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An econometric analysis of the world natural rubber industry

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CHAPTER I. INTRODUCTION

General Discussion

Although the total value of natural rubber in international trade is relatively unimportant compared to other commodities (especially those of manufactured items) it is by no means unimportant to the economies of Malaysia, Indonesia, and Thailand. These are the three most important producers of natural rubber in the order of their importance in terms of output. The other producing countries which are of lesser importance include Ceylon, Vietnam, Laos, Brazil, Cambodia, and India.

To Malaysia, Indonesia, Thailand, and Ceylon, the natural rubber industry has become one of the most important employment and income generating sectors of their economies. The economy of Malaysia is particularly dependent on the natural rubber industry (and on its foreign sector in general, for it is also one of the chief proudcers of palm oil).

While the producing countries are somewhat regional (South-East Asia), the chief consumers are the industrialized nations of the western world, namely: the United States, the United Kingdom, France, West Germany, and Japan. Two other important consuming countries are Mainland China and Russia.

The Problem

The export of natural rubber has been one of the principal foreign exchange earners for the "big three" producers. But after the World War II, the terms of trade became rather unfavorable to the producing countries because of the emergence of a competing commodity, synthetic rubber. During the World War II, as Malaya (now West Malaysia) and Indonesia fell into the hands of the Japanese, the production of natural rubber in these countries was abruptly halted. Because of this, the western world, especially United States, was forced to find a substitute: synthetic rubber.

The existence of synthetic rubber has had a profound impact upon the natural rubber industry. About two-thirds of the world elastomers market (natural and synthetic rubber) is taken by synthetic rubber. Competition between synthetic and natural rubber is not only in price variations but also in quality variations. As synthetic rubber is a manufactured product, its quality is relatively uniform. In contrast to synthetic, the quality of natural rubber varies greatly. A good quality rubber should contain little foreign matter. A major step is taking place, particularly in Malaysia, to improve the quality of natural rubber. And Malaysia now has started to export more of good quality rubber, called technically specified rubber (TSR). TSR guarantees the importers of the quality of rubber they buy. The trend now is to produce more of this type of rubber.

The Objectives

The producing countries have recently begun trying to dampen the fluctuations in natural rubber prices in an effort to stabilize their export revenues from this sector. They are now controlling the export supply by adjusting their stocks of natural rubber.

An economic policy will be more effective the more we understand the economic problem we are trying to solve. In other words, the price stabilization policy on natural rubber would likely be more effective the more we understand the market conditions of natural rubber. When an economist talks about a market, he has an exact meaning in mind. He represents a market by the market supply and demand for the commodity of interest. By market conditions, we mean the various factors that govern the market supply and the market demand. It is conceivable that the more the policy makers understand the nature of these factors, the better the chances they would be able to develop wise policy actions.

The literature on the market for natural rubber is very limited. This study is an attempt to make an exploratory investigation of the natural rubber market to fill the gap.

There are two objectives of this study. The first objective is to estimate the world demand and the world supply functions disaggregated by major consuming and major producing countries respectively. On the demand side, the world is divided into six countries, namely: the United States, the United Kingdom, France, West Germany, Japan, and the rest of the world[1]. And on the supply side, the world will be divided into four countries, namely: Malaysia, Indonesia, Thailand, and the rest of the world. Malaysian rubber industry will be further broken down into West Malaysia and the East Malaysia. West Malaysia will be divided into the estates sector and the smallholdings sector. The East Malaysia is divided into Sarawak and Sabah (these are the two states that make up the East Malaysia).

Malaysia has invested a lot of resources in research and development of its natural rubber industry. Through its rubber research institution, called the Rubber Research Institute of Malaysia, new methods of production have been developed. Thus, the second objective of this study is to examine the effects of these new methods of production on Malaysia. In particular, we will examine the technological progress in the estates sector of West Malaysia and the

[1]Excluding the centrally-planned economies. They consume about 18% of natural rubber.

effect of this technological progress on Malaysian economy.

It is obvious by now that the emphasis of this study is on Malaysian rubber industry. This is because Malaysia is the world's leading producer of natural rubber. Furthermore, the data on Malaysian rubber industry are quite readily available. It is hoped that this study will improve our understanding of the natural rubber market.

CHAPTER II. THE NATURAL RUBBER INDUSTRY

Some Historical Background[1]

Rubber trees are indigenous to the forests in the Amazon Valley. There are many species of natural rubber, but only the specie called Hevea Brasiliensis is of commercial importance in terms of yields, frequency of tappings, and longevity.

The rubber trees grown in Asia today originated in Brazil. In 1839, Thomas Hancock and Charles Goodyear found that rubber could be made resistance to higher temperatures by the process of vulcanization where sulfur dust is added to raw rubber. By the year of 1846, due to the discovery of vulcanization coupled with the industrial revolution, there was a great demand for raw rubber. As a result, Sir Henry Wickham went to Brazil in search for rubber seeds for growth experiments. Some 70,000 seeds were then brought back to England and planted in Kew Gardens, but only a small percentage of the seeds germinated. Some of these young plants were sent to Ceylon. Then 22 of these seedlings were brought to Singapore in 1877. This was the beginning of the natural rubber industry of Malaysia.

[1]Much of the material discussed here is based on Semegen [34].

Since rubber plantations were not very successful in South America, due to a disease called yellow leaf blight, the Malaysian rubber industry expanded rapidly. A research institute called Rubber Research Institute of Malaya (RRIM), was formed in 1926. The main objective of this institute is to increase the yields per acre by growing new clones and by developing better agronomic practices. A clone is obtained through a process called budgrafting, whereby buds from a high yielding tree are grafted to the stem of a seedling stock. By growing these new clones, yields may be increased from 300 pounds to 1,100 pounds per acre per year.

Rubber trees are about 60 feet high. They may be grown on a well-drained flat terrain or terraced hillsides of less than 1,000 feet elevation in a region of hot and damp climate with temperatures of 70 to 90 degrees Fahrenheit and an average rainfall of about 100 inches per year. When seedlings are planted, they will undergo 5 1/2 to 6 years of gestation before they can be harvested.

Types of Natural Rubber Sold (Exported)

Rubber is harvested by tapping (cutting) the bark with a special knife to obtain the latex which flows into a cup underneath. After a few hours, the latex stops flowing and it is collected and processed. Natural rubber is sold in many forms, namely: latex, pale crepe, Ribbed-Smoked-Sheet (RSS), and Technically Specified Rubber (TSR).

The latex so collected is added with a small amount of ammonia and sodium sulphate to prevent coagulation. About 10-20 percent of this latex is concentrated by creaming or centrifuging and then exported.

About 5-10 percent of the latex is converted to pale crepe by adding sodium bisulphite to prevent darkening. It is then coagulated by adding acids and the coagulum is passed through rollers and dried.

The largest single type of dry rubber is the ribbed-smoked-sheet. This is obtained by coagulating latex using formic or acetic acids and the resulting coagulum is passed through rollers several times until it is about 1 1/4 inches in thickness. It is then sent to the smoke-house for drying.

The technically specified rubber is processed in crumb form by mechanical or chemical processes. After washing and drying, the crumb is compressed hydraulically into 70-75 pounds bales, wrapped, sealed in polyethylene bags, and packed on one-ton wooden pallets for export. TSR is uniform, clean, of good appearance, and easy to transport.

Some Properties and Uses of Natural Rubber

When consumed in the manufacture of various products, practically all crude rubber is first converted into compounded rubber by adding one or more chemical agents. One of these agents is a filler, such as carbon black, which is used to modify the physical properties of rubber and also to reduce costs. The compounded rubber is then vulcanized by adding sulfur dust to transform rubber into a strong and elastic product. The resulting product loses its tackiness and becomes insoluble in solvents and resistant to heat, light, and the aging process.

Some of the more important properties of natural rubber are: superior building tack, high strength in non-black formulations, hot tear resistance, retention of strength at high temperatures, low hysteresis (heat build up), excellent dynamic properties, and general fatigue resistance.

The various uses of natural rubber are given in Table 2.1. Although synthetic rubber has replaced natural rubber in many uses, natural rubber, due to the above mentioned properties, is still used as raw material in manufacturing tires and other industrial and consumer articles. From Table 2.1, it is seen that the most important use of natural rubber is for the production of tires and tire products. Synthetic rubber is mainly used for manufacturing passenger

Table 2.1. The uses of natural rubber[a]

	Product	Percent Usage
1.	Tires and tire products	68.0
2.	Mechanical goods	13.5
3.	Latex products	9.5
4.	Footwear	5.5
5.	Adhesives	1.0
6.	Miscellaneous	2.5

[a]Source: Semegen [34].

car tires and tire related products, whereas natural rubber is preferred for truck and airplane tires.

Production and Consumption of Natural Rubber

The total world production of natural rubber has been increasing. Production in Malaysia and Thailand has been rising absolutely and also relative to the total world production (see Table 2.2). But production in Indonesia, the second largest producer, has been up and down.

The production share of the rest of the world[1] also has been up and down. The production of the rest of the world is mostly contributed by Ceylon, Republic of Vietnam, Cambodia,

[1]Other than Malaysia, Indonesia, and Thailand.

Table 2.2. Major producers of natural rubber

	Malaysia		Indonesia		Thailand		Others		World
	PRN[a]	Share	PRN[a]	Share	PRN[a]	Share	PRN[a]	Share	PRN[a]
1965	870.0	.3713	705.7	.3012	213.3	.0909	554.0	.2365	2342.9
1966	925.0	.3854	704.4	.2935	203.9	.0849	566.7	.2361	2400.0
1967	931.0	.3801	750.0	.3062	210.9	.0861	557.3	.2275	2449.2
1968	1044.0	.4027	740.0	.2855	254.8	.0983	553.1	.2134	2591.9
1969	1180.0	.4002	764.8	.2594	277.4	.0941	726.1	.2463	2948.3
1970	1197.0	.3918	796.6	.2608	282.7	.0925	778.3	.2548	3054.6
1971	1250.0	.4125	798.2	.2634	311.4	.1028	670.4	.2212	3030.0
1972	1230.0	.4014	761.6	.2485	331.6	.1082	741.2	.2419	3064.4
1973	1442.0	.4197	871.8	.2537	376.0	.1094	745.8	.2171	3435.6
1974	1462.0	.4243	841.7	.2443	373.3	.1083	768.4	.2238	3445.4

[a]PRN = production in thousand (1,000) long tons [40].

Liberia, and Nigeria. Of these, Ceylon is the most important contributor. It is obvious that the political unrest in Vietnam and Cambodia in the 1960's caused much of the instability in the rest of the world production. The production in Vietnam and Cambodia dropped drastically during the period.

The total world consumption of natural rubber is on an upward trend. The consumption in the major consuming countries is increasing in absolute amount, but their consumption shares, the consumption of each country divided by the total world consumption, are declining except in the United States and Japan. Japan's consumption share has been rising at a modest rate, while the United States share has remained almost constant over the last decade. Since the consumption shares of most major consuming countries has been declining whereas the total world consumption have been increasing, it is obvious that the consumption share of the rest of the world (countries other than the United States, the United Kingdom, France, West Germany, and Japan) has been increasing (see Table 2.3). This indicates that the market of natural rubber is expanding to other countries including developing countries such as India and Brazil.

Table 2.3. Major consumers of natural rubber

	United States		United Kingdom		Japan		France		W. Germany		Others		World
	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]
1965	514.8	.2165	183.8	.0773	198.4	.0834	120.6	.0507	155.4	.0654	1204.3	.5066	2377.3
1966	545.8	.2150	181.0	.0713	212.6	.0837	124.0	.0489	155.1	.0611	1319.3	.5199	2537.8
1967	489.0	.1995	175.7	.0717	239.2	.0975	125.8	.0513	138.8	.0568	1282.6	.5232	2451.1
1968	582.0	.2076	191.1	.0682	251.0	.0896	126.8	.0452	167.3	.0597	1485.4	.5298	2803.6
1969	598.4	.2038	188.4	.0642	263.8	.0899	145.0	.0494	188.2	.0641	1552.7	.5287	2936.5
1970	559.4	.1898	185.3	.0628	278.6	.0945	153.9	.0522	197.6	.0670	1573.5	.5337	2948.3
1971	577.9	.1957	184.3	.0624	290.4	.0984	156.7	.0531	195.1	.0660	1548.8	.5244	2953.2
1972	640.5	.2053	171.3	.0549	307.1	.0984	157.7	.0505	190.0	.0609	1653.9	.5300	3120.5
1973	685.5	.2048	170.3	.0509	329.8	.0885	157.5	.0470	202.4	.0605	1801.5	.5382	3347.0
1974	707.9	.2060	171.3	.0496	319.9	.0931	159.9	.0465	199.8	.0581	1876.8	.5462	3435.6

[a]CN = consumption in thousand (1,000) long tons [40].

The Marketing of Natural Rubber

There are two types of natural rubber markets in the world. They are the actual market and the futures market. Goss and Yamey [15] define futures market as an organized commodity market dealing with the purchase and the sale of the commodity through the medium of highly standardized futures contracts called the futures which provide the delivery of the commodity in the future dates. Under this institution, it is possible to deal with the futures without actually handling the physical commodity. The actual market on the other hand is the trading of actual physical commodity and the market need not be organized.

The futures markets operate in London and New York. Relatively speaking the futures market is not as important as the actual markets and therefore we will ignore the futures market in the subsequent discussion. Moreover, when this particular section was written the New York futures market was temporarily closed.

Broadly speaking, there are three important actual markets of natural rubber. They are the Singapore, London, and New York markets. The Singapore market is the largest actual market and it serves the producing countries in South-East Asia (Malaysia, Indonesia, Thailand, and the other smaller producers in the region). The London market mainly serves the United Kindgom and the other European countries whereas the New York market serves the United States and Canada. Recently, a fourth main actual market was established in Kuala Lumpur (the capital city of Malaysia) to serve Malaysian rubber producers.

