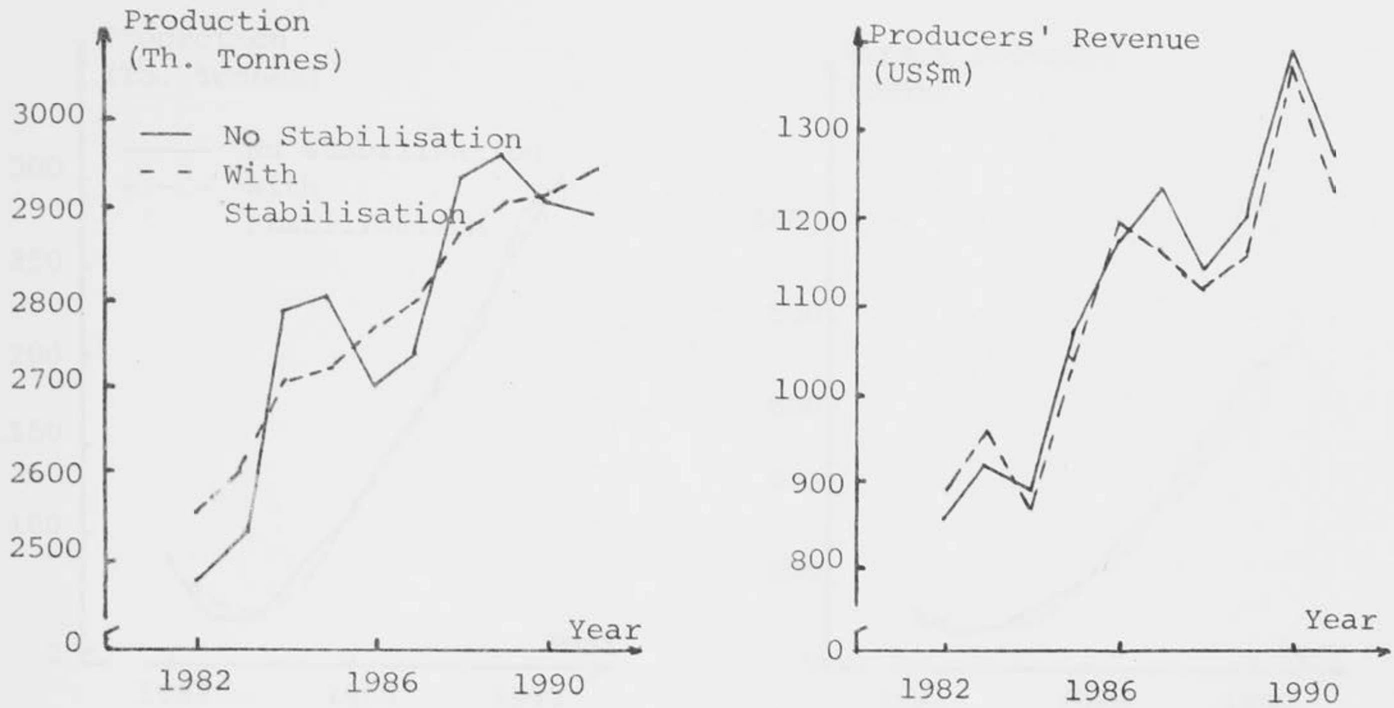


Figure A9.13: Time Paths of Natural Rubber Supply and Producers' Revenue, Malaysian Estates. (Equidistant Price Bands)

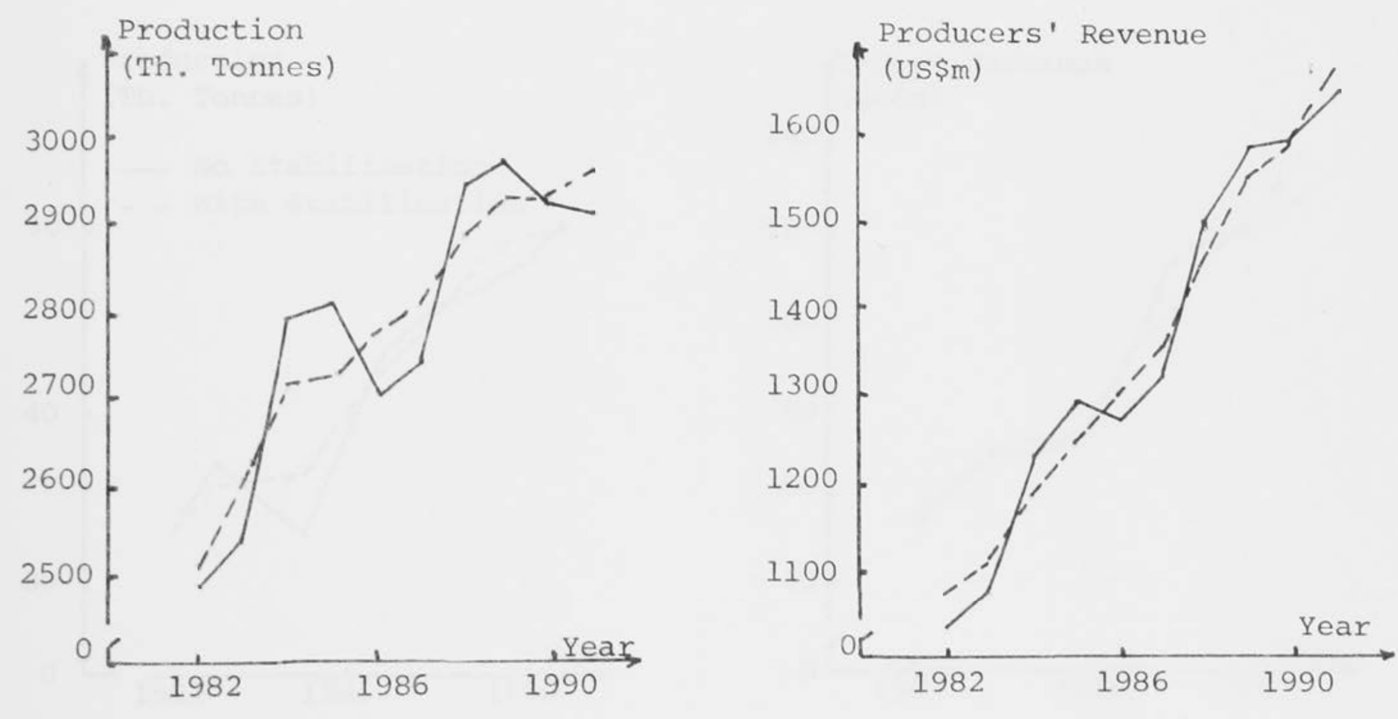


Figure A9.14: Time Paths of Natural Rubber Supply and Producers' Revenue, Malaysian Smallholders. (Equidistant Price Bands)

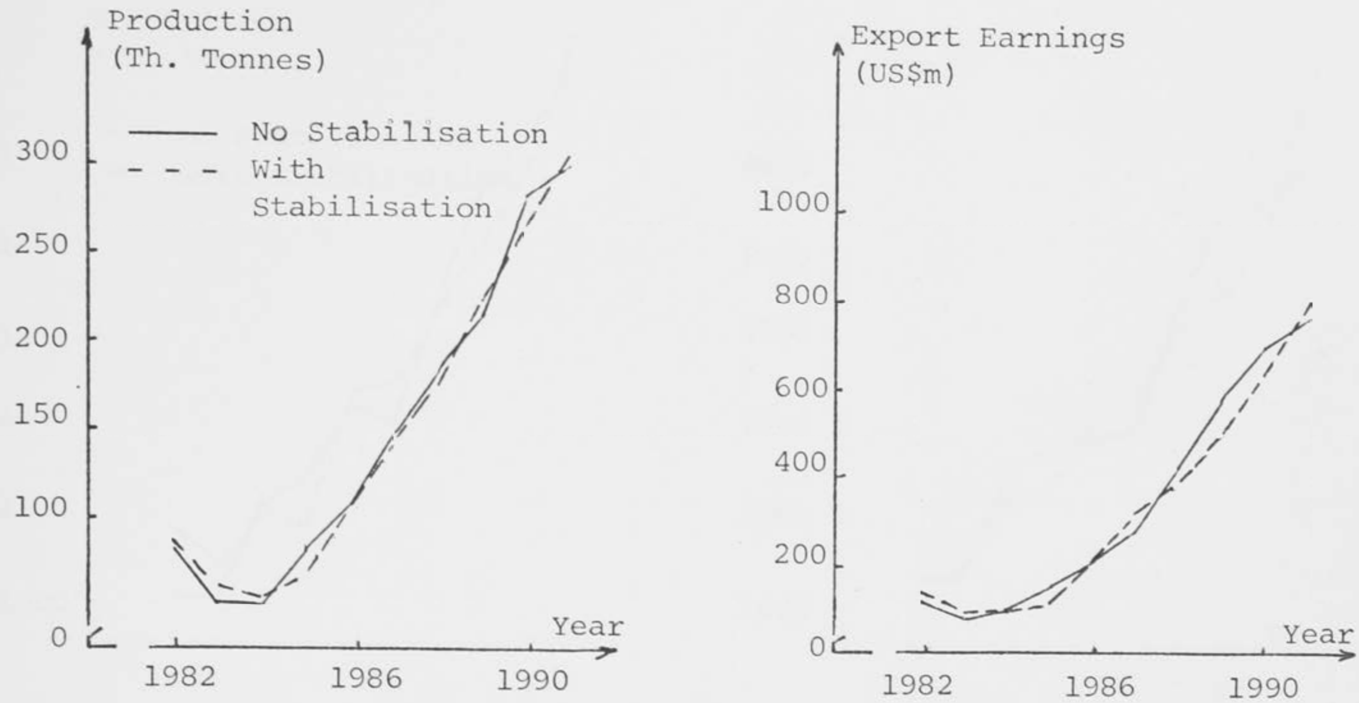


Figure A9.15: Time Paths of Natural Rubber Supply and Export Earnings, Africa. (Non-Equidistant Price Bands)

