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An Econometric Study of the World Rubber Economy

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ABSTRACT. This study attempts to develop an econometric model of the world rubber economy to explain the behaviour of the natural rubber price and its consumption share over time. The model presented is focused primarily on the market for natural rubber. The supply equations were directly estimated for rubber producing countries. The demand for natural rubber was determined in two steps. Firstly, the joint demand was computed for both natural and synthetic rubber with respect to different regions. The demand for natural rubber was then derived with a set of market share equations using the Nerlovian partial adjustment model. The data from the period 1975-1992 were used to estimate all the behavioural equations.

The simulation results indicated that the model is quite capable of capturing most of the past behaviour of key endogenous variables viz. supply, demand, stocks and prices of the world natural rubber economy. The estimated elasticities conformed to priori expectations and suggest some insight into policy implications.

INTRODUCTION

The problems of price and export instability are particularly relevant to Natural Rubber (NR) producing countries. For most of these countries, NR constitutes a significant contribution to their Gross National Product (GNP) and through taxes and duties makes up a substantial portion of the government revenue. Furthermore, as NR production is particularly labour-intensive, the rubber industry is also an important provider of employment. The rapid growth of the Synthetic Rubber (SR) industry since 1950s has adversely affected the NR industry by causing frequent price fluctuation. As the market share of SRs increased, their price began to set the overall price trend and natural rubber producers became, to a large extent, price takers. Therefore, a study of the NR market involves a study of the inter-relations between two commodities: NR and SR.

While NR is openly traded in commodity markets, limited nature of such trading is observed for SRs. In contrast to NR, the SR industry is vertically - integrated: backwards with the oil and petrochemical industry and forwards with the tyre manufactures. Tyre manufacturers and producers of petrochemicals dominate the SR industry in market economies. The structure of the world market for SRs is therefore clearly oligopolistic and characterized by only a limited amount of price competition among large producers. On the contrary, as the market for NR is highly competitive, the prices reflect even small changes in the supply and demand imbalance. Moreover, both demand and supply of NR are inelastic to price changes in the short-run. Hence, NR prices fluctuate widely in response to changes in economic activity and induce demand shifts.

Sri Lanka's market share for NR in the world market is only about 2 percent. Yet, it constitutes a substantial portion of the country's foreign exchange earnings, which accounts for nearly Rs. 3000 million per year (4 percent). Hence, fluctuations in NR prices have a direct impact on the nation's foreign exchange earnings and at the micro level it affects the welfare of rubber producers. This paper therefore attempts to develop an econometric model of the world natural and synthetic rubber economy to explain NR price and its consumption share over time.

STRUCTURE OF THE MODEL

An overview

The ideal approach would have been to model both the SR and NR industries and to explicitly incorporate the simultaneous interaction between them. However, basic information of SR capacities, costs, prices and production are lacking, largely due to the oligopolistic nature of the SR industry and its close integration with other industries. The approach followed therefore, in this study is that, SR prices are included as an exogenous variable in the demand analysis for NR. It first determines the joint demand for natural and synthetic rubber and then the market share of NR. The model presented in this paper focuses on market for NR and consists of four main sets of equations: supply equations for NR, demand equations for total elastomer, demand equations for NR and NR stock and price equations.

The supply-demand imbalance for NR is reflected in changes in NR stocks. Hence, the relationship between stock adjustments and market prices made it possible to link the supply with demand. Secondary data for a seventeen year period (1975-1992) were used to estimate all the 18 behavioural equations. The equations were estimated by the Ordinary Least Square method.

Supply equations

The supply of NR is characterized by the long gestation period. In the very short-run rubber output can be controlled to some extent by adjusting the tapping frequency and intensity. Hence, separate supply equations are required to capture the investment decision and the tapping decision within a specified time interval. Although several theoretical models for the investment behaviour of perennial crops have been described in the literature (Bateman, 1969) and many of these models have produced good results (Ady, 1968; French and Mathews, 1971), application of these models to the rubber economy faced several difficulties (Tan, 1984). Therefore, it was decided to focus on the short-term supply behaviour of producers for which a constant stock of trees is given and output of latex is largely a function of the tapping intensity. A partial adjustment model was chosen for the estimation of the supply equations (Nerlove and Addison, 1968). A trend variable was used in the model to proxy technological change that could account for increases in the productivity of rubber trees.