The marketing process of natural rubber from the point of production to the point of consumption may involve a long chain of intermediaries for the case of a small natural rubber producer in the smallholding sector. A typical small producer in Malaysia sells his rubber to a small local dealer. This dealer in turn sells the raw rubber to a larger dealer. This medium size dealer usually owns transportation vehicles to transport rubber to a more specialized rubber dealer whereby the raw rubber is reprocessed, remilled, and packed into an exportable form. In contrast, an estate producer may or may not be involved with the intermediaries at all. This is because most of the rubber from this sector is already in the exportable forms and thus the producer may sell his rubber directly to the private exporters or he may export the rubber through his marketing agency if he has one. A number of the large plantation producers own their own market organizations.

A natural rubber using firm[1] in the United States, for

[1]Only a few natural rubber using firms own their own natural rubber plantations, see Philips [27].

an example, may purchase natural rubber from the dealers in the New York market or it may purchase directly from the exporters in (say) Malaysia through its agent stationed there. Generally, the rubber using firms prefer direct purchases to buying from the New York dealers. In either case, some kind of contractual arrangement has to be made between the buyer and the seller. One of the possible arrangements is that a firm buys natural rubber in a market today to be delivered within 6-12 months in the future at a price specified today. This is the normal arrangement between the parties involved. The above discussion has indicated that what is purchased this year would be mostly consumed next year. This will be a very important point when we discuss the various assumptions in the theoretical formulation of the demand equations in Chapter IV.

Synthetic Rubber

Synthetic rubber is a class of polymers exhibiting characteristics similar to natural rubber. They are chemical substitutes for natural rubber. However, most of them are not duplicates of natural rubber either in the chemical structure or functional characteristics.

The various types of synthetic rubber polymers are composed of large chains of molecules having structures of varying complexity. Each type has a different degree of tensile strength, elasticity, hardness, and abrasion resistance. These characteristics are changed somewhat on adding chemical compounding agents, such as carbon black, and the vulcanizing agent, sulfur.

Synthetic rubber is sold in either the latex form, which is a milky dispersion of minute rubber particles in water, or dry rubber. Based on uses, synthetic rubber can be classified into two groups: the general purpose rubber (GP-R) and the special purpose rubber. The general purpose rubber is the Styrene-Butadiene rubber (SBR), commercially the most important type of synthetic rubber. While most of SBR is used for making tire treads, some tires are almost exclusively made up of synthetic rubber. There are many kinds of special purpose rubber, namely: Butyl, Neoprene, and Nitrile Butadiene. These rubbers are mainly used for making insulating and protective material and for making equipment requiring high resistance to chemical and petroleum products.

It is important to note that the raw materials used to manufacture synthetic rubber are obtained from petroleum either directly or indirectly. Butadiene and isobutylene are obtained from petroleum. Styrene, which is produced from ethylene and benzene, requires petroleum since benzene is obtained from petroleum (or coal). Acetylene, raw material for Neoprene, is obtained from petroleum (or Calcium Carbide). Thus, there may be a direct relationship between the price of petroleum and the price of synthetic rubber. An increase in the price of petroleum may result in an increase in the price of synthetic rubber.

Production and Consumption of Synthetic Rubber

World production and consumption of synthetic rubber has steadily increased in the last ten years. The production and consumption in the major consuming countries are on an upward trend. The chief producers are: the United States, the United Kingdom, West Germany, and Canada. These producers are also the chief consumers. Other countries which consume significant amounts of synthetic rubber include France and Japan.

The production shares of major producers, that is the ratio of production in the country to total world production, have been declining. Since world production is increasing, this implies that the other countries such as Japan and France may have had taken the initiative to produce their own synthetic rubber. This is fairly well indicated by the fact that in 1965, United States produced about 47 percent of the world output, but this had fallen to about 30 percent by 1974 (see Table 2.4). In contrast, the rest of the world[1] produced approximately 38 percent in 1965, and by 1974 this

[1] All other countries except the United States, the United Kingdom, Canada, and West Germany.

Table 2.4. Major producers of synthetic rubber

	United States		United Kingdom		West Germany		Canada		Others		World
	PRN[a]	Share	PRN[a]	Share	PRN[a]	Share	PRN[a]	Share	PRN[a]	Share	PRN[a]
1964	1842	.4860	174.5	.0460	164.0	.0432	206.2	.0544	1403.3	.3703	3790
1965	2002	.4758	194.0	.0461	195.8	.0465	202.9	.0482	1613.3	.3834	4208
1966	1943	.4482	203.7	.0470	190.2	.0439	200.2	.0462	1797.9	.4147	4335
1967	2165	.4411	236.6	.0482	238.4	.0486	196.8	.0401	2071.2	.4220	4907
1968	2285	.4160	273.0	.0500	291.7	.0531	198.8	.0362	2445.5	.4450	5495
1969	2232	.3800	306.2	.0521	301.9	.0514	205.4	.0349	2827.5	.4814	5873
1970	2277	.3743	276.8	.0455	306.4	.0504	197.4	.0324	3025.4	.4973	6083
1971	2455	.3703	307.1	.0463	300.0	.0452	195.5	.0295	3372.4	.5086	6630
1972	2607	.3474	353.5	.0471	349.5	.0466	229.8	.0306	3965.2	.5383	7505
1973	2517	.3393	327.4	.0441	324.3	.0437	208.7	.0281	4040.5	.5447	7418
1974	1941	.2967	349.9	.0533	278.3	.0425	173.2	.0265	3801.5	.5810	6543

[a]PRN = production in thousand (1,000) metric tons [40].

had increased to about 58 percent.

The consumption shares of major consuming countries, that is the ratio of the consumption of the country in question to total world consumption, have declined as well. Since the total world consumption has increased, this means that the rest of the world consumption[1] share has risen. For example, in 1965 the rest of the world consumption share was about 40 percent but by 1974 the share reached nearly 52 percent (see Table 2.5).

The shift in the production and consumption pattern can be seen more clearly by looking at the ratio of consumption to production in each country (see Table 2.6). If the ratio is more than one, this implies that the country is a net importer, whereas if the ratio is greater than one it is an exporter, and if the ratio is equal to one the country is self-sufficient. These ratio conditions may not be true in the short-run, since a country may consume more (or less) than its production by decreasing (increasing) its stocks. But the conditions are likely to be true in the long-run as a country cannot consume more than its production indefinitely without importing. Sooner or later the stocks will get exhausted. Also, a country may not be able to consume less than its production indefinitely without exporting

[1]All other countries except the United States, the United Kingdom, France, Canada, and West Germany.

Table 2.5. Major consumers of synthetic rubber

	United States		United Kingdom		West Germany		Canada		France		Others		World
	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]	Share	CN[a]
1965	1565	.4192	182.7	.0558	208.5	.0558	97.7	.0262	154.4	.0414	1524.7	.4084	3733
1966	1693	.4076	199.0	.0479	212.2	.0511	108.9	.0262	175.1	.0422	1764.8	.4249	4153
1967	1654	.3880	205.5	.0482	200.6	.0470	110.4	.0259	188.3	.0442	1904.2	.4466	4263
1968	1927	.3967	234.0	.0482	253.0	.0521	106.2	.0219	196.0	.0403	2141.8	.4409	4858
1969	2057	.3864	256.0	.0481	323.0	.0607	129.1	.0242	230.8	.0433	2327.1	.4372	5323
1970	1949	.3471	273.6	.0487	358.1	.0638	135.4	.0241	260.9	.0465	2638.0	.4698	5615
1971	2139	.3541	277.8	.0460	369.2	.0611	158.3	.0262	283.5	.0469	2812.2	.4656	6040
1972	2328	.3525	272.6	.0413	362.8	.0549	172.8	.0261	297.8	.0451	3171.0	.4801	6605
1973	2432	.3323	282.8	.0386	408.0	.0557	186.2	.0254	304.7	.0416	3705.3	.5062	7318
1974	2389	.3291	270.4	.0372	359.0	.0494	180.2	.0248	308.4	.0425	3753.0	.5169	7260

[a]CN = consumption in thousand (1,000) metric tons [40].

Table 2.6. The ratio of consumption to production of synthetic rubber in major consuming countries

Year	United States	United Kingdom	West Germany	Canada	Others
1964	.8496	1.0470	1.2713	.4738	1.1965
1965	.8456	1.0258	1.0858	.5367	1.2024
1966	.8513	1.0088	1.0547	.5514	1.1639
1967	.8901	0.9890	1.0612	.5396	1.1287
1968	.8998	0.9377	1.1073	.6494	1.0459
1960	.8732	0.8935	1.1861	.6592	1.0252
1970	.9394	1.0036	1.2049	.8019	1.0232
1971	.9483	0.8877	1.2093	.8839	1.0286
1972	.9329	0.8000	1.1674	.8103	1.0110
1973	.9491	0.8259	1.1070	.8630	1.0052
1974	.9304	0.7020	1.2124	1.0341	1.1397

(i.e. stockpiling) since it is costly to store rubber for a long period of time. In the short-run, storing rubber is justified if we expect the price is going to increase and the resulting increase in the expected marginal revenue is at least equal to the marginal cost of storage.

By using the ratio conditions, we would be able to draw one very important conclusion. That the consumers of synthetic rubber, with the exception of West Germany and the United Kingdom, show a very strong indication that they are moving toward self-sufficiency. For example, the United States and Canada are exporting less and less, and accordingly the rest of the world is importing less and less, since their ratios are getting closer and closer to one. Even for the United Kingdom and West Germany (an importer) the ratios are above 70 percent. Self-sufficiency will imply that synthetic rubber is becoming less and less important in international trade. This should come as no surprise since international trade in synthetic rubber is rather restricted due to tariffs and/or quotas (for the United States, see Tariff Commission [41]). It is possible that trade in synthetic rubber is restricted because the consuming countries would like to produce their own synthetic rubber and become self-sufficient.

The movement toward self-sufficiency in synthetic rubber is not good news for the natural rubber producers. The reasons are obvious. A synthetic rubber industry is costly to operate at less than full capacity. This means that the producers have to employ optimal plant sizes to take advantage of economies of scale to reduce the costs of production, Philips [27]. As the consumers of elastomers expand the production of synthetic rubber, we would expect them to reduce their importation of natural rubber since it is a substitute. It is possible that the importation of natural rubber will become more restrictive as the consuming countries try to protect the domestic substitute industries.

The Performance of Natural Rubber

In the last ten years the total world consumption of both types of elastomers has been on an upward trend. One of the ways to compare the performance of these two groups of elastomers is by looking at their market shares. The market share of natural rubber is defined as the total world consumption of natural rubber divided by the total world consumption of elastomers. The share of synthetic rubber is obtained by subtracting the natural rubber share from one. On examination of Table 2.7, we see that the market share of natural rubber has declined over the last ten years, implying that the share of synthetic rubber has increased. In 1964, the share of natural rubber was about 41 percent, but by 1974 this had gone down to less than 33 percent. The world natural rubber industry has been giving up its share at a rate of about 1 percent per year, at least in the last ten years.

If this trend continues, the future of natural rubber industry looks very gloomy. We should understand that the quality of synthetic rubber is improving and its physical and chemical properties are getting closer and closer to duplicating that of natural rubber. This might be one of the

Table 2.7. The world consumption of elastomers[a] (1,000 metric tons)

Year	Consumption of Natural Rubber	Consumption of Synthetic Rubber	Market Share of Natural Rubber	Price of Natural Rubber[b]	Price of Synthetic Rubber[c]
1964	2,380	3,445	0.4086	25.2	23.0
1965	2,448	3,740	0.3956	25.7	23.0
1966	2,543	4,135	0.3808	23.6	23.0
1967	2,535	4,270	0.3725	20.6	23.0
1968	2,780	4,870	0.3634	19.6	22.4
1969	2,910	5,358	0.3519	26.2	22.9
1970	2,993	5,625	0.3473	21.1	23.0
1971	3,095	6,130	0.3355	18.0	23.0
1972	3,235	6,605	0.3288	18.1	23.0
1973	3,410	7,318	0.3178	35.2	23.0
1974	3,505	7,260	0.3256	39.8	31.5

[a]Elastomers include natural rubber and synthetic rubber.

[b]Natural rubber prices (RSS1) quoted at New York market in U.S. cents per pound [19].

[c]Styrene butadiene prices quoted in New York in U.S. cents per pound [37].

reasons why synthetic rubber is gaining in popularity.

The only bright spot for the natural rubber industry is due to the price hikes of petroleum by the OPEC members. It has already been discussed earlier that the price of synthetic rubber, to some extent, depends on the prices of petroleum products. Thus, an increase in petroleum price would increase the price of synthetic rubber, making natural rubber more attractive to buyers. The results of the rise in the petroleum price can be seen in Table 2.7. It is seen that the synthetic rubber price rose in 1974 and its consumption declined whereas the consumption of natural rubber increased during the same period. In fact, the natural rubber industry gained about one per cent of its share in 1974.

In 1973 the economies of the major consuming countries of natural rubber were in the upswing as indicated by a large increase in their industrial production indices. It will be seen in Chapter V that the most important determinant of the demand for natural rubber is the industrial production index of the country in question. Thus, the improved general economic conditions coupled with the increase in the price of petroleum in late 1973 resulted in an increase in the demand for natural rubber. As the consuming countries tried to purchase more of natural rubber in the world markets, they drove up the price of natural rubber by about 100 per cent in 1973.

The Price of Elastomers

Although the government of Malaysia has been employing a rubber stocking policy to influence the world rubber market, the policy does not seem to have been successful. Therefore, we may say that the natural rubber market is a free market in the sense that its price is determined by the world supply and the world demand. By looking at the Table 2.7 it will be seen that the prices of natural rubber are very volatile. In fact, the price reached the decade high of U.S. 39.8 cents per pound in 1974.

In contrast, the price of synthetic rubber is very rigid (see Table 2.7). If we define an administered price as one that does not reflect conditions of short-run supply and demand, synthetic rubber price is clearly one of them. Thus, Philips reported

> . . . the base prices of synthetic rubber have remained constant since the industry was transferred to the private ownership in 1955. Only one attempt has been made to change the price structure in the last five years. This occurred on May 1st, 1956, when Goodrich-Gulf Company changed its delivered base price for SBR from 24 cents to 25 cents per pound. However, when other domestic producers failed to follow suit, the increase was promptly retracted and customers who purchased rubber at the increased price received refunds [27].