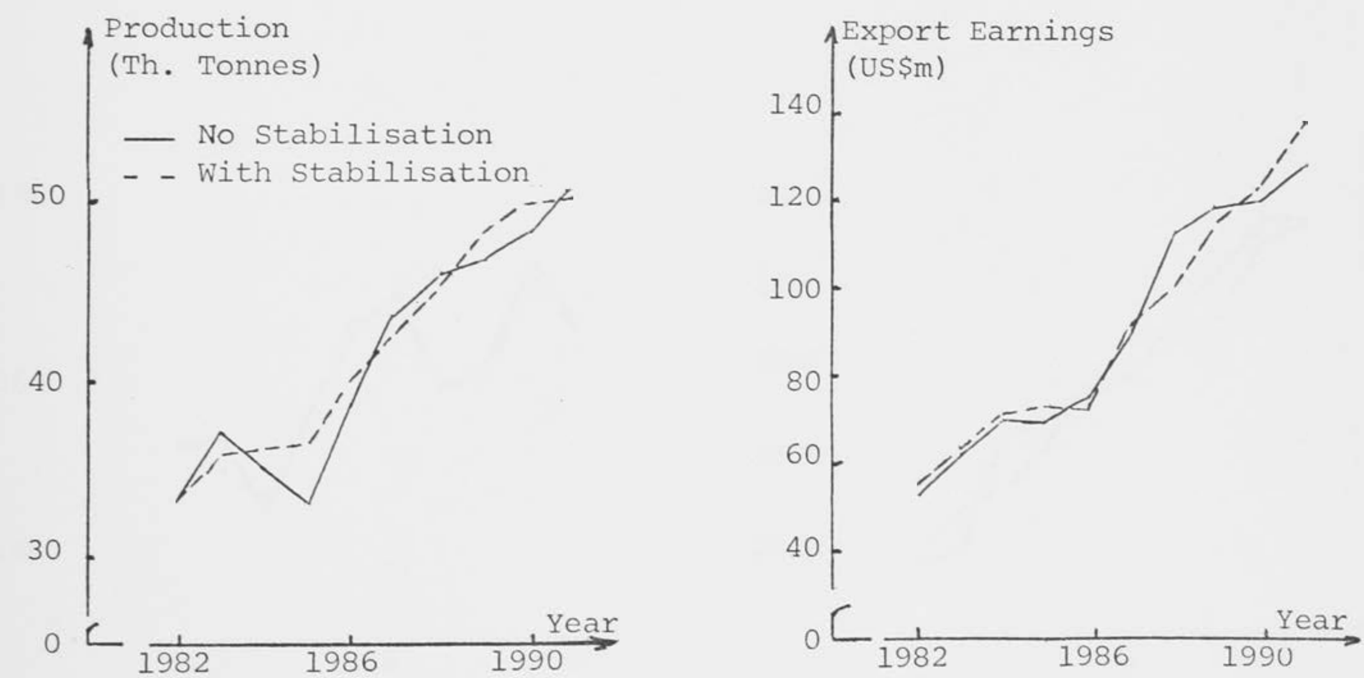


Figure A9.16: Time Paths of Natural Rubber Supply and Export Earnings, Brazil. (Non-Equidistant Price Bands)

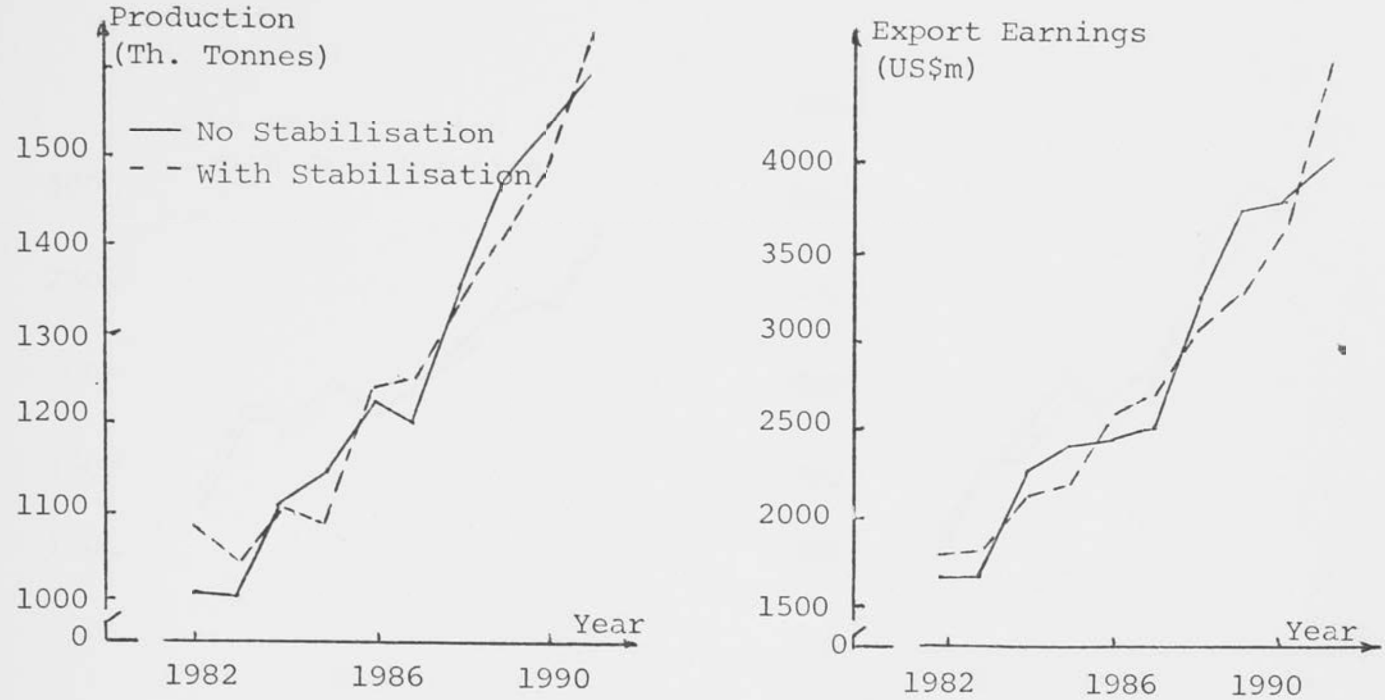


Figure A9.17: Time Paths of Natural Rubber Supply and Export Earnings, Indonesia. (Non-Equidistant Price Bands)

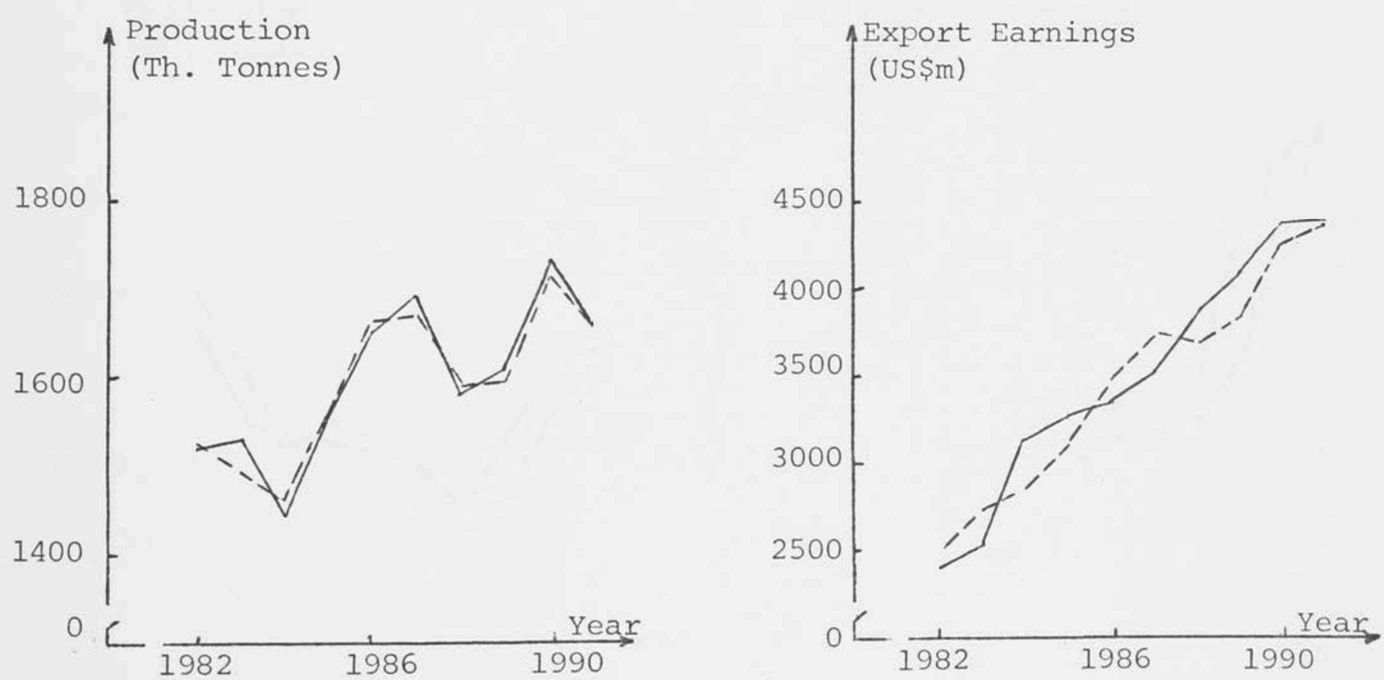


Figure A9.18: Time Paths of Natural Rubber Supply and Export Earnings, Malaysia. (Non-Equidistant Price Bands)