The general form of the supply equation represents as follows;

$$NRS_t = f(NRS_t\text{-}1,\ NRP_t,\ T)$$

where,

NRS = supply of NR
NRP = price received by producers for RSS 1 and
T = time trend (1975=1).

Individual supply equations were estimated for the producing countries; Malaysia, Indonesia, Thailand and for Sri Lanka. An additional equation was estimated to capture the production of rubber in the "rest of the world".

Special effort was made to include the actual prices received by farmers to obtain the best possible estimate for the short-run supply response

of rubber growers. These prices were deflated by the GDP deflator in each producing country/region. The total NR supply which is the summation of the five individual supply equations was calculated in the following manner.

$$TOTWNRS_t = MNRS_t + INRS_t + TNRS_t + SNRS_t + RWNRS_t$$

where,

$TOTWNRS_t$ = total world supply of NR

The exogenous variables refer to the supply of NR from Malaysia, Indonesia, Thailand, Sri Lanka and the "rest of the world" respectively.

Demand equations

The demand for NR was determined in 2 steps. First, the model determines the demand for all elastomers. The demand for NR is then determined with the aid of a set of market share equations.

Demand for total elastomers

The demand for total elastomers is derived from the demand for final goods; about 65 percent derived from the automotive sector (mainly in the production of tyres and tubes) and the balance from the household and industrial sector. Thus, the world elastomer industry is heavily dependent on the state of the automotive industry. Production and use of motor vehicles is in turn closely tied to the growth of real GNP which implies that the automotive industry often follows the more general economic trend. A strong direct relationship can therefore be found between the real GNP growth and total demand for elastomers. This is further reinforced by the fact that the demand for non-automotive sector is also strongly related to industrial production and GNP. Hence, GNP was included as the exogenous variable in the demand equations for all elastomers. The general form of the demand equations for all elastomers can be presented as follows:

$$TED_t = f(GNP_t)$$

where,

TED = total elastomer demand
GNP = index of real GNP

Individual total demand equations were estimated in log-linear form for the six major consuming countries/regions: *viz:* North America, Japan, Western Europe, Centrally Planned Economies (both former and present, consisting of USSR, China and Eastern Europe), "other developed countries" and "developing countries". The total world elastomer demand was estimated as follows:

$$TOTWED_t = NATED_t + JTED_t + WETED_t + CPETED_t + ODTED_t + DCTED_t$$

where,

$TOTWED_t$ = total world demand for all elastomers

The exogenous variables refer to demand for total elastomers from North America, Japan, Western Europe, Centrally Planned Economies, "Other Developed Countries and "Developing Countries" respectively.

Demand for natural rubber

It was assumed that the market share of NR is largely a function of NR prices relative to those of competing SRs. Since NR users adjust their consumption gradually in response to changes in relative prices and technology, only a fraction of the expected use of NR is realized within a certain period. A Nerlovian partial adjustment model (Nerlove and Addison, 1968) was selected to capture this behaviour and to estimate short and long term elasticities of the market share of NR with respect to relative prices.

The general form of the market share equation can be shown as below:

$$NRMS_t = f(NRMS_{t-1}, [NRP/SRP]_t)$$

where,

NRMS = market share of natural rubber (%)
NRP = price of NR
SRP = price of SR

The market share approach was used individually for all major consuming countries/regions (except for centrally planned economies) to estimate the demand for NR. For centrally planned economies, market share of NR was fitted to a time trend since the rubber prices were not available.

The equations of demand for market share of NR and demand for total NR were used in the following manner to calculate the total world demand for NR.

$$TOTWDNR_t = NATED_t (NANRMS_t) + JTED_t (JNRMS_t) + WETED_t (WENRMS_t) + CPETED_t (CPENRMS_t) + ODTED_t (ODNRMS_t) + DCTED_t (DCNRMS_t)$$

where,

TOTWDNR = total world demand for NR

Stock and price equations

NR prices quoted in five major markets are highly correlated. The New York price for RSS No.1 was selected as the representative price for the present analysis.

Inflation rates and changes in inventories are two major factors that affect the short-run price changes of NR whereas the SR prices play a key role in the determination of the long-run trend. Published data on rubber stocks are incomplete and unreliable largely due to NR inventories being kept by traders, producers, consumers and governments. Yet, changes in the volume of stocks play a significant role in determination of prices. Therefore, "indirect" stocks were calculated by considering the stock level published in 1970 as the base year. For each of the following years the total supply of rubber into the markets was added to the previous year's stock to derive the volume of rubber available for consumption in each year. The actual consumption was subtracted from the total availability to derive the level of "indirect" stocks. However, due to lack of data it was assumed that for each year, releases from stockpiles are approximately equal to stockpiling.