The rigidity of the synthetic rubber prices is fairly well illustrated by the eleven years prices given in Table 2.7. From 1964 to 1973, the price remained almost unchanged. But, in 1974 the price shot up to 31.5 cents per pound due, at least partially, to the increase in the price of petroleum. The rigidity in prices leads us to suspect that the synthetic rubber industry is oligopolistic in its behavior. FAO stated

> . . . the 1972 experience. . . . During the first half of the year, and into the third quarter, natural rubber prices fluctuated at extremely low levels. During this period . . . SBR - the general purpose synthetic rubber . . . normally priced below natural rubber . . . was reportedly being sold at an exceptionally large discount . . . perhaps even below cost, to satisfy consumers who threatened to shift to natural rubber. In October, however, natural rubber prices began to move rapidly upward, and in November 1st, announcement regarding price increases for SBR and Polybutadiene in the United Kingdom was made, followed by similar announcements in United States, Japan, and Western Europe in Spring 1973 [39, p. 223].

From the remark made by FAO, it is evident now that price-leadership pattern, one of the common characteristics of an oligopolistic industry, does appear in the synthetic rubber industry. But Table 2.7 shows the list price of synthetic rubber in the New York market. It is highly possible that the list price is different from the actual transacted price, but we have no way of knowing it.

Technological Progress in Malaysian Rubber Industry

Malaysia, the most important producer of natural rubber, has been experiencing technological progress in its natural rubber industry. In this section, we try to point out the causes, the evidence, and the effect of technological progress on Malaysian economy.

Technological progress defined

Economic growth or simply the persistent increase in the real outputs per capita is one of the most important issues in the developing economies. Economic growth occurs due to either an increase in the quantities or an improvement in the qualities of resources in the economy. Since the former cause is not of our concern here, we then concentrate on the latter.

Fundamentally, technological progress consists of some change in the form of a given production function. For clarity, we define a production function as a technical relationship that shows the maximum amount of output that can be produced with various combinations of resources at the given state of technology. Thus, an improvement in technology would enable us to produce the same level of output with less resources or a higher output with the same amount of resources. Now, let the production function be

$$q = f(K,L) \tag{2.1}$$

where q is the output, K is capital, and L is labor. Then technological progress can be introduced into (2.1) as

$$q^* = f(\alpha(t)K,L) \tag{2.2}$$

where $q^* \geq q$ and $\alpha(t) \geq 1$ is a factor representing the qualitative change in the productive capacity of capital. Clearly, we are now specifically dealing with the case of embodied capital-augmenting technological progress. This is to say that capital stock is comprised of different vintages and the current vintage is more productive. And by capital-augmenting we mean that the quality of capital of later vintage is a multiple of the old vintage. If we let $\alpha(t=0)=1$, $\alpha(t=1)=2$, $\alpha(t=2)=2.5$, then we can say that capital of vintage one is twice as productive as those before the occurrence of technological progress. In this sense one could certainly add the capital of different vintages by choosing the capital of one particular vintage as a base. As an example, let the capital be the different type of fertilizers measured in pounds. Then if a farmer has one pound of each vintage of fertilizers, the total number of pounds he owns, in terms of capital of initial vintage, is $1K + 2K + 2.5K = 5.5K$. In other words, the three pounds that he has is equivalent to 5.5 pounds of initial fertilizer type. Thus, the farmer could produce q^* by using only the initial fertilizer type in greater amounts.

Application

Thus far we have discussed the theoretical aspect of technological progress to give us some background about the subject. Now, we are in the position to make use of the principles to explain the real world situation, the rubber industry in Malaysia in particular. Let the production function in the Malaysian rubber industry be

$$q = f(K,A,L) \tag{2.3}$$

where K is the total number of rubber trees representing capital, A is the total acreage of land planted with rubber, and L is labor measured in man-hours. It is assumed here that the function is homogeneous of degree one. Dividing (2.3) by A gives

$$\frac{q}{A} = f(\frac{K}{A}, \frac{L}{A}) \tag{2.4}$$

The expression (2.4) says that the yield per acre will depend on the number of trees per acre and the number of man-hours used per acre. Introducing technological progress in capital, we have

$$\frac{q^*}{A} = f(\frac{\alpha(t)K}{A}, \frac{L}{A}) \tag{2.5}$$

where $q^* \geq q$ and $\alpha(t) \geq 1$. It is to be assumed here that the number of trees per acre and the number of man-hours per acre are used in fixed proportions,[1] which is very close to the truth for the case of estate sector (an estate is defined as any rubber plantation greater than 100 acres). The assumption will imply that the output per man-hour depends on capital labor ratio. Furthermore, since the number of trees and the number of man-hours per acre are maintained, it is clear now that we are talking about neutral technological progress and thus the yield per acre increases, that is $q^* > q$. This is the Solow-neutral technological progress. By a neutral technological progress we mean that the technological progress is not biased toward the use of more labor or more capital by the producers of natural rubber.

<u>The causes</u>

Malaysia, through its rubber research institution called Rubber Research Institute of Malaysia has been trying to find ways of improving the competitive position of natural rubber over its rival, synthetic rubber. It has been suggested that one of the ways is via decreasing the costs of production through increasing the yield per acre or per tree.

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[1] The determination of the factor proportions is exogenous to the model.

In fact, Malaysia has succeeded in its search for new varieties or clones that have the capability of increasing yield per acre significantly over the traditional varieties. Yield per acre can also be increased by employing better techniques in fertilizer application, better crop maintenance, and through application of yield stimulants.

The evidence

If we examine the total acreage planted with rubber trees in the estates sector, we see that it is declining over time. In fact, the total planted acreage in the estates sector has been on the downward trend since 1958 (see Table 2.8). On the other hand, the total production in the estates sector has been steadily increasing. Then how could one explain the reason for the increase in the production? Obviously, technological progress will account for the most part of the increase in the production which is fairly well indicated by a steady increase in the annual yield per acre.

The decrease in the total acreage implies that the estates sector has been releasing its rubber land for other agricultural uses. It could be argued that some of the estates are being fragmented into smaller plantations. This may be true, but it is relatively small. Most of the released land goes to the planting of oil palms, since it is the second best crop in terms of profitability. All these

Table 2.8. Summary of principal rubber statistics in West Malaysia[a]

Year	Planted acreage (1,000 acres)		Yield per tapped acre (pounds)	Production (1,000 metric tons)[b]	
	Estates[c]	Small-holdings[d]	Estates	Estates	Small-holdings
1958	1,989.0	1,500.0	586.0	396.4	277.1
1959	1,949.6	1,839.0	n.a.	414.5	294.1
1960	1,942.2	1,892.0	n.a.	419.8	297.5
1961	1,937.4	2,035.0	n.a.	435.4	311.0
1962	1,926.5	2,224.0	n.a.	445.3	316.3
1963	1,919.4	2,332.0	n.a.	465.7	333.6
1964	1,893.2	2,411.0	818.0	484.5	352.9
1965	1,859.0	2,525.0	850.0	498.8	353.2
1966	1,813.3	2,571.0	898.0	522.1	392.6
1967	1,746.4	2,602.6	921.0	536.6	404.0
1968	1,675.8	2,608.0	986.0	572.1	479.2
1969	1,638.8	2,636.7	1,028.0	603.0	596.5
1970	1,597.6	2,662.0	1,061.0	627.9	594.8
1971	1,560.7	2,684.0	1,149.0	662.0	609.0
1972	1,508.0	2,698.3	1,180.0	680.0	599.0
1973	1,456.5	2,729.3	1,229.0	698.0	791.0

[a]Department of Statistics, Malaysia [6].

[b]Production Yearbook, FAO [38].

[c]An estate is any rubber plantation greater than 100 acres.

[d]Any rubber plantation less than 100 acres.

tend to indicate that there is a shift, although slowly, in the utilization of land from rubber to oil palm production. Why more oil-palms? The answer is quite straight forward. The price of palm oil is relatively more favorable than that of rubber. This is to say that the relative price of palm oil to rubber is rising over time making investment in oil palms more profitable.

The declining in the price of natural rubber is something that we can explain quite easily. Obviously, the supply has been increasing more rapidly than the demand and we may account the excess supply in rubber production to technological progress. Malaysia is a large country in terms of natural rubber output or in terms of the total acreage committed to the planting of rubber. So, a small increase in yield per acre or per tree is going to end up in a large increase in total production. Since almost nothing is consumed locally, the increase in the total production has to be sold in the world rubber market, depressing the price (assuming that the supply increases more than the demand). Perhaps the Malaysian rubber industry is experiencing immizerizing growth which is meant that as a result of economic growth in the sector, Malaysia or the people directly involved with the rubber production end up themselves at a lower indifference curve than that before the economic growth. But, we do not have enough evidence to make a strong conclusion. In any event, the technological progress in its rubber industry tends to be pro-trade biased. In this sense, by pro-trade biased is meant that Malaysia tends to export more and more rubber relative to local consumption resulting in a deterioration in the terms of trade. Clearly, Malaysia could dampen the deterioration in natural rubber price by increasing its local absorption.

The optimal policy

Facing falling terms of trade, then what kind of economic policy should be undertaken by Malaysia to at least maintain a reasonable price of natural rubber? Malaysia could impose export duties on all its rubber exports. This will tend to reduce the domestic production of natural rubber and thus increase the world price. Secondly, Malaysia could employ quantitative restriction, that is by increasing its inventory of natural rubber to reduce exports. This also would tend to result in an increase in the price of natural rubber. The two policies would tend to be more effective the more price inelastic the foreign demand. It will be seen in Chapter V that the foreign demand for natural rubber is price inelastic.

The two policies have been employed by Malaysia and so far they do not seem very successful. This does not mean that those policies could not be effective policies. There are a number of reasons why they are currently not very effective. First of all, the impact of export tax policy in the short-run is probably negligible. This is because of the nature of rubber trees. Once they are planted they are going to be economically productive for at least 25 years or so. Once planted, the decision to harvest or not to harvest will depend on the prevailing price of natural rubber. As long as the price of natural rubber covers the average variable costs, a rubber producer will produce in the short-run. But in the long-run, if the price is persistently low then we would expect that the less efficient producers will leave the industry and divert their resources to other uses. And indeed they do. It was argued previously that Malaysian rubber industry is contracting in terms of acreage planted with rubber. It can be concluded that export tax policy should be effective in the long-run.

Secondly, the buffer-stock policy that is being employed by Malaysia needs at least a year or so before its effect is shown in the world rubber market. And to store rubber for a long time requires a substantial amount of money and, moreover, it requires a certain level of amount of stock before the policy becomes effective. Thus, when Malaysian government buys rubber for stocking purposes it may run out of funds before the stock reaches the required effective level. Because of this reason and coupled with the pressure of inflating costs of storage, Malaysia then has to sell the stored rubber in the world market even before the price starts to rise. We may say now that the buffer-stock policy possibly has not been effective. Worse still, it is likely possible that whenever Malaysia employs the policy, the other producing countries release their stocks of rubber and even increase their rubber production which tends to result in neutralizing the effectiveness of Malaysian buffer-stocking policy. All in all, Malaysia needs cooperation from other producing countries and also sufficient funds to make its policy more effective.

Yield per acre growth rate estimated

To estimate the growth rate, we assume that yield per acre is growing exponentially as

$$Y_t = A_0 e^{A_1 T} U_{2t}$$

where A_0 is a constant, e is the base of natural logarithm, A_1 is the parameter, and U_{2t} is the error term. Changing the equation into natural logarithm and using the small letters to denote the logarithm values, we obtain

$$y_t = a_0 + A_1 T + u_{2t}$$

where u_{2t} is to be assumed as normally distributed with zero mean and constant variance. This is our estimating equation of growth rate.

The growth function is estimated using ten observations on the annual yield per acre from the estates sector. The estimated growth function is

$$y_t = -77.24 + 0.0427\ T$$
$$(5.2444)\quad (0.0027)$$

$$R^2 = 0.97,\ d = 1.64,\ r = -0.126,$$

where the values in the parentheses are the standard errors of the coefficients, R^2 is the square of the multiple correlation coefficient, d is the Durbin-Watson statistic, and r is the coefficient of the first-order autoregressive process of the error term. All the estimated coefficients are significantly different from zero at 1 per cent level and the fit is very good. In other words, time is able to explain about 97 per cent of the variations in the yield per acre and the yield is growing at the constant rate of about 4 per cent per year. The results tend to support the hypothesis that Malaysian rubber industry is experiencing rapid technological progress.

CHAPTER III. SOME PROBLEMS WHEN ESTIMATING THE IMPORT DEMAND FUNCTIONS

Introduction

The question of the effectiveness of international trade policies such as tariffs to discourage imports from abroad, export taxes to discourage exports, and currency devaluations to stimulate the foreign demand for exports and to discourage demand for imports have been widely discussed by both economists and policy makers. Although there is no clear answer to this question, economists tend to agree that the effectiveness of those policies is highly dependent upon the price elasticity of import demand, the price elasticity of export supply, and the income elasticity of import demand. Thus, precision in the estimation of these elasticity coefficients should be given an important consideration.

In this chapter we will examine some theoretical problems that one has to face when estimating the import demand functions, since at least two of the coefficients mentioned above could be estimated from the estimated demand function directly or indirectly. Furthermore, since this study is concerned with the market for natural rubber, our primary interest will be on the estimation of import demand for factors of production. Our attention will be mostly devoted to the following headings. First, we derive explicitly the import demand function. Then we explain briefly as to how we go about estimating it. In particular, we will discuss the identification problem. And finally, we examine critically the various assumptions to be made when one wants to avoid the identification problem.

The Demand for Factors

The demand for factors of production or the theory of derived demand by a firm has been extensively examined by many. But most of the material on this topic in the last fifteen years was contributed by Ferguson [9, 10, 11]. The purpose of this section is not to examine these articles, but rather to give some expository view on the subject matter.