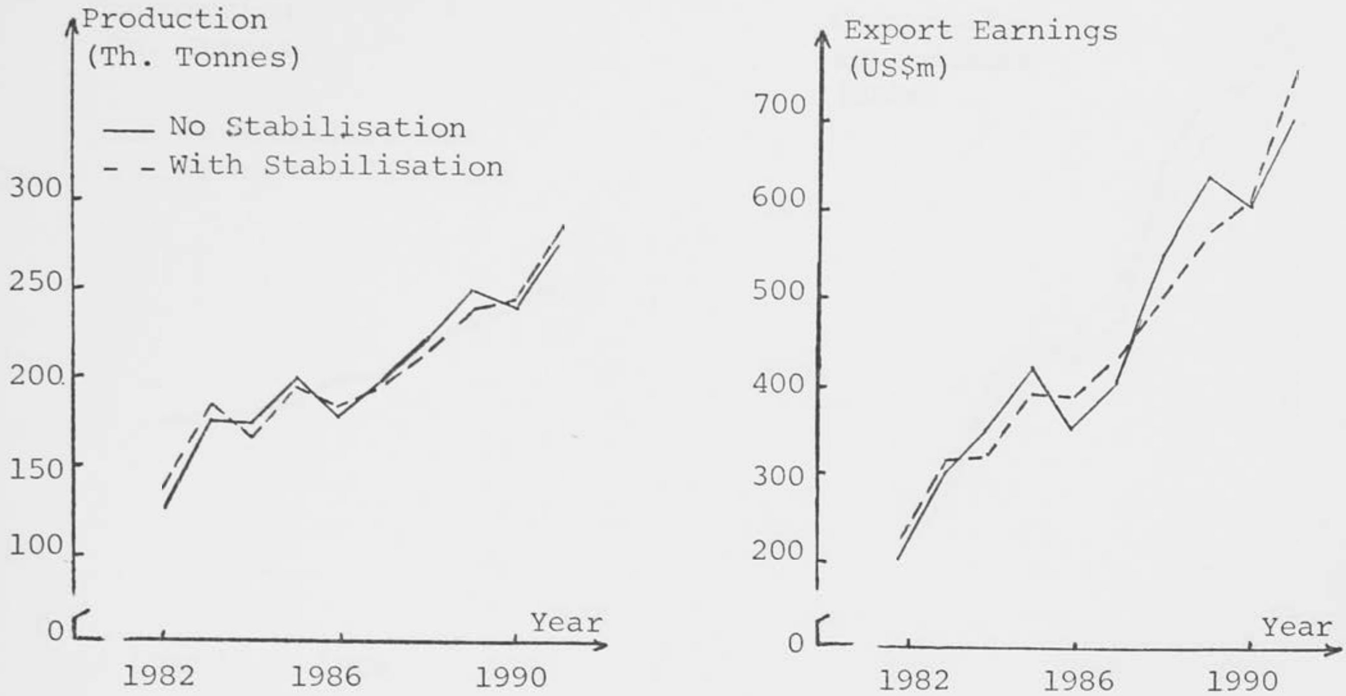


Figure A9.19: Time Paths of Natural Rubber Supply and Export Earnings, Sri Lanka. (Non-Equidistant Price Band)

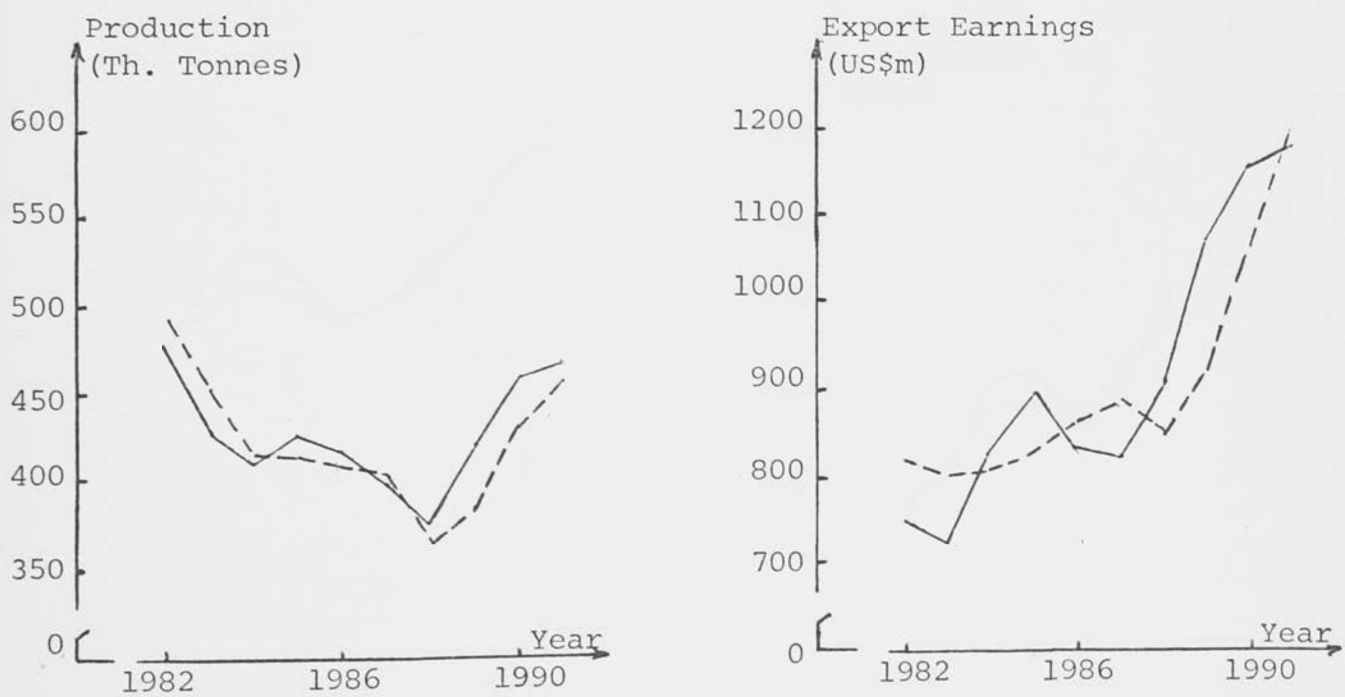


Figure A9.20: Time Paths of Natural Rubber Supply and Export Earnings, Thailand (Non-Equidistant Price Band)

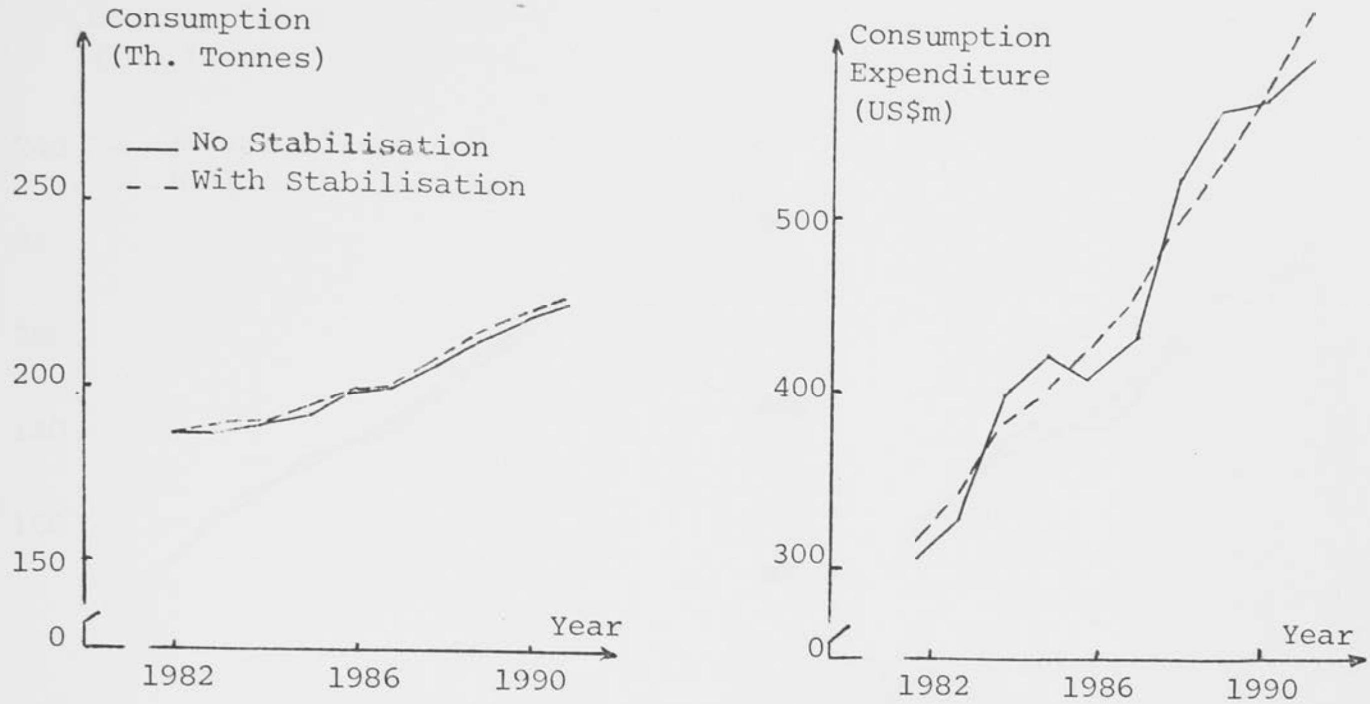


Figure A9.21: Time Paths of Natural Rubber Consumption, France.
(Non-Equidistant Price Bands)