Prices in the model were expressed in real terms, deflating by US GNP deflator. Since US produce Styrene Butadene Rubber (SBR) (the major SR) on a large scale, it dominates the price determination of SBR. Hence, the US price was taken as the proxy for world SBR prices. The NR prices are directly related to those of SBR. A drop in SBR prices would apply pressure on NR prices and vice versa. The "indirect" stock levels were entered into the model as a ratio between stocks and consumption. It is hypothesized that a decline in stocks relative to the level of consumption would apply an upward pressure on prices and vice versa.

The "indirect" NR stocks were determined by the following equation which was also used to close the model.

$$S = S_{t-1} + TOTWNRS_t - TOTWDNR_t$$

where,

S = stocks of NR ('000 MT)
TOTWNRS = total supply of NR ('000 MT)
TOTWDNR = total demand for NR ('000 MT)

The sources of statistical information used in this study are listed in Appendix I.

RESULTS AND DISCUSSION

Supply equations

The estimated supply functions and short-run supply price elasticities for NR are shown in Table 1. All the estimated coefficients of the deflated price variables included in the supply equations were statistically significant. There was no evidence of auto-correlation as indicated by the Durbin Watson statistic. The calculated short-run supply elasticities varied from 0.14 (Sri Lanka) to 0.29 (Thailand). The short-run supply elasticities suggest that the supply of NR in the short-run is inelastic as the supply cannot be increased or decreased by large quantities in response to price fluctuations. Yet, the producers adjust their output to some extent particularly by manipulating tapping systems in response to changes in market prices according to varying degrees. This response is usually more pronounced in small holder dominating countries such as, Thailand with 95% small holdings when compared to Sri Lanka with only 33% small holdings. The response however, is small in all the rubber producing countries since it usually takes a long time for market information to reach small producers in rural areas. There is some evidence from Sri Lanka to believe that certain small producers are forced to tap their trees more frequently when NR prices decline in order to maintain a steady level of income. Nevertheless, the estimated short-run supply elasticities are generally in line with the results of previous econometric studies (Chan, 1962; Chow, 1975; Tan, 1984). The weighted average price elasticity of supply was 0.22 percent for the short-run.

Table 1. Estimation of NR supply equations (1975 - 1992) and supply elasticities

Country/ Region	Dependent variable	Constant	$NNRS_{t-1}$	NRP_t	T	R^2	D.W	Elasticity1
Malaysia	$MNRS_t$	691.292	0.404 (0.241)	0.271 (0.136)	-10.422 (4.089)	0.83	1.89	0.20
Indonesia	$INRS_t$	472.399	0.326 (0.142)	0.331 (0.076)	18.945 (7.280)	0.91	2.19	0.21
Thailand	$TNRS_t$	-5.831	1.005 (0.109)	0.052 (0.001)	9.721 (9.560)	0.99	2.38	0.29
Sri Lanka	$SNRS_t$	85.008	0.429 (0.244)	0.007 (0.003)	-1.859 (0.664)	0.83	2.18	0.14
Rest of the world	$ROWNRS_t$	167.253	0.214 (0.023)	0.034 (0.011)	17.652 (4.631)	0.93	2.09	0.19

1/ The short run supply price elasticity for Natural Rubber were estimated at the means of production and prices using the supply equations.

The values in parenthisis are standard errors for the coresponding estimates.

The inelastic nature of rubber supply associated with the fluctuations in price imply instability of income to the producers. Evidence from Sri Lanka suggest that during low prices of rubber particularly in the recent years, an increasing number of smallholders and tappers turned into other industries which provided more incentive employment opportunities. This phenomenon could possibly continue to occur during periods of low prices for NR. Moreover, the tendency for supplementary income through mixed or diversified agricultural practices are expected to be adopted and will probably result in a more elastic supply in the NR sector.