To serve our purpose, let us assume that we have one firm producing one product using two factors of production.[1] It is to be further assumed that this firm is a perfect competitor in its product and factor markets. In this case we are assuming that the firm is selling its product and buying its factors of production in the domestic markets and as well as from abroad. For simplicity, we assume that free trade prevails. Now, let the production function be

[1]For the case of one product and many factors of production, see Ferguson [9, 10].

$$q = f(x_1, x_2) \tag{3.1}$$

and define the total costs as

$$c = w_1 x_1 + w_2 x_2 + A \tag{3.2}$$

where

q = product

x_i = factor i, $i = 1,2$

c = total costs

w_i = price of factor i

A = fixed costs

Assume further that the firm is maximizing profits, $\overline{II}$,

$$\overline{II} = pq - w_1 x_1 - w_2 x_2 - A \tag{3.3}$$

where

p = the product price.

Substituting (3.1) into (3.3),

$$\overline{II} = pf(x_1, x_2) - w_1 x_1 - w_2 x_2 - A \tag{3.4}$$

Differentiating (3.4) with respect to each factor, the first order conditions for maximum are

$$\frac{\partial \overline{II}}{\partial x_1} = p \frac{\partial f}{\partial x_1} - w_1 = 0 \tag{3.5}$$

$$\frac{\partial \overline{II}}{\partial x_2} = p \frac{\partial f}{\partial x_2} - w_2 = 0 \tag{3.6}$$

The conditions of (3.5) and (3.6) say that if the firm is to maximize profits, it must produce up to the point where the value of marginal product of each factor is equal to the price of the factor.

The sufficient conditions for maximum are obtained by partial differentiating (3.5) and (3.6). Thus, we obtain

$$\frac{\partial^2 \overline{\Pi}}{\partial x_1^2} = p\,\frac{\partial^2 f}{\partial x_1^2}$$

$$\frac{\partial^2 \overline{\Pi}}{\partial x_1 \partial x_2} = p\,\frac{\partial^2 f}{\partial x_1 \partial x_2}$$

$$\frac{\partial^2 \overline{\Pi}}{\partial x_2^2} = p\,\frac{\partial^2 f}{\partial x_2^2}$$

$$\frac{\partial^2 \overline{\Pi}}{\partial x_1 \partial x_2} = p\,\frac{\partial^2 f}{\partial x_2 \partial x_1}$$

Now, let

$$\frac{\partial f}{\partial x_i} = f_i, \quad i = 1,2$$

$$\frac{\partial^2 f}{\partial x_i^2} = f_{ii}$$

$$\frac{\partial^2 f}{\partial x_i \partial x_j} = f_{ij}, \; i \neq j$$

and

$f_{ij} = f_{ji}$, $i \neq j$ by Young's Theorem.

Define the Hessian matrix, H

$$|H| = \begin{vmatrix} pf_{11} & pf_{12} \\ pf_{21} & pf_{22} \end{vmatrix}$$

The second order conditions require that the quadratic forms of $d^2\overline{\Pi}$ be negative definite. This can equivalently be stated in terms of H. The principal minors of H must alternate in sign, starting with negative. That is

$$pf_{11} < 0, \quad pf_{22} < 0 \tag{3.7}$$

and

$$|H| > 0. \tag{3.8}$$

Condition (3.7) states that at the maximum, profits must decrease with the addition of x_1 or x_2. While condition (3.8) ensures that profits decrease with the increase or decrease of both x_1 and x_2.

Solving Equations (3.5) and (3.6) for x_1 and x_2

$$\begin{aligned} x_1 &= g_1(w_1, w_2, p) \\ x_2 &= g_2(w_1, w_2, p) \end{aligned} \tag{3.9a}$$

Equations (3.9a) say that the demand for factor i (i=1,2) depends on the price of factor i, the price of the other factor of production used in conjunction with factor i, and the price of the product. This is called the derived demand. The factors are not demanded <u>per se</u>, but rather to be used for production of other products demanded by the consumers.

Under profit maximization, a perfect competitor will produce an output where the product price is equal to the short-run marginal cost. When product price and marginal cost functions are known, the optimal output is also known. The higher the product price the higher the profit maximizing output. Clearly, there is a positive partial relationship between the product price and the optimal output. Thus, for statistical analysis, one may substitute the optimal output, q, for the product price in the demand Equations (3.9a), giving

$$\begin{aligned} x_1 &= g_1(w_1, w_2, q) \\ x_2 &= g_2(w_1, w_2, q) \end{aligned} \qquad (3.9b)$$

Equations (3.9b) are the basic demand equations to be estimated and a further discussion is given in Chapter IV.

Now, let us differentiate (3.5) totally. This gives

$$\frac{\partial f}{\partial x_1} dp + P \frac{\partial^2 f}{\partial x_1^2} dx_1 + P \frac{\partial^2 f}{\partial x_1 \partial x_2} dx_2 - dw_1 = 0$$

giving

$$P \frac{\partial^2 f}{\partial x_1^2} dx_1 + P \frac{\partial^2 f}{\partial x_1 \partial x_2} dx_2 = - \frac{\partial f}{\partial x_1} dp + dw_1 \qquad (3.10)$$

Similarly, we totally differentiate (3.6)

$$P \frac{\partial^2 f}{\partial x_2 \partial x_1} dx_1 + P \frac{\partial^2 f}{\partial x_2^2} dx_2 = - \frac{\partial f}{\partial x_2} dp + dw_2 \qquad (3.11)$$

In matrix form, (3.10) and (3.11) give

$$\begin{bmatrix} Pf_{11} & Pf_{12} \\ Pf_{21} & Pf_{22} \end{bmatrix} \begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \begin{bmatrix} -f_1 dp + dw_1 \\ -f_2 dp + dw_2 \end{bmatrix}$$

Thus

$$\begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = H^{-1} \begin{bmatrix} -f_1 dp + dw_1 \\ -f_2 dp + dw_2 \end{bmatrix}$$

$$= \frac{P^{-1} \begin{bmatrix} f_{22} & -f_{12} \\ -f_{21} & f_{11} \end{bmatrix} \begin{bmatrix} -f_1 dp + dw_1 \\ -f_2 dp + dw_2 \end{bmatrix}}{|H|} \qquad (3.12)$$

Using (3.12), let us consider only factor x_1

$$dx_1 = \frac{P^{-1}}{|H|} [-f_1 f_{22} dp + f_{22} dw_1 + f_2 f_{12} dp - f_{12} dw_2]$$

(i) Set $dp = dw_2 = 0$

$$\partial x_1 = \frac{P^{-1}}{|H|} f_{22} \partial w_1$$

since $P>0$, $f_{22} < 0$, $|H| > 0$

$$\frac{\partial x_1}{\partial x_1} < 0.$$

We may conclude unambiguously that an increase in the price of factor i will decrease the quantity demanded. In other words, the slope of the demand curve of factor i is negative with respect to its own price.

(ii) Set $dw_1 = dp = 0$

$$\partial x_1 = \frac{-P^{-1} f_{12} \partial w_2}{|H|}$$

giving

$$\frac{\partial x_1}{\partial w_2} = \frac{-P^{-1} f_{12}}{|H|} \lessgtr 0$$

according to $P>0$, $|H| > 0$, and $f_{12} \gtrless 0$. The sign of $\frac{\partial x_1}{\partial w_2}$ is ambiguous depending upon the sign of f_{12}. With a homogeneous production function,[1] $f_{12}>0$, giving $\frac{\partial x_1}{\partial w_2} < 0$, and we say that x_1 and x_2 are complementary. If $\frac{\partial x_1}{\partial w_2} > 0$, we say that x_1 and x_2 are substitutes and if it is equal to zero, then the two factors are said to be independent.

[1]Consider a production function, $q = f(x_1, x_2)$. Now, we increase each factor by a proportion of λ

$$f(\lambda x_1, \lambda x_2) = \lambda^k f(x_1, x_2) = \lambda^k q$$

Then the production is said to be homogeneous of degree k. If k=1, the production is said to be linear homogeneous or constant returns to scale. In this analysis, we preclude the case of $k \gtreqqless 1$.

The Identification Problem[1]

In this section, we consider the identification problem that one may face in estimating one of the import demand functions of (3.9). For simplicity, let us consider only the factor X_1. Further, we let X_1 be our imported goods from abroad and be represented by M^d and its price as P_m. The factor, X_2, is taken to be the domestic substitute good and its price is denoted as P_d. Now, we hold the price of output and the price of substitute constant. Thus, we represent the import demand and the supply of our import from abroad as

$$M_t^d = A_o + A_1 P_{mt} + u_{1t} \tag{3.13}$$

and

$$M_t^s = B_o + B_1 P_{mt} + B_2 T + u_{2t} \tag{3.14}$$

where

M_t^d = import demand in period t

M_t^s = import supply in period t

P_{mt} = price of imported goods in period t

T = time[2]

u_{it} = the stochastic disturbance

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[1]For more details see Theil [35], Chapters 9 and 10.

[2]We may assume the variable T as a proxy variable for technological progress.

A_i, B_j are the parameters of interest, $i = 0,1$ and $j = 0,1,2$.

It is clear that the equilibrium price, P_{mt}, is determined simultaneously by the supply (3.14) and the demand (3.13).[1] At equilibrium, $M_t^d = M_t^s = M_t$. The variable T is determined outside of our model, that is, it is an exogeneous variable. M_t and P_{mt} are determined within the model, so they are endogenous variables. Equations (3.13) and (3.14) are called the structural equations and since we have as many equations as the number of endogenous variables, our system of equations (structural equations) is complete.

Now, we are interested in estimating the demand, Equation (3.13). Since M_t^d and u_{1t} are correlated and P_{mt} is partially determined by M_t^d, it is clear that P_{mt} then should be correlated with u_{1t}. The correlatedness of P_{mt} and u_{1t} violates one of the basic assumptions of the classical regression model and thus applying ordinary least squares to estimate Equation (3.13) will give inconsistent estimates of the parameters of interest.

Thus, if we were to estimate the demand equation, we need additional information, namely from the supply equation. Solving Equations (3.13) and (3.14) simultaneously and set

[1] Note that now we are talking for the firms in aggregate in the country of interest. It is assumed that the firms in aggregate are not necessarily price takers.

$M_t^d = M_t^s$, we obtain

$$P_{mt} = \frac{B_0-A_0}{A_1-B_1} + \frac{B_2}{A_1-B_1} T + \frac{u_{2t}-u_{1t}}{A_1-B_1}$$

or

$$P_{mt} = \frac{B_0-A_0}{A_1-B_1} + \frac{B_2}{A_1-B_1} T + v_{1t} \qquad (3.15)$$

where

$$v_{1t} = \frac{u_{2t}-u_{1t}}{A_1-B_1}$$

and

$$M_t = \frac{A_1B_0-A_0B_1}{A_1-B_1} + \frac{A_1B_2}{A_1-B_1} T + v_{2t} \qquad (3.16)$$

where

$$v_{2t} = \frac{A_1u_{2t}-B_1u_{1t}}{A_1-B_1} \qquad (3.17)$$

Equations (3.15) and (3.16) are called the reduced forms of the structural equations. They are the endogenous variables expressed in terms of exogenous variab[illegible] , T. By assumption, T is independent of u_{it} (i=1,2). Therefore, the reduced forms can consistently be estimated by ordinary least squares.

The demand Equation (3.13) can be estimated via estimating the reduced forms (3.15) and (3.16) using ordinary least squares and then solve for the estimate of A_1. In the following analysis, we take the small letters to denote the estimates of the parameters of the equation of our interest.

Applying ordinary least squares to the reduced forms, we obtain

$$\frac{b_2}{a_1 - b_1} = C_1 \qquad (3.18)$$

and

$$\frac{a_1 b_2}{a_1 - b_1} = C_2 \qquad (3.19)$$

where C_i are the estimates of the coefficients for T in Equations (3.15) and (3.16) respectively, $i = 1,2$.

Dividing Equation (3.19) by Equation (3.18), we have

$$a_1 = \frac{C_2}{C_1} \qquad (3.20)$$

Once A_1 is estimated, A_0 can be estimated by using the fact that the estimated demand Equation (3.13) passes through the means of M_t^d and P_{mt} during the sample period. Equation (3.20) is our estimate of the parameter in our demand Equation (3.13). The procedure described above enables us to estimate every parameter in the demand equation, and we say that the demand equation is identified (exactly identified in this case). The method is called the indirect least squares. The method applies only to the equation which is exactly identified. The supply equation cannot be estimated by using the reduced forms (3.15) and (3.16). Thus, we say that the supply equation is not identified.

By now it should be clear that the presence of the exogenous variable, T, in the supply equation plays a crucial role in making the demand equation exactly identified. This amounts to saying that the purpose of having T is to shift the supply curve over the fixed demand curve giving us the intersection points, thus tracing out the demand curve.

We close this section by giving the necessary conditions for identification. An equation is said to be identified (in the context of econometrics), when the number of endogenous variables (say k) in the equation to be estimated is at most equal to the number of exogenous variables (say K) outside the equation to be estimated but within the sytstem. If k = K, the equation is exactly identified. If k is greater than K, it is not identified. And if k is less than K, then the equation is overidentified. There are a number of procedures which can handle an overidentified equation. The most popular one is the Two-Stage least squares, see Johnston [20, pp. 380-384].

The Assumption Therefrom

After reading numerous articles on the estimation of import demand function[1] it was found that economists tend to

[1] See Houthakker and Magee [18], Kreinin [21, 22], and Price and Thornblade [28].

neglect the identification problem. In other words, they simply apply ordinary least squares on the demand equation without taking into account the simultaneity problem. And in this section we will examine the various assumptions one is supposed to be making if the simultaneity problem is to be avoided, at least theoretically.