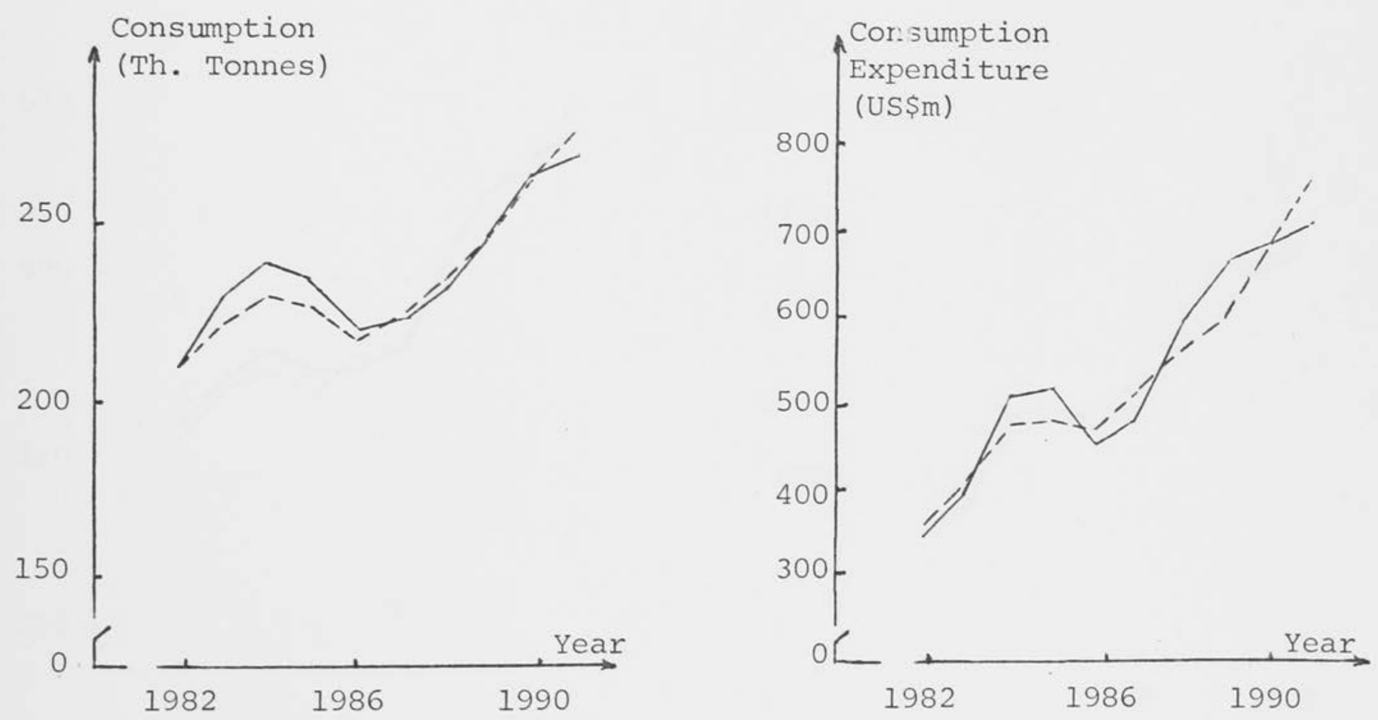


Figure A9.22: Time Paths of Natural Rubber Consumption, West Germany.
(Non-Equidistant Price Bands)

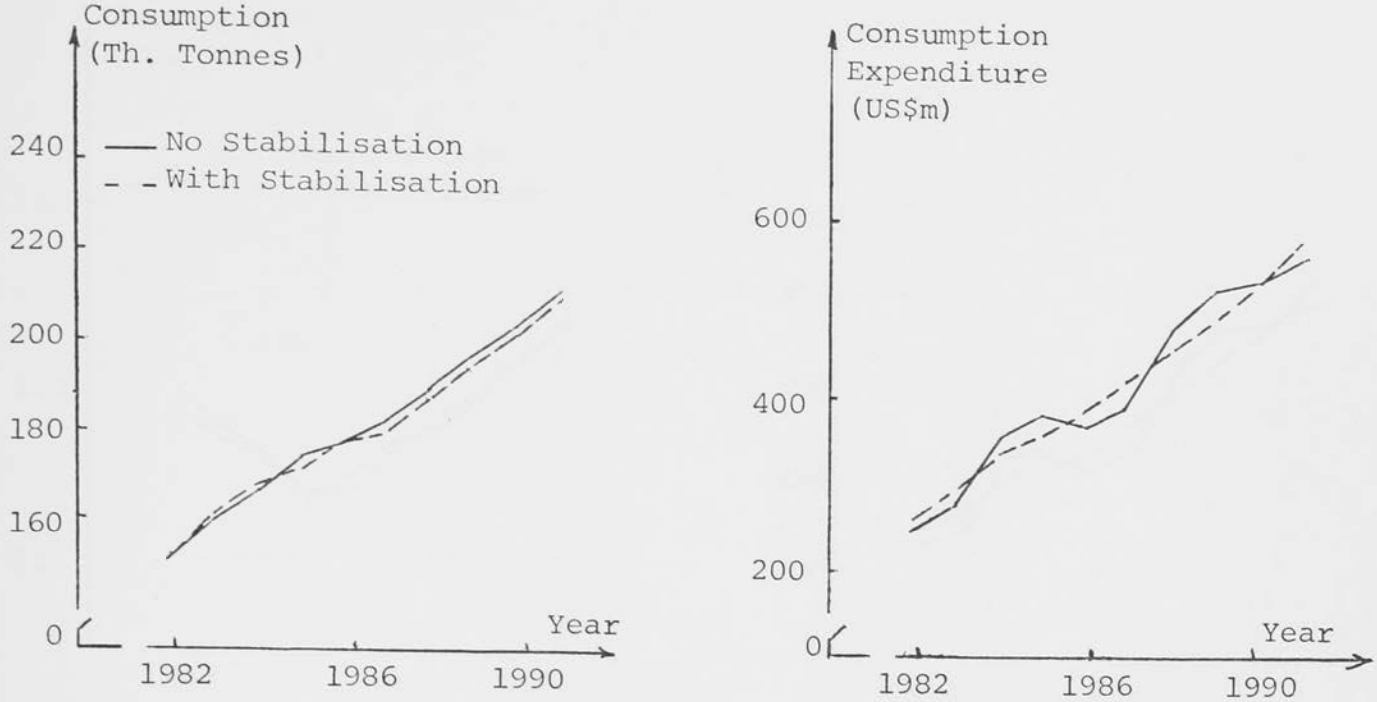


Figure A9.23: Time Paths of Natural Rubber Consumption, Italy. (Non-Equidistant Price Bands)

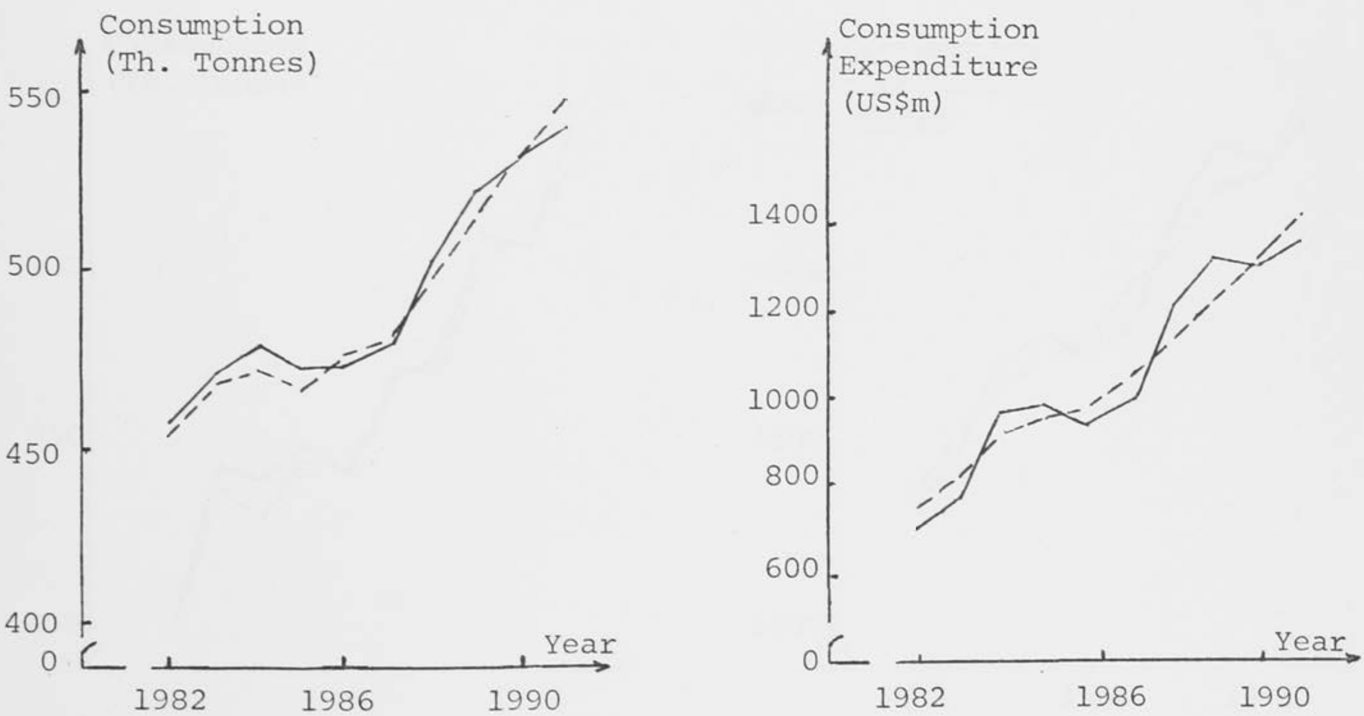


Figure A9.24: Time Paths of Natural Rubber Consumption, Japan. (Non-Equidistant Price Bands)