Demand equations

The estimated demand functions for total elastomers and for market share for NR are given in Tables 2 and 3 respectively. The coefficients of the income variables presented in Table 2 were statistically significant. All the estimated coefficients of the relative price variables included in the demand equations for the market share of NR were also significant except the estimates for "other developed countries" (Table 3). More than 88 percent of total variations in the dependent variables have been explained by the respective independent variables included in the demand equation models for the market share of NR. Durbin Watson statistic indicates absence of auto-correlation in all cases except for Centrally Planned Economies. The short-run and long-run price elasticities for the market share of NR with respect to relative prices are shown in Table 4. Significant values for elasticities were found excluding "Other Developed Countries". The computed elasticities varied from 0.13 to 0.39 and 1.26 to 3.45 for short-run and long-run respectively. It is reasonable to assume that in the short-run a change in relative market prices has only a minimal impact on the decision to select between the two types of rubber due to limitations imposed by the technical substitutability of the rubber products. However, the influence grows stronger in the long-run; where product manufacturers tend to shift from NR to SR and vice versa depending on their relative prices. Moreover, the elasticities are much higher for developing countries when compared to developed countries as the tyre industry in general is vertically integrated in developed countries unlike in developing countries. The estimated elasticities are quite reasonable and conform to priori expectations. The weighted average elasticities were 0.17 for the short-run and 1.73 for the long-run.

Table 2. Estimation of demand equations for all elastomers, 1975 - 1992

Country/Region	Dependant variable	Constant	GNP_t	R^2	D.W
North America	$NATED_t$	0.913	1.094 (0.213)	0.92	2.33
Japan	$JTED_t$	2.185	1.307 (0.431)	0.97	1.85
Western Europe	$WETED_t$	0.654	1.432 (0.012)	0.95	1.78
Centrally Planned Economies[1]	$CPETED_t$	1.904	1.836 (0.045)	0.98	1.64
Other Developed Countries	$ODTED_t$	0.173	1.343 (0.312)	0.92	2.43
Developing Countries	$DCTED_t$	3.761	1.839 (0.016)	0.86	1.78

1/ Former/present USSR, China and Eastern Eropean Countries
The values in parenthesis are standard errors for the corresponding estimates

Table 3. Estimation of demand (market share) equations for natural rubber, 1975 -1992

Country/Region	Dependant Variable	Constant	$NRMS_{t-1}$	$\{NRP\}_t/\{SRP\}_t$	T	R^2	D.W
North America	$NANRMS_t$	0.064	0.889 (0.217)	-0.025 (0.003)	-	0.95	2.22
Japan	$JNRMS_t$	0.026	0.899 (0.034)	-0.036 (0.011)	-	0.92	2.14
Western Europe	$WENRMS_t$	0.073	0.901 (0.132)	-0.039 (0.004)	-	0.97	1.88
Centrally Planned Economics	$CPENRMS_t$	0.066	0.925 (0.365)	-	0.005 (0.013)	0.88	1.64
Other Developed Countries	$ODNRMS_t$	0.063	0.841 (0.289)	-0.018 (0.132)	-	0.99	2.29
Developing Countries	$DCNRMS_t$	0.098	0.887 (0.312)	-0.412 (0.029)	-	0.97	2.16

Table 4 Short-run and Long-run Price Elasticities for the Market Share of Natural Rubber

Country/region	Price elasticity of market share	
	Short-run[1]	Long-run
North America	0.13	1.26
Japan	0.14	1.39
Western Europe	0.18	1.82
Developing countries	0.39	3.45

1/. The elasticities were estimated at the means using market share equations

Price equations

The estimated price equation is as follows:

$$(NRP/GNP)_t = 633.632 + 0.213(NRP/GNP)_{t-1} + 3.814(SBRP/GNP)_t -$$
$$\quad (0.163) \qquad (0.121)$$

$$1936.632\ (S/TOTWDNR)_t$$
$$\quad (183.632)$$

$$R^2 = 0.93 \qquad D.W = 1.68$$

where,

NRP = Price of RSS No1, in bales, spot, New York (cts/kg)
GNP = US GNP deflator
SBRP = US price of SBR (cts/kg)
S = "Indirect" stocks of NR ('000 MT); and
TOTWDNR = Total demand for NR ('000 MT).

The magnitudes of the coefficients indicate that if the industry cannot respond very quickly to changes in price, a divergent cob-web type fluctuation in rubber prices is possible.

VALIDATION OF THE MODEL

The estimated equations were used to simulate the behaviour of the world rubber economy for the period 1980-1992. The actual and simulated variables are presented in Figure 1 for key endogenous variables: world supply, demand, stocks and prices. The simulation results are very satisfactory. The model is capable of simulating both the trends and the turning points of the above 4 variables in quite satisfactory manner. The model picks up both price peaks in 1983 and 1988 and the troughs in 1982 and 1986. Hence, the model is particularly remarkable with respect to its "price-tracking" behaviour.