In trying to avoid the simultaneity bias, economists assume that the export supply of the commodity in question is infinitely elastic. Murray and Ginman [24] argued that it is reasonable to make such assumption if the economy of the exporting country is not at full employment. But we will see soon that their [24] assumption unfortunately turns out to be fatal for statistical purposes, at least in the short-run. To show the weakness of less-than full employment assumption, let us consider the model

$$M^d = D(P_m, P_d) \tag{3.28}$$

$$M_s = S(P_m, T) \tag{3.29}$$

where P_d is the price of domestic substitute and all the other variables are as defined previously. Equation (3.28) would imply that we are holding the price of output constant. If we hold P_d and T constant, Equation (3.28) and (3.29) can be represented by Figure 3.1.

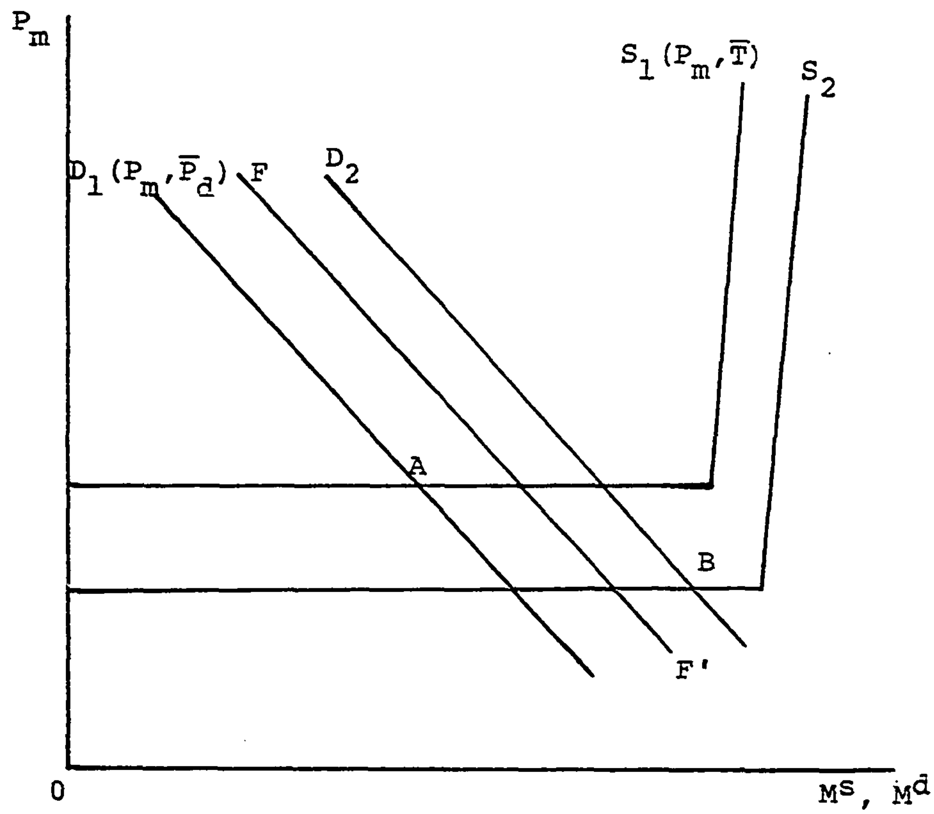

Figure 3.1. The supply and demand curves

In the short run, let us assume for a moment that P_d is fixed.[1] The variable T is certainly fixed in the short run. The fixity of P_d is certainly favorable, but since T does not change, will mean that we could only obtain one intersection point, such as point A. Thus, estimation of the demand curve is just impossible in the short run. To relax our assumption, now let us allow P_d to change. As P_d changes, the demand curve changes giving us the equilibrium points. But in this case, changes in P_d will trace out the supply curve rather than the demand curve. Thus, we can say that in the short run, less-than-full employment assumption fails to identify the demand curve.

In the long run, every variable changes and so do P_m, P_d, and T. For simplicity assume now that P_d increases shifting the demand curve to the right, that is from D_1 to D_2. As technological progress occurs (a long run phenomenon), this increases the marginal productivity of resources used in the production of the importing commodity from abroad. This makes the foreigners willing to export more of the commodity even at the same price. In other words, technological progress shifts the supply curve from S_1 to S_2 intersecting the new demand curve, D_2, at B. Now, we can say that as demand and supply curves are shifting to the right, we would

---

[1] P_d may assume to be fixed if the economy of the importing country is not at full employment.

be able to estimate the demand curve such as FF' unbiasedly by ordinary least squares.

But it is highly probable that P_d may even decrease in the long run due to the technological progress or the economies of scale in the import-substitute industry, shifting the demand curve to the left.[1] It is highly unrealistic to assume that technological progress in the foreign country would result in an increase in the costs of producing our imported goods. That is, it is unrealistic to imagine that the supply curve shifts upward due to technological progress. Since under the less-than full employment assumption, the supply curve would not shift to the left, there is no way we would be able to obtain equilibrium points above the line AS_1.

From the above discussion, it is seen that less-than full employment assumption is very restrictive and even fails to identify the demand curve in the short-run. Now, let us consider an alternative assumption. It will be seen that if we want to use ordinary least squares without considering the simultaneity bias, the assumption of perfect competition in the product and the factor markets must be satisfied.

In this analysis, we define our conceptual model of

[1]We assume here that P_d and T are exogenous variables.

perfect competition as a market situation where no single seller or buyer is able to influence the market price appreciably, Robinson [31]. In this particular case, we are talking from the point of view of the importers (buyers). Each buyer takes the price as given as dictated by the world supply and demand. We define the world supply as the horizontal summation of individual supply of producing countries and the world demand is the horizontal summation of individual demand of importing countries. For clarity, consider Figure 3.2, where

D_{US} = United States demand

S_{US} = supply to United States

D_W = World demand

S_W = World supply

D_C = demand for Ceylon product

S_C = Ceylon supply

In what follows, the demand Equation (3.28) and the supply (3.29) are assumed to hold. Firstly, let us consider the short-run case. During this time span, P_d is assumed unchanged,[1] and therefore the demand curve, D_{US}, is fixed. Starting with equilibrium price, P_m^1, now assume that the prices

[1]Hereafter, United States is assumed to be selling its import substitute both in the domestic and foreign markets. United States is assumed to be a price taker in its imports market and exports market.

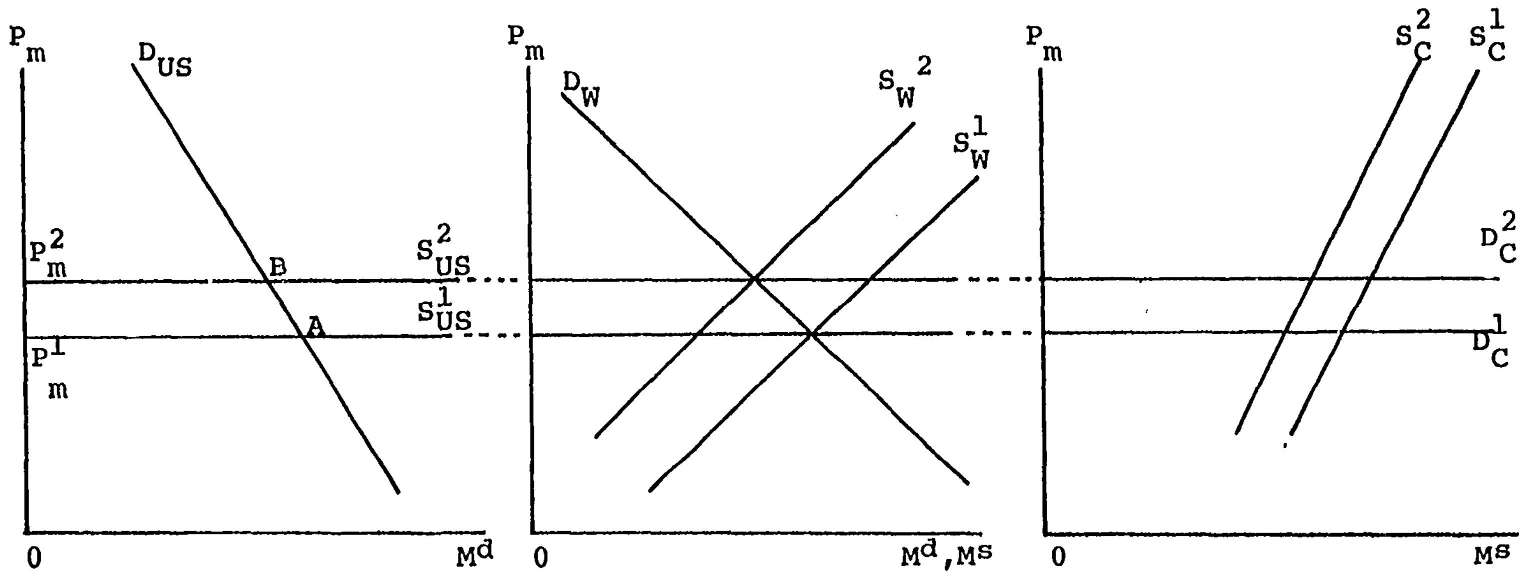

Figure 3.2. The world demand and supply curves

of resources used in the production of U.S. imported good increase, at least in a good many of the producing countries. This will clearly shift the world supply curve from S_W^1 to S_W^2 (say). Since world demand is assumed to be fixed, the decrease in the world supply increases the price to P_m^2, which is in fact the supply curve of U.S. imported goods, intersecting the fixed D_{US} at B. Thus, as factor prices change, the S_{US} changes accordingly tracing out the D_{US} curve, and D_{US} is then identified. So, AB is our demand curve. Since P_m and P_d are assumed to be fixed (U.S. is a price taker in both markets), application of ordinary least squares to the demand function of U.S. is justified.

In the long run, both P_d and T change. As P_d changes, D_{US} changes and as T changes the world supply curve changes too. We need no more diagram for illustration. It will be seen that in the long run, we will be estimating the demand curve such as the line FF' in Figure 3.1. This illustrates that in order to use the ordinary least squares in the estimation of the import demand function, make sure that the small country model is at least approximately satisfied.

The Determinants of Elasticity of Derived Demand[1]

One of the objectives of estimating the demand equation is to estimate its elasticity. Assuming that the demand function is linear, its elasticity, E, is given by

$$E = - \frac{dM^d}{dP_m} \cdot \frac{P_m}{M}$$

$$= A \cdot \frac{P_m}{M}$$

where A is the regression coefficient of P_m. In empirical estimation, the estimate of A is substituted for A, while P_m and M are replaced by their means. There are many factors that may determine the elasticity of demand of a commodity with respect to its own price. Hicks [17] gives four Marshallian rules governing this coefficient, namely:

1. "The demand for a factor is likely to be more elastic, the more readily substitutes for that factor can be obtained.

2. The demand for a factor is likely to be more elastic, the more important is the part played by the cost of that factor in the total costs of producing a product it contributes to produce."

Rule two is true only if the substitution elasticity of other factor for that factor is less than the elasticity of demand of the product it contributes tc produce.

[1] See Hicks [17, pp. 241-247]. A deeper treatment is given by Sato and Koizumi [33].

3. "The demand for a factor is likely to be more elastic, the more elastic is the supply of the co-operant agents of production.

4. The demand for a factor is likely to be more elastic, the more elastic is the demand for any further thing that it contributes to produce."

CHAPTER IV. THE MODEL

The Theoretical Formulations

Our main task in this section is to theoretically explain how we obtain the demand and the supply equations. Let us begin with the demand side of the market. We have already discussed the marketing of natural rubber in Chapter II. It involves a contractual arrangement between the buyer and the seller. The time lag between the purchase and the actual delivery of the physical commodity ranges from 6 to 12 months.

For clarity, let us consider an example. Assuming now we have a firm from the United States purchasing natural rubber from Malaysia. The firm knows there is going to be a delivery lag of 6-12 months. Thus, it is assumed here that this year's purchase of natural rubber is to be consumed next year. It is further assumed that the firm has a next year consumption plan obtained by way of profit maximization discussed in Chapter III using the current price of natural rubber prevailing in the New York market. From the practical point of view, the firm could base its consumption decision on any actual market. This is because the prices prevailing on all the markets on any given day should be very close to each other. The difference in the prices between any two markets should only reflect the transportation costs. If the divergence in the prices is greater than the transportation costs the arbitragers would come in and their activities would equalize the price (excluding the transportation costs) accordingly.

Knowing the next year's desired consumption, the firm then makes the necessary contractual arrangement with an exporter in Malaysia today with the physical commodity to be delivered within 6-12 months from now at a price specified today. It is possible that the exporter has very little raw rubber in the storage when the deal is made. Thus, the exporter has to actually buy the raw rubber from the producers (smallholders or estates producers) and the rubber may have to pass through a chain of intermediaries as discussed in Chapter II. This might explain why the delivery period is quite long in order to give the exporter ample time to gather the required quantities purchased by the United States firm.

It is also assumed that the firm could not adjust its consumption plan within a year. This is because the firm has to adjust its nonoptimal plant size to the optimal one. As every firm manufacturing rubber products tries to purchase more capital goods for investment purposes, their actions in aggregate will certainly drive up the price of capital goods, at least in the short-run. This implies that rapid adjustment to the optimal situation is costly to the firm, and thus it will adjust to its desired consumption slowly.

For ease of exposition and without the loss of generality, let us assume that this year's optimal consumption of each country depends on the lagged price of natural rubber. It is the last year price that determines the current desired consumption since the current desired consumption was decided and purchased last year at a price prevailed during that period. Furthermore, we let the relation be additive as

$$C_t^* = \alpha_0 + \alpha_1 PN_{t-1} + U_{1t} \tag{4.1}$$

where

C_t^* = current optimal consumption of natural rubber

PN_{t-1} = lagged price of natural rubber

U_{1t} = stochastic disturbance

α_0, α_1 = the parameters of interest.

As C_t^* is not observable, we need to make further assumption. Since the consumption plan is frustrated by the reasons just discussed, the firm then slowly adjusts to the equilibrium situation. Let the adjustment process be approximated by

$$C_t - C_{t-1} = \lambda_1 (C_t^* - C_{t-1}) \tag{4.2}$$

where

C_t = current actual consumption

C_{t-1} = lagged actual consumption

λ_1 = adjustment coefficient, $0<\lambda_1<1$.