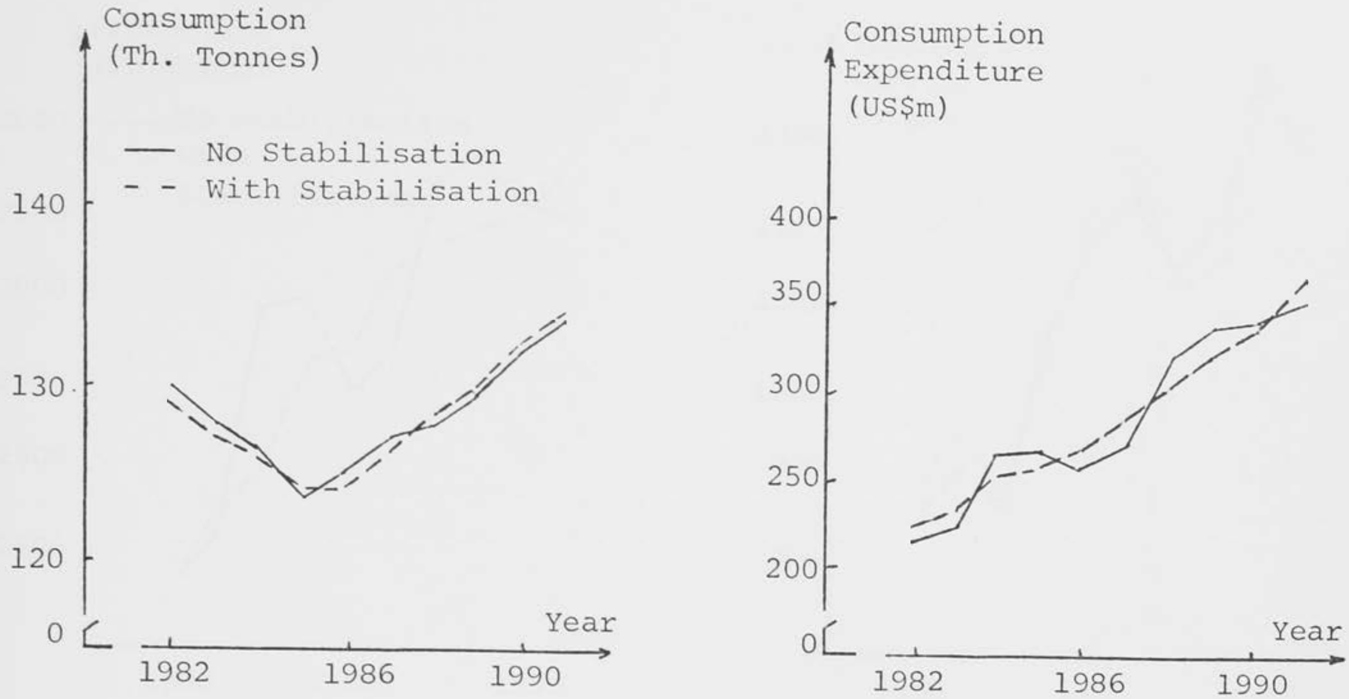


Figure A9.25: Time Paths of Natural Rubber Consumption, UK. (Non-Equidistant Price Bands)

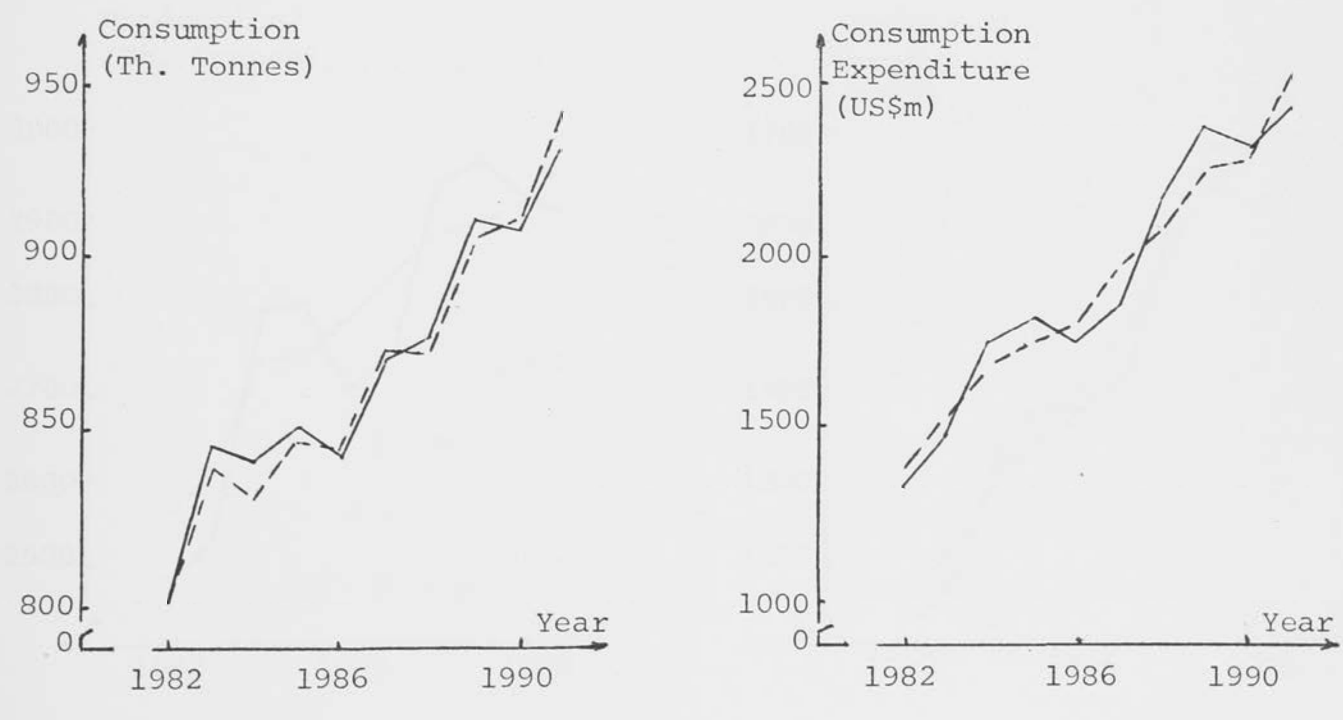


Figure A9.26: Time Paths of Natural Rubber Consumption, USA. (Non-Equidistant Price Bands)

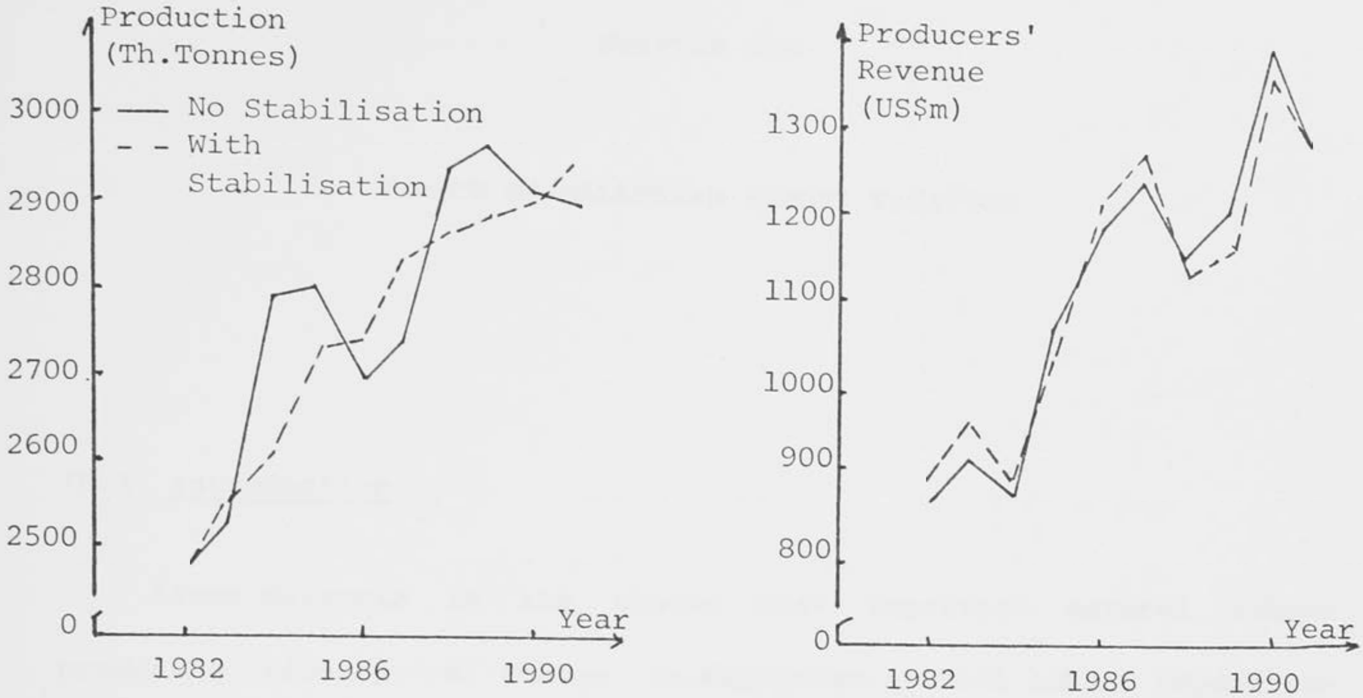


Figure A9.27: Time Paths of Natural Rubber Supply and Producers' Revenue, Malaysian Estates. (Non-Equidistant Price Bands)

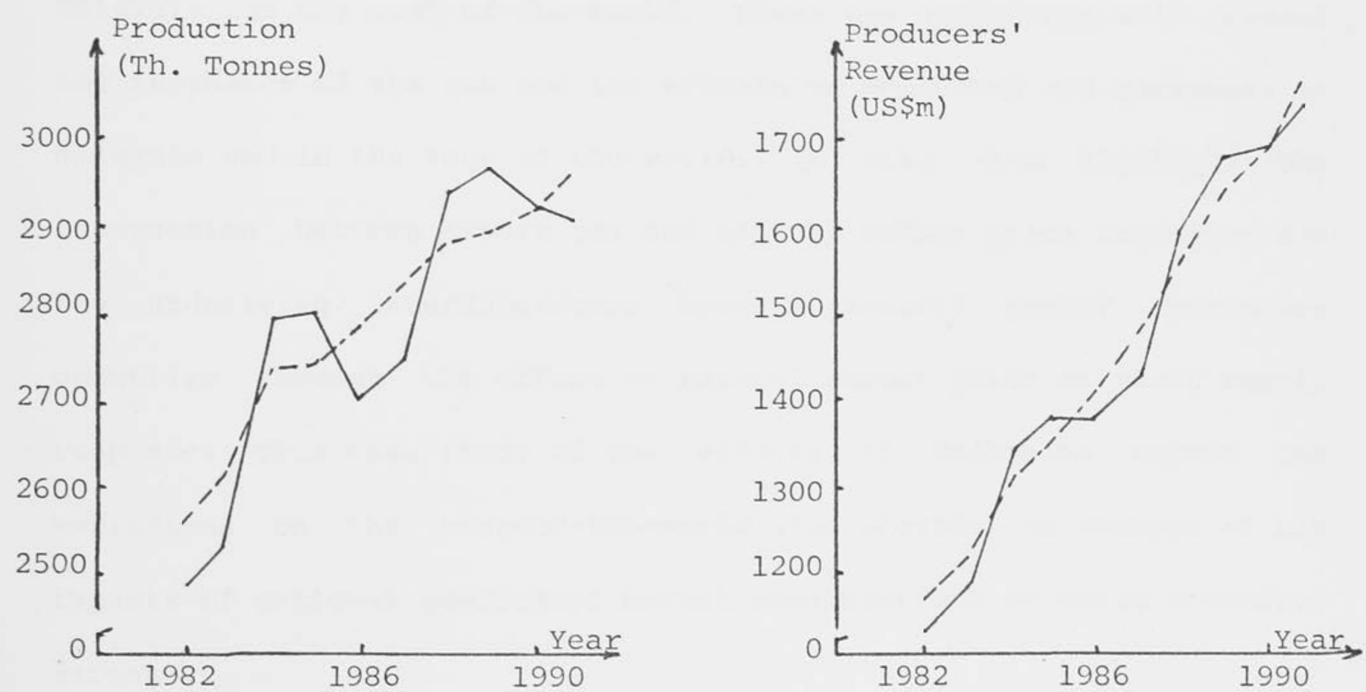


Figure A9.28: Time Paths of Natural Rubber Supply and Producers' Revenue, Malaysian Smallholders. (Non-Equidistant Price Bands)

CHAPTER TEN

IMPACT OF MALAYSIAN EXPORT TAXATION

10.1 Introduction

Since Malaysia is the single most important natural rubber producing country, a change in Malaysian natural rubber production would, *ceteris paribus*, affect total world production, and hence world price. This final chapter examines the role of Malaysian natural rubber export tax in the world rubber market, by varying the level of export taxes and examining the consequences of such tax variations on Malaysia and the rest-of-the-world. These tax variations will reveal the incidence of the tax and its effects on producers and consumers in Malaysia and in the rest of the world. It will also highlight the interaction between export tax and natural rubber price formation and the underlying interdependence between natural rubber producing countries through the effect of natural rubber price on their supply response. This case study of the effects of Malaysian export tax variations on the rest-of-the-world also provides an example of the impacts of national government market interventions on world commodity markets.

10.2 Effects of Lower Malaysian Export Taxes

The Malaysian export tax rates will be varied in order to evaluate the sensitivity of natural rubber price formation to the levels of this tax. The effects of lower export tax rates will be examined within the context of the world rubber market under low oil price scenario. In doing this, the forecast values of prices, production and consumption under alternative tax rates will be compared with the forecast values in the free market (without stabilisation) presented in Chapter Eight.

In varying the export tax rates, it was found that the world rubber market under a low oil price scenario was insensitive to a 15 percent reduction in the existing rate. But the market was found to be sensitive if the export taxes were reduced by 30 percent. The effects of a 30 percent reduction in Malaysian export taxes on world production and consumption will now be discussed.

Under a 30 percent reduction, the generalised export tax functions now become:

$$t^S = 0.08 \qquad \text{if} \quad PN \leq \$1540$$

$$= 0.08 + 0.0642(PN - 1540/1000) \qquad \text{if} \quad \$1540 < PN \leq \$2800$$

$$= 0.1610 + 0.0525(PN - 2800/1000) \qquad \text{if} \quad PN > \$2800$$

and

$$t^E = (22.0500/PN) \qquad \text{if} \qquad PN \leq \$1540$$

$$= 0.0280 + 0.0914(PN - 1540/1000) \qquad \text{if } \$1540 < PN \leq \$3000$$

$$= 0.1600 + 0.0555(PN - 3000/1000) \qquad \text{if} \qquad PN > \$3000$$

The lowering of export taxes by 30 percent means that producers will receive a higher share of world prices. Malaysian producers will respond to these higher 'farmgate' prices by increasing production, thereby raising world natural rubber output. Although natural rubber price is determined by the demand for stocks in the consuming regions, it is also negatively related to the volume of world natural rubber output. The higher Malaysian output, and hence higher world output will lead to a fall in world price unless this higher output is matched by a corresponding rise in demand for stockholdings in the consuming regions. The interest here is to see whether in the final outcome the tax falls mainly on the suppliers or on the buyers. This question of tax incidence is complicated in a dynamic model because of the lagged effects of any tax change "shock" to the world market.

Table 10.1 presents the various natural rubber prices under the existing tax rates and those lowered by 30 percent. The various price series shown in Table 10.1 are as expected: price net of export tax received by Malaysian producers are <u>higher</u> when the export tax rates are reduced. But the 30 percent reduction in Malaysian export taxes results in a maximum fall in world prices of 2 percent only over the whole period. These results substantiate the argument that despite

Table 10.1: Comparison of Price Forecasts Under Alternative Export Tax Rates, 1981-1995

Year	Existing Tax Rates			Reduced Tax Rates		
	PN^{Spot}	PN^{Sing}	PN^{Sing}-Tax	PN^{Spot}	PN^{Sing}	PN^{Sing}-Tax
1981	657.78	2810.00	2221.00	656.90	2807.20	2403.45
1982	802.23	3324.80	2476.90	794.70	3276.40	2701.90
1983	855.76	3457.40	2540.40	844.20	3415.60	2790.30
1984	1031.87	4045.20	2789.20	1019.00	3977.40	3125.30
1985	1062.63	4063.50	2796.10	1053.30	4013.10	3145.40
1986	998.00	3811.60	2696.70	987.70	3737.50	2986.50
1987	1048.55	3923.60	2742.10	1042.00	3928.70	3097.60
1988	1218.10	4476.60	2938.00	1203.70	4429.40	3369.30
1989	1278.40	4547.70	2959.80	1266.00	4496.80	3403.70
1990	1233.78	4395.00	2912.00	1221.50	4325.30	3315.10
1991	1258.40	4363.70	2901.80	1261.40	4345.80	3325.88
1992	1345.57	4477.40	2938.30	1342.20	4470.80	3390.50
1993	1434.72	4586.00	2971.20	1420.70	4531.70	3421.40
1994	1499.40	4657.60	2991.90	1480.80	4607.35	3459.20
1995	1491.48	4454.30	2931.00	1465.00	4382.40	3345.00

Notes: (1) PN^{Spot} refers to the London Spot price for RSS1-grade natural rubber, in Sterling Pounds per tonne.

(2) PN^{Sing} refers to the f.o.b. Singapore price for RSS1-grade natural rubber, in Singapore Dollars per tonne.

(3) PN^{Sing}-Tax refers to the f.o.b. Singapore net of export tax for RSS1-grade natural rubber, in Singapore Dollars per tonne.

being a major producer, Malaysia nevertheless remains basically a price taker in the world rubber market. Hence the tax falls chiefly on the Malaysian suppliers and there is negligible terms of trade effect.

As world price remains relatively unaffected by a reduction in Malaysian export taxes, the overall effects of price stabilisation by buffer stock operations are similar to those reported earlier and will not be repeated here. The focus here will therefore be on comparing the effects of stabilised prices on Malaysian production, producers' revenue and export tax revenues under the two different tax regimes. Since Malaysian smallholder production was treated exogenously, the comparison of export tax effects concern Malaysian estate production only.

Table 10.2 compares the behaviour of Malaysian estate production under the two different export tax regimes and equidistant price band stabilisation about the price of S$3650. From Table 10.2 it can be seen that a downward adjustment of export tax results in an all-round gain to estates as one would expect. Increased output leads to higher export earnings. However, the biggest gain due to reduced export taxes accrue to producers' revenue which rises by 23 percent. Thus it can be inferred that, in the absence substantial terms of trade effects, the burden of export taxation falls almost entirely on producers. For the Malaysian government, lower export taxes will mean a fall in natural rubber export tax revenue, but this is more than offset by the tax revenue from a higher volume of exports; the net effect of <u>lowering</u> export taxes by 30 percent is an <u>increase</u> in export revenue by almost 5 percent.

Table 10.2: Effects of Alternative Export Tax Rates and Price Stabilisation on Malaysian Estate Production, Export Earnings, Producers' Revenue and Export Tax Revenue, 1982-1991.

Variable	Higher Export Tax Rates	Lower Export Tax Rates	Increase (%)
Output	6740.9	7223.8	7.2
Export Earnings	24347.4	28955.8	18.9
Producer's Revenue	18680.3	23017.9	23.2
Export Tax Revenue	5667.1	5937.9	4.8

Notes: (1) Outout refers to estate natural rubber production in thousand tonnes.

(2) Export Earnings, Producer's Revenues and Export Tax Revenues are in Million Singapore Dollars.

10.3 Effects of Zero Malaysian Export Taxation

This section examines the role of Malaysian natural rubber export tax in the world rubber market by examining the interaction between this tax and other key variables when tax is reduced to zero. In doing so, the pattern of interaction between variables in the model will also be highlighted.

In section 10.2 above, it was found that a 30 percent reduction in export tax lowers world price by 2 percent at most. Hence the effect of this partial tax reduction on other variables is marginal. To illustrate the interaction between export tax and other variables more clearly, a 100 percent tax reduction will now be applied so that Malaysian producers will receive the full world price. The effect of this higher 'farmgate' price on producers in other countries and on consumers, other things remaining constant, will now be discussed.

The forecast prices of natural rubber with and without Malaysian natural rubber export tax are compared in Table 10.3. As before, the reduced tax will mean higher prices for producers who will respond by increasing output. This will lead to higher world production and hence lower world prices. However, Malaysian producers now receive the world price in full. As seen from Table 10.3, the price rise for Malaysian producers due to zero export taxes range from 25.4 to 49.7 percent. In contrast, the fall in world prices range from 0.9 to 5.3 percent only.