Equation (4.2) states that the firms are adjusting from a nonoptimal to an optimal situation. The adjustment from one period to another is a fraction of the difference between the current desired consumption and the preceding actual consumption. If $\lambda_1 = 1$, then the current actual consumption is equal to the current desired consumption, implying that the firms are instantaneously adjusted and thus always in equilibrium. If $\lambda_1 = 0$, then the current actual consumption equal to the preceding actual consumption, meaning that the firms are not adjusting. Since when $\lambda_1 = 0$ or 1 the situation is not interesting, we will restrict the adjustment coefficient between zero and one.

Now, substituting (4.1) into (4.2) for C_t^*, we obtain

$$C_t = \lambda_1\alpha_0 + \lambda_1\alpha_1 PN_{t-1} + (1-\lambda_1)C_{t-1} + \lambda_1 U_{1t} \tag{4.3a}$$

or

$$C_t = \beta_0 + \beta_1 PN_{t-1} + \beta_2 C_{t-1} + W_{1t} \tag{4.3b}$$

where

$$\beta_k = \lambda_1\alpha_k, \quad k = 0,1$$
$$\beta_2 = (1-\lambda_1)$$
$$W_{1t} = \lambda_1 U_{1t}.$$

Equation (4.3b) is the equation to be estimated and β_0, β_1, and β_2 are the parameters of interest.

On the supply side, we assume the supply of natural rubber from each country depends on its expected long-run price. It is also additively related as

$$Q_t = \delta_0 + \delta_1 PN_t^* + U_{2t} \qquad (4.4)$$

where

Q_t = current actual production of natural rubber

PN_t^* = current expected long-run price

U_{2t} = disturbance term

δ_0, δ_1 = the parameters of interest.

We assume further that the producers update their expected long-run price in the direction of actual price according to

$$PN_t^* - PN_{t-1}^* = \lambda_2 (PN_t - PN_{t-1}^*) \qquad (4.5)$$

where $0<\lambda_2<1$. Equation (4.5) says that the producers are updating the expected price each period by a fraction of the difference between the current actual price and the preceding expected long-run price. Equation (4.5) can be written as

$$PN_t^* = \lambda_2 PN_t + (1-\lambda_2) PN_{t-1}^* \qquad (4.6)$$

Lagging (4.4) by one period, we obtain

$$Q_{t-1} = \delta_0 + \delta_1 PN_{t-1}^* + U_{2t-1}$$

giving

$$PN_{t-1}^* = \frac{1}{\delta_1} Q_{t-1} - \frac{\delta_0}{\delta_1} - \frac{1}{\delta_1} U_{2t-1} \qquad (4.7)$$

Substituting (4.6) into (4.4) for PN_t^*

$$Q_t = \delta_0 + \delta_1\lambda_2 PN_t + \delta_1(1-\lambda_2)PN_{t-1}^* + U_{2t} \tag{4.8}$$

Substituting (4.7) into (4.8) for PN_{t-1}^* and rearranging

$$Q_t = \lambda_2\delta_0 + \lambda_2\delta_1 PN_t + (1-\lambda_2)Q_{t-1} + U_{2t}$$

$$- (1-\lambda_2)U_{2t-1} \tag{4.9a}$$

or

$$Q_t = \gamma_0 + \gamma_1 PN_t + \gamma_2 Q_{t-1} + W_{2t} \tag{4.9b}$$

where

$$\gamma_0 = \lambda_2\delta_0$$

$$\gamma_1 = \lambda_2\delta_1$$

$$\gamma_2 = (1-\lambda_2)$$

$$W_{2t} = U_{2t} - (1-\lambda_2)U_{2t-1}.$$

Equation (4.9b) is the equation to be estimated and γ_0, γ_1, and γ_2 are the parameters of interest.

Lagged Production as a Regressor: An Interpretation

Model formulation (4.4) gives us lagged production as one of the regressors. While the meaning of this regressor may be difficult to interpret for other cases, it is very clear for the case of natural rubber and other tree crops such as coffee and oil palms. Now, consider this identity

$$Q_t = \psi_t A_t \tag{4.10}$$

where

ψ_t = yield per acre at time t

A_t = total acreage harvested at time t.

Now write

$$\tau_{t,j} = \theta_{t,j} A_{t,j} \tag{4.11a}$$

where

$\tau_{t,j}$ = total number of trees planted j years ago and survive to year t and harvested at time t

$\theta_{t,j}$ = number of rubber trees per acre at time t planted j years ago

$j = 6,7,\ldots,\ell$

ℓ = productive life of a rubber tree

$A_{t,j}$ = acreage planted with rubber trees j years ago harvested at time t.

For practical purposes, one may assume that $\theta_{t,j} = \theta$, that is the number of trees per acre planted j years ago which survive to year t is a constant. Thus

$$\tau_t = \theta \sum_{j=6}^{\ell} A_{t,j}$$

$$= \theta A_t \tag{4.11b}$$

or simply

$$A_t = \frac{1}{\theta} \tau_t \tag{4.12}$$

where A_t is the total acreage planted with rubber trees which are harvested at time t.

Substituting (4.12) in (4.10) for A_t,

$$Q_t = \frac{1}{\theta} \psi_t \tau_t \qquad (4.13)$$

Lagging (4.13) by one period

$$Q_{t-1} = \frac{1}{\theta} \psi_{t-1} \tau_{t-1} \qquad (4.14)$$

Clearly, τ_{t-1} embodies past investments committed by the rubber producers. We know that the gestation period of natural rubber is about 6 years. During the period the producers have to commit a significant amount of expenses to maintain rubber trees. These expenses may be in the form of labor costs, fertilizers costs, costs of herbicides and insecticides, and others. All these costs will be embodied in these rubber trees. The yield per acre, ψ_{t-1}, also embodies past investments, that is the investments in research and development to find new clones and new forms of techniques to help increase the production of natural rubber. Thus, we may conclude now that Q_{t-1} really represents past investments committed by rubber producers.

The Empirical Model

This section contains the various equations that were fitted in the study. Starting with the consuming countries, the consumption equation for each country is given by

$$C_t = \beta_0 + \beta_1 PN_{t-1} + \beta_2 PS_{t-1} + \beta_3 IPI_t + \beta_4 T + \beta_5 C_{t-1} + W_{1t} \quad (4.15)$$

where

PS_{t-1} = lagged price of synthetic rubber

IPI_t = current industrial production index

T = time

$\beta_k = \lambda_1 \alpha_k, \quad k = 0,1,\ldots 4$

$\beta_5 = (1-\lambda_1)$

All other variables are as defined previously. Equation (4.15) postulates that the current consumption of natural rubber depends on its lagged price, the lagged price of synthetic rubber, the current industrial production index, time trend, and its lagged consumption. Obviously, the inclusion of variables IPI and T needs further explanation. In Chapter III, the demand for a factor of production was derived and it was found that how much of a factor of production a firm uses will depend on the level of output the firm wants to achieve. This is to say that the demand for natural rubber will depend on the level of output of rubber products the firm would like to produce. The higher the level of output, the more natural rubber will be demanded. There are many kinds of rubber products being produced and the data on them are not easily available from the various countries that we are interested in. Thus, in this study the level of output of rubber products is proxied by the index of industrial production. We would expect that the level of output of rubber products is positively correlated with the level of industrial production index.

The variable T is included as an effort to capture the effect of factors other than the prices of natural and synthetic rubber and industrial production which affect the demand for natural rubber. If the change is in favor of natural rubber then the coefficient should be positive. A negative coefficient would indicate a favor to synthetic rubber.

The supply equation of each country is represented by

$$Q_t = \gamma_0 + \gamma_1 PN_t + \gamma_2 T + \gamma_3 Q_{t-1} + W_{2t} \qquad (4.16)$$

where

T = time

All other variables are as defined before.

The inclusion of time trend in the equation is worth explaining. In the last decade or more, there has been a tremendous technological progress taking place in the natural rubber industry. These may take in several forms such as the growing of high yielding clones and the development of better agronomic practices. T is added as an attempt to take account of these factors, thus reducing the specification error.

We close the model by giving some identities. In each consuming country, this identity holds

$$C_t = M_t + \Delta S_t^c$$

where

M_t = import of natural rubber in period t

ΔS_t^c = the change in inventory of natural rubber in each of the consuming countries in period t

$= S_t^c - S_{t-1}^c$

and in each producing country the following identity holds

$$Q_t = X_t + \Delta S_t^q$$

where

X_t = export of natural rubber in period t

ΔS_t^q = the change in inventory of natural rubber in the producing country in period t

$= S_t^q - S_{t-1}^q$

For the world as a whole, these identities hold as

$$TM_t = TC_t + \Delta TS_t^c$$

$$\Delta TS_t^c = TS_t^c - TS_{t-1}^c$$

$$TX_t = TQ_t + \Delta TS_t^q$$

$$\Delta TS_t^q = TS_t^q - TS_{t-1}^q$$

and at equilibrium

$$TX_t = TM_t$$

where

TM_t = total world import of natural rubber in period t

TX_t = total export of natural rubber in period t

ΔTS_t^c = the change in the total stocks of natural rubber in the consuming countries in period t

ΔTS_t^q = the change in the total stocks of natural rubber in producing countries in period t

TC_t = total world consumption of natural rubber in period t

TQ_t = total world production of natural rubber in period t

Estimation Procedure and Methods

In this study, it is assumed that we have three important world natural rubber markets,[1] namely: Singapore, London, and New York markets. For consuming countries, it is assumed here that they base their consumption decisions as follows: a) United States and the rest of the world[2] on New York prices, b) European countries on London prices, and c) Japan on Singapore prices. Since the prices of synthetic rubber are not available for countries other than the United States, United

[1]RSS1 (Ribbed-Smoked-Sheet number one) prices of natural rubber from these markets will be used in the estimation of supply and demand functions.

[2]Excluding centrally-planned economies.

States prices[1] will be used for the other countries. On the production side, it is assumed that they base their production decisions on the Singapore prices.

For each country, whenever appropriate, we will convert those prices into local currency using its exchange rates and then deflate these prices by the country's wholesale price index.

The following methods are used to estimate the various equations. For each of the demand equations, ordinary least squares will be used. Since the consumption share of each country is small it is assumed, under normal conditions, that each country is a price taker in the natural rubber markets. But since we are using time series data, this leads us to suspect that the error terms might be serially correlated. When the error terms are serially correlated, application of the usual least-squares formulae to estimate the variances of the regression coefficients will likely underestimate these variances, Johnston [20, pp. 246-249].

If the disturbance terms are serially correlated, it is to be assumed that the errors are generated by a first order autoregressive process

$$W_t = \rho W_{t-1} + e_t \qquad (4.18)$$

[1]SBR (Styrene Butadiene Rubber) prices will be used.

where $|\rho| < 1$ and e_t are independently and normally distributed with mean zero and constant variance. Let the estimate of ρ be r, where

$$r = \frac{\sum_{t=2}^{n} w_t w_{t-1}}{\sum_{t=2}^{n} w_{t-1}^2}$$

and w_t denotes the estimates of W_t. The hypothesis that $|\rho| = 0$ against $|\rho| \neq 0$ is tested using h-statistic,

$$h = r\sqrt{\frac{n}{1-nV(b_5)}}$$

where $V(b_5)$ is the estimate of the sampling variance of β_5, the coefficient of the lagged dependent variable as the regressor. For detail on h-statistic, see Durbin [7]. The h so obtained is compared with the standard normal deviate. If the hypothesis is rejected at 5% level of significant, autocorrelation problem will be corrected.

Let us consider an example to see how correction for autocorrelation is done. Let the model be

$$C_t = \beta_0 + \beta_1 PN_{t-1} + \beta_5 C_{t-1} + W_{1t} \tag{4.19}$$

and W_{1t} is generated by the process of (4.18). To estimate Equation (4.19), first apply ordinary least squares to (4.19) to obtain the estimate of W_{1t}. Use these estimated residuals to obtain r. If r is significantly different from zero, autocorrelation is corrected as follows. Substituting (4.18) in (4.19) for W_{1t}

$$C_t = \beta_0 + \beta_1 PN_{t-1} + \beta_5 C_{t-1} + \rho W_{1t-1} + e_t \qquad (4.20)$$

Lagging (4.19) by one period

$$C_{t-1} = \beta_0 + \beta_1 PN_{t-2} + \beta_5 C_{t-1} + W_{1t-1}$$

giving

$$W_{1t-1} = C_{t-1} - \beta_0 - \beta_1 PN_{t-2} - \beta_5 C_{t-2} \qquad (4.21)$$

Substituting (4.21) in (4.20) for W_{1t-1} and rearranging

$$C_t - \rho C_{t-1} = \beta_0 - \rho\beta_0 + \beta_1 (PN_{t-1} - \rho PN_{t-2})$$

$$+ \beta_5 (C_{t-1} \rho C_{t-2}) + e_t$$

Substituting r for ρ, gives

$$C_t - rC_{t-1} = \beta_0 - r\beta_0 + \beta_1 (PN_{t-1} - rPN_{t-2})$$

$$+ \beta_5 (C_{t-1} r C_{t-2}) + e_{2t} \qquad (4.22)$$

Ordinary least squares is applied to (4.22) to obtain the estimates of β_0, β_1, and β_5. Substitute these estimates into Equation (4.19) to obtain another estimates of W_{1t} from which another r is calculated. Substitute this r in (4.22) and ordinary least squares is applied again to this equation to obtain another estimates of β_0, β_1, and β_5. The process is repeated until the estimates of ρ, β_0, β_1, and β_5 converge. In this study, the estimates tend to converge after three iterations.