Table 10.4 shows the effects on Malaysian estate production when export tax is reduced to zero. While such tax reduction will cause estate production to rise by 23.5 percent, the increase in producers'

Table 10.3: Forecasts of Natural Rubber Prices With and Without Export Tax in Malaysia, 1981-1995

Year	With Export Tax			Without Export Tax		
	PN^{Spot} (1)	PN^{Sing} (2)	PN^{Sing}-Tax (3)	PN^{Spot} (4)	PN^{Sing} (5)	$\equiv PN^{Sing}$-Tax (6)
1981	657.78	2810.00	2221.00	653.05	2785.60 (-0.9%)	(+25.4)
1982	802.23	3324.80	2476.90	782.31	3237.50 (-2.6%)	(+30.7)
1983	855.76	3457.40	2540.40	816.70	3280.70 (-5.1%)	(+29.1)
1984	1031.87	4045.20	2789.20	993.89	3875.00 (-4.2%)	(+38.9)
1985	1062.63	4063.50	2796.10	1021.42	3917.10 (-3.6%)	(+40.1)
1986	998.00	3811.60	2696.70	953.07	3608.70 (-5.3%)	(+33.8)
1987	1048.55	3923.60	2742.10	1021.73	3822.10 (-2.6%)	(+39.4)
1988	1218.10	4476.60	2938.00	1192.91	4387.50 (-2.0%)	(+49.3)
1989	1278.40	4547.70	2959.80	1244.88	4422.90 (-2.7%)	(+49.3)
1990	1233.78	4395.00	2912.00	1195.10	4231.70 (-3.7%)	(+45.3)
1991	1258.40	4363.70	2901.80	1232.97	4278.90 (-1.9%)	(+47.5)
1992	1345.57	4477.40	2938.30	1318.32	4355.80 (-2.7%)	(+48.2)
1993	1434.72	4586.00	2971.20	1392.17	4472.70 (-2.5%)	(+50.5)
1994	1499.40	4657.60	2991.90	1437.36	4477.50 (-3.9%)	(+49.7)
1995	1491.48	4454.30	2931.00	1405.08	4238.10 (-4.9%)	(+44.6)

Notes: (1) PN^{Spot} refers to the London Spot price for RSS1-grade natural rubber, in Sterling Pounds per tonne.

(2) PN^{Sing} refers to the f.o.b. Singapore price for RSS1-grade natural rubber, in Singapore Dollars per tonne.

(3) PN^{Sing}-Tax refers to the f.o.b. Singapore price net of Export Tax for RSS1-grade natural rubber, in Singapore Dollars per tonne.

(4) Figures within parentheses are percentage changes between Corresponding prices With and Without export tax.

Table 10.4: Effects of Export Tax on Malaysian Estate, Production, Export Earnings, Producers' Revenue and Export Tax Revenue, 1982-1991.

Variable	With Export Tax	Without Export Tax	Difference(%)
Output	6740.9	8326.1	+23.5
Export Earnings	24347.4	32465.9	+33.3
Producers' Revenue	18680.3	32465.9	+73.8
Export Tax Revenue	5667.1	0.0	-100.0

Notes: (1) Output refers to estate natural rubber production in thousand tonnes.

(2) Export Earnings, Producers' Revenue and Export Tax Revenue are in Million Singapore Dollars.

revenue amounts to nearly 74 percent. At the national level, export earnings from estate production will rise by 33.3 percent but the tax revenue from this source of exports is now reduced by the full 100 percent. The effects of reduced export taxes on Malaysian smallholder producers are not presented here because of the exogenous treatment of smallholder production so that smallholder supply is assumed to be unaffected by export tax variations. An implication of this is that the export tax discriminates in favour of smallholders' share of Malaysian production. However, it may be surmised that the qualitative effects of reduced export taxation on smallholders will be similar to those for estate production.

Table 10.5 compares natural rubber production in the main producing countries for 1982-1991 with and without Malaysian export taxes on natural rubber. For Malaysia, reducing export taxes completely is seen to induce a 9.8 percent increase in production over a 10-year period. However, such export tax reduction impacts on the remaining producing countries negatively. With the exception of Africa, all other producing countries/regions show reduced output by about 2 percent. Consequently, the net result is an increase in world output of less than 2 percent over the entire period.

The effect of zero export taxation in Malaysia on world rubber consumption and natural rubber consumption share will now be discussed. Since reduced export taxes mean lower world prices for natural rubber, a resultant increase in natural rubber consumption is to be expected due to the lower relative price of natural to synthetic rubbers. This substitution of natural for synthetic rubbers is borne out by Table 10.6. However the degree of substitution is marginal,

Table 10.5: Effects of Malaysian Export Tax on Natural Rubber Supply in Main Producing Countries, 1982-1991 (Thousand Tonnes)

Country	With Export Tax	Without Export Tax	Difference (%)
Africa	1523.1	1555.5	+2.1
Brazil	415.7	406.3	-2.3
Indonesia	12,700.4	12456.3	-1.9
Malaysia	16,021.6	17593.1	+9.8
Sir Lanka	2064.2	2029.3	-1.7
Thailand	4302.3	4181.9	-2.8
Rest-of-the-world	10865.8	10603.5	-2.4
World	47893.1	48825.9	+1.9

Table 10.6: Effects of Malaysian Export Tax on World Natural and Synthetic Rubbers Consumption, 1982-1991

Variable	With Export Tax	Without Export Tax	Difference (%)
Natural Rubber Consumption	46,865.6 (30.1)	47,602.5 (30.6)	+1.6
Synthetic Rubber Consumption	108,690.4 (69.9)	107,713.5 (69.4)	-0.9
Total Rubber Consumption	155,556.0(100.0)	155,316.0(100.0)	-0.2

since the natural rubber consumption share increases by 0.5 percentage point only over the entire 10-year period. Table 10.6 also shows an overall fall in rubber consumption of 0.2 percent, which averages to a fall of only 2000 tonnes total rubber consumption annually. Thus a maximum fall in world natural rubber price of 5 percent will induce an increase in natural rubber production of 1.6 percent over the same period, indicating the low price elasticity of substitution between natural and synthetic rubbers under the present industrial organisation.

Table 10.7 compares natural rubber consumption in the main consuming countries in situations with and without export tax in Malaysia during 1982-1991. The biggest increase in natural rubber consumption of 13 percent was in France while the USA -- the largest consumer -- was seen to increase natural rubber consumption by less than 1 percent. The value of the findings presented in Table 10.7 lies in the insight they provide on the distribution of the increased natural rubber consumption between countries. A study of the numbers in Table 10.7 shows that no generalisation of the distributional effects is possible. Whereas higher increases and hence greater substitution are observed for the medium-sized consuming countries of France and West Germany, the increases are found to be marginal for the smaller-sized consuming countries of Italy and UK as well as the bigger consuming countries of Japan and USA.

Table 10.7: Effects of Malaysian Export Tax on Natural Rubber Consumption in Main Consuming countries, 1982-1991

Country	With Export Tax	Without Export Tax	Difference (%)
France	2037.5	2303.2	+13.0
West Germany	2386.3	2532.8	+ 6.1
Italy	1817.1	1836.5	+ 1.1
Japan	4924.6	5004.8	+ 1.6
United Kingdom	1285.7	1298.7	+ 1.0
USA	8678.3	8758.8	+ 0.9

10.4 Indirect Effects of Export Tax Variations on Market Instability

So far the discussion has centered on the direct consequences of variations in Malaysian export taxes on Malaysian production, production of the other producing countries and on world rubber consumption. The discussion has shown that the direct effects of varying export taxes in one country on the rest of the rubber market is minimal. The discussion will now turn to the question of the indirect effects, since the exogenous variations in export tax rates of a major producer are a source of randomness and instability in the world market. The implications of the above findings for price stabilisation in general will then be considered.

Chapters Eight and Nine have shown that successful price stabilisation by buffer stock operations depends on a variety of factors, chief of which are the correct identification of the long-run equilibrium price and appropriate prospective buffer stock operations. The simulation results have also shown that the goal of price stabilisation need not be compatible with that of achieving steady growth of export earnings. Furthermore, the uneven distribution of stabilisation gains raises the problem of fund contributions to the buffer stock.

The problems of buffer stock price stabilisation become more complicated once the possibility of changes in the export taxation of producing countries in the interim is taken into consideration. This chapter has shown that a change in the export taxation of one country affects world price and hence production of the remaining countries as well as world rubber consumption. Given that most natural rubber producing countries impose export taxes on their rubber exports, successful operations of a buffer stock scheme would entail that the judgement of the buffer stock manager encompass, among other things, the potential effects of prospective changes in export tax structures of the producing countries.

CHAPTER ELEVEN

SUMMARY AND CONCLUSION

11.1 Introduction

This chapter summarises the key results of Chapters Two to Ten, focussing on the world rubber market structure and problems associated with effective price stabilisation.

11.2 Empirical Findings For 1956-1978

The estimated annual model of the world rubber market consists of two supply-demand type submodels, and abstracts from speculative and hedging activities. These submodels differ (a) in their level of disaggregation and (b) in their representation of market structure.

The disaggregated natural rubber submodel consists of separate natural rubber supply and demand equations for the major producing and consuming countries respectively. Perfect competition in the natural rubber market is reflected in the price formation equation which is based on disequilibrium demand for natural rubber stocks in the consuming regions. The synthetic rubber submodel consists of disaggregated consumption equations corresponding to those for natural rubber, but presents world synthetic rubber supply in aggregate. To proxy the imperfect competition within the synthetic rubber industry, the assumption of monopolistic synthetic rubber supply was used; thus synthetic rubber supply and price in each period are jointly determined within this submodel with synthetic rubber stocks as a residual. The nexus between the two submodels is provided by the relative price variables in the demand equations.

The dominant features of the estimated model are (a) the lag structure in the natural rubber supply equations as well as the natural rubber and synthetic rubbers consumption equations, and (b) the residual nature of synthetic rubber stocks. The significance of these features lies in their implications for buffer stock operations for natural rubber price stabilisation.

For the historical period, natural rubber supply was found to be influenced by price up to 14-year lags. Demand for both types of rubber were also found to depend on lagged prices, albeit up to four years only. Consequently, successful price stabilisation requires the stabilisation authority to anticipate business cycles (because of the derived demand for rubbers) and understand the differential lagged price effects on production and consumption that would arise from any market intervention.

The residual nature of synthetic rubber stocks is related to the organisation of the synthetic rubber industry and its ability to adjust production and inventories according to market conditions. This is vividly illustrated in the post-1973 period when synthetic rubber production was curtailed upon the quadrupling of oil price. This led to a temporary trend reversal in consumption shares favouring natural rubber for the first time since the "take-off" of the world synthetic rubber industry in 1956. The flexibility of the synthetic rubber industry in adjusting production and inventories, the proximity of the industry to consumers and the trading of synthetic rubbers under unpublicised price discounting provides the raison d'etre for explaining natural rubber spot price formation in terms of demand for natural rubber stocks in consuming regions. This is because rubber goods manufacturers generally cover their minimum natural rubber requirements by long-term contracts and use the terminal spot markets to obtain additional requirements. As general-purpose synthetic rubbers and natural rubber are substitutable in the range beyond the minimum requirements, the choice between the two types of rubber beyond their minimum requirements is explained by their relative prices.

Empirical validation of the model by ex post one-period and dynamic simulations of the 1970-1978 period generated time paths which tracked the market reasonably well. The causal structure of this 87-equation model by causal ordering of the equations substantiate the fact that the determination of natural rubber price has been causally-dependent on the price of synthetic rubbers and co-determined with natural rubber production and total consumption of all rubbers.

As indicated in Chapter One, a sound analysis of the postwar natural rubber market entails understanding the interrelations between natural rubber and the synthetic rubbers in consumption. This turns on an understanding of the dependence of the synthetic rubber industry on the oil and petrochemical industries. Thus the natural rubber market cannot be understood in isolation. This study reported the estimation and validation of an econometric model representing the world natural and synthetic rubbers market with price of oil incorporated explicitly. The findings provide the basis for using the model (a) to forecast natural rubber price under the assumption of an unchanged market structure, (b) to simulate alternative buffer stock schemes for the purpose of stabilising natural rubber price and increasing producers' incomes and (c) to examine the effects of changes in Malaysian natural rubber export taxation to illustrate the impacts of national government interventions on world commodity markets.

11.3 Implications of Price Stabilisation, 1981-1991

The model was first used to forecast the time paths of natural rubber prices in the primary and terminal markets under a low oil price scenario for 1980-1995. On the basis of these forecast prices, buffer stock operations were then simulated in accordance with the rules of the International Natural Rubber Agreement (INRA). In view of the long price lags in the estimated model, medium- (5 years) and long-term (10 years) stabilisation were simulated to ascertain the effect of the choice of time horizon on the attainment of the INRA goals of stabilising price and inducing steady growth of natural rubber export revenues of the producer-countries.

As the model is based on annual data, the relevant INRA rule for buffer stock operations is that the net change in the buffer stock between any two points in time not exceeding 18 months should not be more than 100,000 tonnes. In this study, the INRA rule is translated approximately into the condition that net change in buffer stock does not exceed 80,000 tonnes between any two consecutive years. The simulated buffer stock operations were made to satisfy this constraint.

Under the low oil price scenario, the natural rubber prices forecast by the model with no intervention were found to lie outside the stabilisation price bands specified by the INRA. Thus in the buffer stock simulations, the stabilisation price bands were determined from the relevant forecast price ranges.

In all the stabilisation results reported below, the constraint of net change in buffer stocks not exceeding 80,000 tonnes annually was binding. The results of medium- to long-term price stabilisation for the future period on the basis of non-stochastic simulations may be summarised as follows.

First, the simulations show prospective buffer stock operations to be an essential part of successful partial price stabilisation. This arises from the need to consider the lagged effects in a dynamic system. The stabilisation results discussed below therefore pertain to stabilisation with prospective buffer stocks operations.

Second, the simulations show that the stabilisation results are critically dependent on the choice of reference price and the use of equidistant or non-equidistant price bands. Partial price stabilisation about equidistant price bands for a 5-year period results is a loss in producers' incomes. But if stabilisation is conducted about non-equidistant price bands, then the loss in producers' export earnings is found to be lower than in the equidistant case, the lower export earnings stemming from lower natural rubber production. This comparison highlights the importance of the choice of reference price and equidistant/non-equidistant price bands about which to stabilise. This is because the lower loss in export earnings in the case of non-equidistant price band stabilisation can be seen as a shift of income to producing countries. The results of stabilisation with equidistant and non-equidistant price bands also reiterate the relative inelasticity of natural rubber demand vis-a-vis that of natural rubber supply; for both types of price stabilisation, the change in world natural rubber consumption over the stabilisation is seen to be negligible.

Third, the simulations show that price stabilisation causes differential effects across countries. Among producing countries, price stabilisation benefits Africa, Brazil, Indonesia and Malaysia by raising their average export earnings. However, stabilisation resulted in lower average export earnings for Sri Lanka and Thailand. Similarly, the effects of stabilisation on consuming countries are uneven; furthermore, the outcomes for individual consuming countries were sensitive to the use of equidistant or non-equidistant price bands stabilisation.

In order to ascertain the persistence of these qualitative effects of stabilisation in the presence of random disturbances, *ex post* stabilisation with equidistant price bands was simulated for 1971-1980. The simulation results reiterated the qualitative effects of stabilisation on production and consumption volumes presented above. At the global level, price stabilisation has negligible effect on the world natural rubber consumption volume because of the inelastic demand for natural rubber. As a result of this inelastic demand and the price rise for natural rubber in the 1970s, expenditure on natural rubber consumption increased. As for non-stochastic simulation, price stabilisation for 1971-1980 will lead to lower natural rubber production. However, due to the stabilisation of the marked fall in natural rubber price during 1974-1976, higher export earnings are obtained for the lower volume of output. This increased export earnings stem from a greater number of countries experiencing higher export earnings under the stochastic than under non-stochastic simulation. Over the 1971-1980 period, price stabilisation would have led to higher export earnings for the majority of the main producing countries, viz. Africa, Indonesia, Malaysia and Sri Lanka. Although the export earnings for Brazil is lowered by stabilisation, this decrease is negligible. The uneven effects of stabilisation on consuming countries are repeated, with France, West Germany and Japan expending less on natural rubber consumption due to their higher long-run elasticities of natural rubber demand. In contrast, Italy, UK and USA would have higher natural rubber consumption expenditures under stabilisation.

Thus it can now be stated that the operations of INRA will shift revenue from consumers to producers. This study has shown how this shift will affect the most important countries.

11.4 Caveats for Successful INRA Operations

The results of *ex post* stochastic simulation of price stabilisation during 1971-1980 and the non-stochastic simulation for 1982-1991 have indicated that producers benefit from price stabilisation. However, three caveats for the successful operation of INRA to stabilise price and increase export earnings are in order.

First, the need for prospective buffer stock purchases/sales is contingent on foresight about the behaviour of business cycles and natural rubber price in future periods. The importance of foresight for successful stabilisation highlights the critical reliance on the judgement, and ability to act appropriately, of the buffer stock manager -- the decision-maker in the timing of the buffer stock operations. As Nurkse (1958) and Benoit (1958) have indicated, buffer stock operations could result in investing excessive arbitrary authority on the buffer stock manager.

Second, the simulations have shown that given the INRA resources and the constraint on annual net change in buffer stock, the buffer stock operations are more useful in modifying price over a two to three year period than in affecting price significantly in any one period. This limited impact is due to the lagged price structures in the system. The need to consider wide price fluctuations due to random disturbances in any year is prompted by the historical sensitivity of natural rubber price to political developments in consequence of it being an industrial and strategic raw material. For the future period, it is necessary to add the oil price uncertainty to the political dimension so that price fluctuations wider than those forecast may be envisaged. These considerations add to the difficulties associated with the determination of the reference price and price bands about which to stabilise.

Third, the uneven effects of stabilisation raise the question of distribution of financial responsibility among countries participating in INRA and hence the problems of feasibility and management of the buffer stock operations. In reality, the gains to producing countries from price stabilisation by buffer stock schemes will be weighed against the contributions which these countries have to make towards the cost of operating the buffer stock.

11.5 A Final Perspective

The buffer stock simulations presented in Chapters Eight and Nine were conducted with no regard for the private sector storage responses that may be induced by the buffer stock operations. This is unrealistic. Furthermore, it is pragmatic to consider the reaction of speculative and hedging ativities to the implementation of buffer stock operations. This factor is reinforced by the non-participation of Singapore (a major natural rubber primary market with active speculative and hedging trading) in the INRA. Although buffer stock operations constitute direct intervention, and have immediate effects in principle, the simulation results have shown that the effects are limited by the resources at the disposal of the INRA. Consequently, a scenario of destabilising speculation in response to buffer stock operations cannot be precluded. In view of the difficulties associated with buffer stock operations discussed above, it is pertinent to consider other alternatives to buffer stock operations.

Given the long gestation in natural rubber production, its long productive lifespan and its essentiality to the modern economy, a more efficient way to ensure adequate world natural rubber supply as well as minimise long-run uncertainties may be via price support schemes. The advantage of a price support scheme is that it would ensure producers' returns and provide guidelines for resource allocation. The significance of the latter point lies in the land and labour inputs required for natural rubber production. To ensure that consumers will not be faced with unforseen shortages, an optimal stockpiling policy could then be identified and incorporated.

However, the uncertainties for the rubber market, such as those raised by oil price and the business cycle behaviour, lead to the question of a stockpiling policy that is also aimed at managing short-run surplus/shortages due to these uncertainties. Gardner (1978) for example, has emphasised the sub-optimality of price band stabilisation because of the absence of an overall objective function. As seen from the stabilisation results presented in the preceding chapters, the range of feasible outcomes are dictated by oil price, industrial activity and interest rates. In this context, Gardner therefore asserts that the use of an analytical framework such as that developed by Massell does not permit formulation of a stockpiling policy because the implications of optimal stockholding for price behaviour and optimal price stabilisation are not sufficiently recognised. Since a stockpiling policy is in essence a market price policy, Gardner therefore argues for an optimal stockpiling (price) policy which meets the requirements of <u>all possible scenarios</u>. The optimal stockpiling policy involves an optimisation problem, the solution of which would define a set of optimal storage rules over an infinite time horizon and for all feasible levels of supply. The optimal level of stocks for every scenario will therefore be derived from the optimal storage rules.

This study has developed a model of the world rubber market with explicit treatment of the synthetic rubber industry and oil price, the latter being a key variable about which there is great uncertainty. In this study the model was first validated and then used to evaluate the effects of natural rubber price stabilisation under a low oil price scenario and according to the INRA stockpiling constraints. However, in the absence of an objective function, the optimality of the stockpiling programmes from buffer stock simulations cannot be assessed. It is proposed that the model presented here be considered as a basis for further work on the world rubber market, along lines similar to that of Gardner (1978). Once the objective function is defined, the model could be used to search for the optimal choice of instruments and targets for all possible scenarios.

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