On the supply side, it is somewhat unrealistic to assume that such a country like Malaysia, producing about 42 per cent of world natural rubber, as a price taker in the world natural rubber market. In an attempt to eliminate this simultaneity bias, the Instrumental Variable approach developed by Fair [8] is employed to obtain consistent estimate of the coefficients in the supply equations.[1] This method was used by Fisher and others [14] in their studies of the world copper industry. To demonstrate the essence of the method consider this supply equation

$$Q_t = \gamma_0 + \gamma_1 PN_t + \gamma_2 Q_{t-1} + W_{2t} \qquad (4.23)$$

where W_{2t} is generated by (4.18). The problem with Equation (4.23) is that PN_t is correlated with W_{2t} violating one of the basic assumptions of the classical linear regression model. To estimate (4.23), Fair suggested that we first estimate PN_t by regressing PN_t at least on PN_{t-1}, Q_{t-1}, Q_{t-2}. In other words, the method requires that the endogenous variable PN_t be estimated by regressing PN_t on all the exogenous variables, all the predetermined variables, all the lagged values of exogenous variables, all the lagged values of predetermined

[1]All the supply equations are estimated by using the Instrumental Variable Method.

variables, and the lagged value of endogenous variable in the equation. The estimate of PN_t is substituted in (4.23) for PN_t and fit the resulting equation by ordinary least squares to obtain preliminary estimates of the parameters. Substitute the preliminary estimates into the original Equation (4.23) to estimate the residual, W_{2t}. Once this is done, the procedure in the estimation of the demand functions discussed previously can be applied to test autocorrelation, to correct autocorrelation, and to obtain the final estimates.

In this study, the other instruments which are used other than that required by Fair's method are the ratio of lagged stock of natural rubber in all consuming countries to the lagged stock of natural rubber in all the producing countries and the ratio of the lagged total world consumption to the lagged total world production of natural rubber.

CHAPTER V. EMPIRICAL RESULTS

The Estimated Demand Equations

In Chapter II, we discussed the price of the synthetic rubber industry. It was found that the price of synthetic rubber is an administered one. Thus, the use of these prices in the regression analysis is not very satisfactory, since the prices under the sample period are almost unchanged. Now, the choice is either to incorporate the price of synthetic rubber into the model or we drop it altogether. In this study, it was decided to incorporate the price of synthetic rubber into the model to see whether synthetic rubber is a substitute or a complement. If the sign on the price of synthetic rubber is positive it is a substitute and if the sign is negative it is a complement.

Below are the results of the regression analysis and they are interpreted and discussed country by country. The consumption is measured in thousand (1,000) long tons and the elasticities are calculated at their means.

United States

$$C_t = 45407.6 - 600.522\ PN_{t-1} + 712.857\ PS_{t-1} + 2.6835\ IPI_t$$

(12913.5) (134.239) (1118.86) (0.8745)

(3.5135) (-4.4735) (0.6371) (3.0684)

$$- 23.1536\ T + 0.1473\ C_{t-1} - 10.7386\ D_1 + 114.168\ D_2$$

(6.6331) (0.1768) (46.1425) (47.9533)

(-3.4906) (0.8328) (-0.2327) (2.3808)

$R^2 = 0.7753$, $r = -0.0166$, Year = 1950-1974, 1950 = 100,

where[1] the values in the parentheses are the standard errors of the coefficients and the ratios of the coefficients to their standard errors respectively, R^2 is the multiple coefficient of correlation, r is the first order autoregressive coefficient. D_1 and D_2 are the dummy variables to take into account the variations in consumption of natural rubber during the Korean War in 1950-1952 and the energy crisis in 1973-1974. The dummies will take the value one during the period and zero outside the period. These two periods are not very important for other consuming countries and thus they will not be included for these countries.

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[1]The values of h-statistic will not be reported in this study unless they are significantly different from zero at 5 per cent level.

The ratio of the coefficient to its standard error will be used as the criterion to determine whether the coefficient is significantly different from zero. If the ratio is two[1] or more, we will take it as significant. The results for the United States are as follows. The fit (R^2) is not very good. The signs of the coefficients came out as expected from the theory. Note that the most important[2] variable that could explain the consumption in the United States is the price of natural rubber. The second most important variable is the time trend and it shows us that the consumption is declining over time during the sample period. This may indicate that the United States is shifting its consumption pattern in favor of synthetic rubber. Thirdly, the industrial production index does explain the variation in the consumption of natural rubber. The Korean War did not seem to affect the United States consumption, although the sign came out as expected, that is negative, since the consumption did slow down during the period. The 1973-74 energy crisis did significantly explain the consumption and the positive sign indicates that the United States is shifting its consumption back in favor of natural rubber although it is too early to make a strong conclusion.

[1]This is approximately the t-value at 5% significant level.

[2]Hereafter, the importance of each variable as a determinant of consumption or production is judged from the ratio of the coefficient to its standard error, the higher the more important it is.

The United States seems to adjust pretty well to its optimal consumption plan and in fact about 85 per cent of it is adjusted within one year, that is the adjustment coefficient is 0.8528. The short-run own-price elasticity of natural rubber consumption is 0.2761 and the long-run elasticity is 0.3343. The short-run elasticity with respect to the industrial production index is 0.8754 which is relatively high. The short-run consumption elasticity with respect to the price of synthetic rubber is 0.2548 and the long-run elasticity is 0.2988.

United Kingdom

$$C_t = \underset{\substack{(6761.196)\\(2.0863)}}{14106.01} - \underset{\substack{(17472.44)\\(-1.9026)}}{33242.75}\, PN_{t-1} + \underset{\substack{(76638.30)\\(1.9043)}}{145941.94}\, PS_{t-1} + \underset{\substack{(0.7284)\\(2.0066)}}{1.4617}\, IPI_t$$

$$+ \underset{\substack{(0.1647)\\(3.1853)}}{0.5246}\, C_{t-1} - \underset{\substack{(3.4962)\\(-2.0858)}}{7.2925}\, T$$

$R^2 = 0.7308$, $r = 0.0426$, Years = 1950-74, 1950 = 100.

For the United Kingdom, the fit is not that good but all the variables in the equation seem to show that they are important determinants of consumption. Here, the effect of the lagged consumption starts to show, and in fact, it is the most important determinant of the United Kingdom consumption. The speed of adjustment is 0.4754, which is relatively slow. In other words, about 48 per cent of the optimal consumption is satisfied in one year. As expected, the United Kingdom consumption of natural rubber is declining as indicated by the time trend coefficient.

The short-run elasticity of consumption with respect to its own price is 0.1062 and the long-run elasticity is 0.2233. The short-run elasticity with respect to industrial production index is 1.2531 which is elastic. The short-run elasticity of consumption with respect to the price of synthetic rubber is 0.3845 and the long-run elasticity is 0.8087.

West Germany

$$C_t = 7173.49 - 2042.68\ PN_{t-1} + 8498.84\ PS_{t-1} + 0.4312\ IPI_t$$

(3598.67)	(644.18)	(2728.69)	(0.1397)
(1.9934)	(-3.1710)	(3.1146)	(3.0840)

$$+ 0.4387\ C_{t-1} - 3.6947\ T$$

(0.1326)	(1.8531)
(3.3086)	(-1.9937)

$R^2 = 0.9648$, $r = -0.0686$, Years = 1950-74, 1950 = 100.

The fit for West Germany is very good and the sign of the coefficients are consistent with the expectation from economic theory. All the variables are important determinants of West Germany's consumption. The speed of adjustment is relatively slow, that is the coefficient of adjustment is 0.5613. Like the United Kingdom, the lagged consumption is the most important explanatory variable. As in the United States and the United Kingdom, Germany's consumption of natural rubber shows a downward trend.

The short-run own-price elasticity of consumption of natural rubber is 0.1267 and the long-run elasticity is 0.2257. The elasticity with respect to the industrial production index in the short-run is 0.7937. The short-run elasticity of consumption with respect to the price of synthetic rubber is 0.5297 and the long-run elasticity is 0.9437.

<u>Japan</u>

$$
\begin{aligned}
C_t = \; & -15510.32 \;-\; 3.9527\, PN_{t-1} \;+\; 0.3838\, PS_{t-1} \;+\; 0.0205\, IPI_t \\
& \quad (4469.66) \qquad (10.3334) \qquad\quad (17.2362) \qquad\quad (0.0096) \\
& \quad (-3.3701) \qquad (-0.3825) \qquad\quad (0.0223) \qquad\quad (2.1354) \\
& + 0.1477\, C_{t-1} + 7.9784\, T \\
& \quad (0.2184) \qquad (2.2950) \\
& \quad (0.6760) \qquad (3.4764)
\end{aligned}
$$

$R^2 = 0.9927$, $r = 0.1087$, Years = 1950-74, 1955 = 100.

The fit for Japan is very good, but the only important determinant of Japan's consumption of natural rubber, other than the time trend, is the industrial production index. The trend shows us that consumption in Japan has been increasing in the sample period. Japan, like the United States, does show a rapid adjustment to the desired consumption. The adjustment coefficient is 0.8523 which is about the same as that of the United States. The short-run elasticity of consumption with respect to its price is 0.0151 and the long-run elasticity is 0.0177. The short-run elasticity with respect to the industrial production index is 0.0931 which is low compared to the coefficients of the other consuming countries.

France

$$C_t = \underset{\substack{(1855.66)\\(0.2597)}}{2148.59} - \underset{\substack{(7.8782)\\(0.6035)}}{6.8864}\, PN_{t-1} - \underset{\substack{(38.7338)\\(0.9575)}}{2.0367}\, PS_{t-1} + \underset{\substack{(0.0765)\\(1.1743)}}{0.0898}\, IPI_t$$

$$+ \underset{\substack{(0.1251)\\(6.19)}}{0.7747}\, C_{t-1} - \underset{\substack{(0.9604)\\(1.13)}}{1.0878}\, T$$

$R^2 = 0.8905$, $r = 0.0607$, Years = 1950-74, 1950 = 100.

The fit for France is not very good. The coefficient on the lagged price of natural rubber came out as expected, although it is not significant. But the coefficient on the lagged price of synthetic rubber is negative which implies that the synthetic rubber in France is a complementary factor of production. Since the coefficient on synthetic rubber price is not significant, we could not say for sure that natural rubber and synthetic rubber in France are complementary factors of production.

The lagged consumption is the only regressor that could explain the natural rubber consumption in France supporting our theoretical model formulation as discussed in Chapter IV. France seems to adjust to its desired consumption quite slowly since only about 22 per cent is adjusted per year. The short-run elasticity of consumption of natural rubber with respect to its price is 0.034 and the long-run elasticity is 0.151. The short-run elasticity of consumption with respect to industrial production index is 0.1705 and the long-run elasticity is 0.757.

The rest of the world

The estimation of the rest of the world consumption equation needs some clarification. The major countries that make up the rest of the world are India, Australia, Canada, and Italy. In an attempt to deflate the prices of natural rubber and synthetic rubber, the method used by Fisher et al. [14] was employed with slight modification. First, the wholesale price index of each of the four countries is multiplied by its index of the exchange rate, expressed in terms of U.S. dollar per unit of the country's currency, to convert the wholesale price index into a common unit of measurement. In other words, we are converting the wholesale price index into U.S. dollar equivalent. Then, we take the weighted average of the dollar equivalent wholesale price index to represent the wholesale price index of the rest of the world. The weight being the ratio of the natural rubber consumption of the country divided by the total consumption of the four countries.

The industrial production index of the rest of the world will be proxied by the index of the car production from the countries that make up the rest of the world. Since most of the raw rubber are used for manufacturing tires, we would expect the demand for natural rubber to increase as more cars are produced. The index of the rest of the world car production is denoted by $WCAR_t$. The results of the analysis are given below.

$$C_t = -86.7893 - 103.5758\ PN_{t-1} + 131.5890\ PS_{t-1}$$
$$(386.3332)\ (280.1381)\qquad (1091.029)$$
$$(-0.22)\quad (0.37)\qquad (0.12)$$
$$+30.4742\ WCAR_t + 0.9694\ C_{t-1}$$
$$(26.7527)\qquad (0.2309)$$
$$(1.14)\qquad (4.20)$$

$R^2 = 0.9667$, $r = -0.1984$, year = 1958-1974, 1958 = 100.

Although the fit for the rest of the world is good, the only regressor capable explaining the natural rubber consumption is the lagged consumption itself. The sign of the coefficient on price of natural rubber is consistent with the expected sign from the economic theory.

The rest of the world seems to adjust its consumption plan very slowly. Only about 3 per cent of its desired consumption is adjusted within one year. The short-run elasticity of consumption with respect to natural rubber price is 0.0326 and the long-run elasticity is 1.065. The short-run elasticity of consumption of natural rubber with respect to synthetic rubber price is 0.0363 and the long-run elasticity is 1.186. The short-run elasticity of consumption with respect to the rest of the world car production index is 0.100 and the long-run elasticity is 3.274.

The Estimated Supply Equations

It is to be noted that in the case of supply side, we are assuming that the production decisions of each producing country are based upon the current price at the Singapore market. Obviously, we would want to use the domestic price actually received by the producers, but these data are not available. Even the information required for calculating the price received is very difficult to obtain. But this should not deter us from making the analysis of this side of the market. If we cannot get the first best data, then we have to be satisfied with the second best data. In other words, we have to be satisfied with the use of proxy variables. Thus, we take the price at the Singapore market multiplied by the country's exchange rate to convert into the local currency. We would hope that the so converted prices are positively correlated with the actual price received by the producers, the higher the better.

The Malaysian rubber industry will be broken into four parts, namely: the Estates in West Malaysia, the smallholdings in West Malaysia, Sarawak, and Sabah of East Malaysia. Their productions are measured in thousand (1,000) metric tons. The production for Malaysia as a whole, Indonesia, Thailand, and the rest of the world are measured in thousand (1,000) long tons. The results of the regression analysis are given below and the elasticities are calculated at the means.

<u>West Malaysia: estates</u>

$$Q_t = -7763.99 - 20.8851\ PN_t + 0.7652\ Q_{t-1} + 4.0278\ T$$
$$(3144.17)\quad (15.0366)\qquad (0.0973)\qquad (1.6246)$$
$$(-2.47)\quad (-1.48)\qquad (7.86)\qquad (2.48)$$

$R^2 = 0.9927$, $r = 0.0016$, years = 1952-74, 1955 = 100.

The fit of the estates sector in West Malaysia is excellent. The determinants of supply are the lagged production and the time trend, and the current price of natural rubber is not an important factor. The time trend is supposed to pick up the technological progress and it is significant. In Chapter IV, we interpreted the lagged production as to represent past investments made by the rubber producers. Since the lagged production is the most important determinant of supply, my further interpretation of the effect of this variable is just that, the producers after seeing that they have already committed their investments in the rubber plantations, they will produce as long as the short-run price of natural rubber covers the short-run average variable cost. And they will continue producing until the trees are no longer economically productive, which is about 25 years.

The coefficient on the current price is negative, thus violating our economic theory that the supply should be positively related to price. But it is very clear that the coefficient on the current price of natural rubber is not significant even at 10 percent level. The short-run elasticity of production with respect to the price is 0.035 and the long-run elasticity is 0.1491.

West Malaysia: smallholdings

$$Q_t = -14339.98 + 61.5349\ PN_t + 0.8656\ Q_{t-1} + 7.3187\ T$$

(6040.72)	(57.0872)	(0.1331)	(3.0910)
(-2.37)	(1.08)	(6.50)	(2.37)

$R^2 = 0.9452$, $r = -0.13191$, years = 1952-74, 1955 = 100.

The fit is still quite good. Like the estates sector, the lagged production and the time trend do explain the variation in the supply. The current price is not an important factor determining the production, but unlike the estates sector, the coefficient on price came out as expected from the theory. Although the smallholdings sector also experiences technological progress, it is not expected to be as great as the estates sector. The reasons are quite simple. The producers in the smallholdings sector are the laggards or at best they are only the skeptics. In other words, the rate of the acceptance of the new technology in this particular sector is relatively slow as compared to the estates sector. They are mostly the people who practice a wait and see policy before they accept any new technology. We cannot blame them for being so skeptical. They are skeptical simply because they are small farmers who just cannot afford to take big risks. Furthermore, most of the producers cannot use yield stimulants to increase the yield per acre because they are too expensive for them.

The short-run own-price elasticity of supply is 0.1214 and the long-run elasticity is 0.9241, showing that although the short-run supply is very inelastic, the long-run supply is relatively elastic.

East Malaysia: Sarawak

$$Q_t = -1689.21 + 39.7764\ PN_t + 0.4222\ Q_{t-1} + 0.85556\ T$$

$$\begin{array}{llll} (427.21) & (6.7420) & (0.1200) & (0.2158) \\ (-3.95) & (5.90) & (3.52) & (3.96) \end{array}$$

$R^2 = 0.7706$, $r = 0.0256$, years = 1952-74, 1955 = 100.

Although the fit is not very good, all the regressors are important determinants of natural rubber production in Sarawak. In fact, all the regressors are significantly different from zero even at 0.23 per cent level of significance. In terms of the ratio of the coefficients to their standard errors, the most important determinant of production is the current price of natural rubber. It is to be noted further that the price used here is that of the deflated price of West Malaysia as the wholesale price index from the state was not available. The short-run price elasticity is 0.8813 which is the most elastic supply of natural rubber obtained from this study. The long-run price elasticity is 1.5253.

East Malaysia: Sabah

$$Q_t = -1027.84 + 7.1054\ PN_t + 0.5790\ Q_{t-1} + 0.5262\ T$$

(275.83)	(2.8140)	(0.2109)	(0.1419)
(-3.73)	(2.53)	(2.75)	(3.71)

$R^2 = 0.8498$, $r = 0.1913$, years = 1952-74, 1955 = 100.

The fit for Sabah is a lot better than that of Sarawak although they are about the same size in terms of natural rubber outputs. Like Sarawak, all the variables are important determinants of Sabah production. For the same reason as that of Sarawak, West Malaysia deflated price was used in the analysis. Again, we see that current price is an important determinant of production, but the elasticities of supply with respect to current price are somewhat lower than that of Sarawak. The short-run own price elasticity of production is 0.2401 and the long-run elasticity is 0.5703.

Malaysia

$$Q_t = -21602.87 + 19.3829\ PN_t + 0.8786\ Q_{t-1} + 7.7635\ T$$

$$\qquad (55.82) \qquad (0.0934) \qquad (3.6185)$$

$$\qquad (0.35) \qquad (9.40) \qquad (2.15)$$

$R^2 = 0.9729$, $r = 0.30$, $h = 1.69$, year 1952-74, 1955 = 100.

By Malaysia we mean both of the West and the East Malaysia. It includes the estates sector and the smallholdings sector of West Malaysia, and Sabah and Sarawak of East Malaysia. The fit for Malaysia as a whole is satisfactory. As expected, lagged production is the most important variable that is capable of explaining the production of natural rubber. We do not expect the current price of natural rubber to be an important determinant of production because of the reasons previously discussed. But the coefficient of time trend could explain the production. The positive coefficient of time trend indicates that the supply of natural rubber in Malaysia has been shifting to the right during the sample period. The short-run elasticity of production of natural rubber with respect to its current price is 0.018 while the long-run elasticity is 0.148.

Indonesia

$$Q_t = -9362.14 + 2315.02\ PN_t + 0.6103\ Q_{t-1} + 4.9071\ T$$

(5886.86) (4448.15) (0.1559) (3.0092)

(-1.59) (0.52) (3.91) (1.63)

$R^2 = 0.6249$, $r = -0.1395$, years = 1952-74, 1955 = 100.

The only important variable that could explain the production of natural rubber from Indonesia is the lagged production. We do not expect the coefficient of time trend to be significant because as we had already seen in Chapter II, that the production in Indonesia is relatively unstable. The fit is not satisfactory, but that is the best that could be obtained from the various models that were tried. The short-run elasticity of supply with respect to the price is 0.0166 and the long-run elasticity is 0.0426.

Thailand

$$Q_t = -5356.76 + 135.16\ PN_t + 0.8361\ Q_{t-1} + 2.7478\ T$$

(3492.83) (83.9549) (0.1587) (1.7955)

(-1.53) (1.61) (5.27) (1.53)

$R^2 = 0.9739$, $r = -0.1047$, years = 1952-74, 1955 = 100.

Although the only important variable that is capable of explaining the supply of natural rubber from Thailand is the lagged production, the fit is very good. The coefficient of the time trend cannot significantly explain the production, but it has the positive sign as expected, implying that production in this country is in the upward trend. We would expect that there is some technological progress in the natural rubber industry of Thailand, but we do not expect it to be as great as that of the estates sector of West Malaysia. The short-run elasticity of supply with respect to price is 0.0326 and the long-run elasticity is 0.1989.

The rest of the world

$$Q_t = -2754.32 + 1672.75\ PN_t + 0.2613\ Q_{t-1} + 14.2286\ T$$

(8154.27)	(2487.48)	(0.2174)	(4.2066)
(-3.38)	(0.67)	(1.20)	(3.38)

$R^2 = 0.9234$, $r = 0.0689$, years = 1952-74, 1955 = 100.

Before we discuss the results, the following should be noted. The price used here is in terms of Ceylon currency and the deflator is also the wholesale price index of Ceylon. This is not as bad as it looks. The largest contributor in the rest of the world output is Ceylon. Other contributors include Vietnam, Cambodia and Laos. They were all experiencing some political unrest at least in a good part of the sample period. Therefore, it was felt that it is not worthwhile to take into account the changes in the exchange rates and the wholesale price indices from these countries. Furthermore, we do not expect the current price to be an important factor in determining the production, as we have already seen all along.

The results from the rest of the world is a surprise to me. The fit is good, but only the time trend is able to explain the production. It is expected that the price is unimportant, but the insignificance of lagged production is somewhat unusual from the various results that we have already seen so far. It is possible that the effectiveness of the lagged production is lost as a result of aggregation. In other words, we expect that the producers from different countries to exhibit different modes of behavior in their production decisions. The short-run elasticity of production with respect to the current price is 0.0360 and the long-run elasticity is 0.0487.

CHAPTER VI. CONCLUSIONS AND POLICY RECOMMENDATIONS

Summary and Conclusions

The study shows that the most important factor that determines the demand for natural rubber is the industrial production index of the consuming country. The importance of the industrial production index as a determinant of natural rubber consumption would imply that the consumption of this particular agricultural commodity is relatively sensitive to the general economic activities in the consuming countries. In fact, the elasticity of consumption of natural rubber with respect to industrial production index is relatively elastic as compared to the elasticity with respect to natural rubber price. Thus, if there are recessions in these countries, we might expect the demand for natural rubber to decrease.

The study also indicates that the consumption of natural rubber has been declining over time, except for Japan. This is within our expectation since the consumers of natural rubber are switching their consumption patterns in favor of synthetic rubber. This fact is further supported by the evidence that most of the major consumers of natural rubber are moving toward self-sufficiencies in the synthetic rubber production.

Generally, the price of natural rubber is not an important determinant of its consumption. The short-run elasticity of consumption of natural rubber with respect to its price is very inelastic. We cannot say for sure how accurate the estimated elasticity coefficients are, but it is a proven fact that the demands for most agricultural products are inelastic. Moreover, the magnitude of the elasticity coefficients on a particular demand curve varies. The elasticity coefficients tend to be higher at higher prices and low at lower prices. Since the means of natural rubber prices are low during the sample period (for an example the mean price at New York market is 26 cents per pound), this might be one of the reasons as to why the estimated coefficients of elasticity are low.

On the supply side, the study indicates that the production of natural rubber has been in the upward trends, especially the production from the estates sector of West Malaysia. Since the estates sector is contracting in terms of the total acreage planted with rubber trees, the increase in the total production from the sector is due to the increase in the yield per acre or per tree. The increase in yield per acre could be accounted by the adoption of new production techniques such as the planting of new high yielding varieties; the improved methods of fertilizer application; and the use of yield stimulants, etherel, to increase the yield. In other words, the estates sector is gaining the most benefits of technological progress in the natural rubber industry.

Although the estates sector in West Malaysia is contracting, this does not mean that there has not been any planting of rubber trees in the sector. As the old rubber trees are no longer economically productive, they are felled. Some of this land is replanted with new high yielding varieties and some of the land may be released for the production of other competing commodities such as oil palms. Replanting is also done in the smallholdings sector of West Malaysia and as well as in the other producing countries.

It is rather unfortunate that we could not examine the other producers of natural rubber as detailed as that of the estates sector in West Malaysia. This is mainly due to the unavailability of data. But it is conceivable that the new technology also spreads to the other producers of natural rubber and the diffusion of these new techniques of production to the rest of the producers is very sluggish.

The most important factor capable of explaining the natural rubber production is its lagged production. According to my view, lagged production could be interpreted as the already committed investments in rubber trees by the producers. The rubber is produced because the trees are there. In other words, the producers will produce rubber in the short-run as long as the prevailing market price covers the average variable cost. But in the long-run, the producers may divert their rubber land to the production of other cash crops such as oil palms and coffee if the price of rubber is persistently declining relative to the price of these competing crops.

Policy Recommendations

Malaysian government is currently employing the buffer stock scheme to control its export of natural rubber as an attempt to increase the world price of natural rubber. This is to say that the government has some desired price to achieve. When the world price is below the desired price, the government purchases natural rubber in its domestic market and stores the purchased commodity. When the world price is higher than the desired price, the government disposes of the stored commodity.

Now, here are two supplementary policies. Firstly, the government should discourage, by whatever means, the use of yield stimulant in the estates sector of West Malaysia. Keep in mind that this estates sector is the second largest producer of natural rubber (the largest being Indonesia) in the world. But we have already seen that the Indonesian production is unstable. So, it is clear that the bulk of the increase in the world natural rubber production comes from the estates sector of West Malaysia. Previously, we have already noted that one of the causes that increases the production is due to the application of yield stimulant. Thus, as yield stimulant is not applied, we would expect the rubber production in Malaysia to decrease. This should decrease the amount of rubber that has to be purchased by the government from the local producers in order to control the export supply. Thus, the financial burden of the government would be lessened considerably and the recommended policy tends to make the buffer stocking policy more effective.

The above recommended policy is a short-run policy. As a long range policy, the government should increase the export tax imposed on the rubber producers of the estates sector to discourage production and investment in rubber plantations. On the other hand, the government should decrease the export tax imposed on the oil palms producers. In other words, the oil palms producers should be subsidized to encourage the rubber producers in the estates sector to shift their rubber land towards more production of oil palms. We have already seen that the estates sector is diverting its rubber land to oil palms production, but the movement to this desirable direction would be hastened through subsidization. This is really an effort to balance up the production of natural rubber relative to oil palms.

Both recommendations directly concern with the estates sector. The reasons are simple. Firstly, the yield stimulant is not widely used in the smallholdings sector because it is not economical for small producers. Secondly, the planting of oil palms is not very conducive to the smallholdings sector because of the nature of the oil palms production. The processes involved in the oil palms production is relatively more sophisticated compared to the rubber production processes. And furthermore, the bulk of the smallholders are too small (in terms of farm sizes) to erect their own processing plants. In other words, the plant and equipment used to process oil palms fruits are too expensive for the smallholders.

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APPENDIX: SOURCES OF DATA

Consumption, Production, and Stock

The data on the consumption and production of both natural and synthetic rubber and the stock of natural rubber were obtained from the United States Commodity Yearbook [40]. The data on production of natural rubber from the estates sector and smallholdings sector of West Malaysia and that of Sabah and Sarawak of East Malaysia were taken from the United Nations Production Yearbook [38]. The world production of cars and the consumption of synthetic rubber of countries of lesser importance were obtained from the United Nations Statistical Yearbook [36].

Prices

The New York prices, London prices, and Singapore prices of natural rubber; the exchange rates; and the whole sale price indices were taken from the International Financial Statistics [19]. The exchange rates and the wholesale price index for Indonesia were obtained from the United Nations Statistical Yearbook [36]. The price of synthetic rubber was taken from the United Nations Monthly Bulletin of Statistics [37].

Acreage and Yield per Acre

The total acreage planted with rubber trees and the yield per acre of the estates sector of West Malaysia were obtained from Malaysia Rubber Statistics Handbook [6].