Some simulation statistics are also summarized in Table 5. These results too indicate that the structure of the model is sound and the model is capable of capturing most of the behaviour of the world NR economy. The results therefore strongly suggests that this model could be used to gain some insight into the likely prospects for NR.

Table 5 Some Simulation Statistics for Selected Endogenous Variables

Statistic	Endogenous variable			
	Supply (TOTWNRS)	Demand (TNRD)	Price (NRP)	Stocks (S)
Mean (Actual data)	4,623	4,562	112	1,652
Mean (Simulated data)	4,643	4,591	117	1,672
RMS Error[1]	161.8	119.4	15.8	65.2
C.V.[2]	0.035	0.026	0.135	0.039

CONCLUSIONS AND POLICY IMPLICATIONS

It was revealed that the econometric model developed in this study captured the past behaviour of the world NR economy. The estimated elasticities were quite reasonable and conformed to priori expectations. The inelastic short-run supply price elasticities suggested that the producers adjust their production to some extent in response to changes in the market prices. This response was more pronounced in countries where the bulk of the production comes from small holdings.

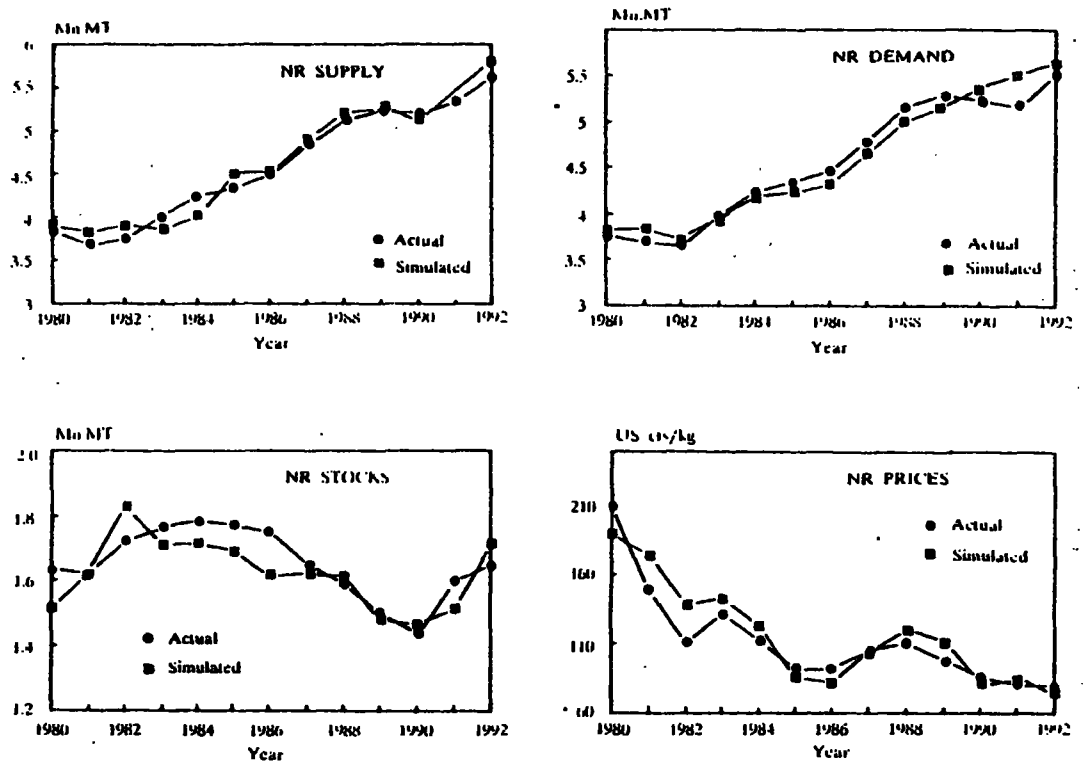

Figure 1. Historical simulation of the Rubber model, 1980 – 1992

The computed short-run price elasticities for the market share of NR with respect to relative rubber prices indicated only a marginal influence on the decision to select between two types of rubbers. Yet, this impact was much stronger in the long-run. Moreover, both short-run and long-run elasticities were much lower in developed countries as opposed to developing countries largely due to the vertically integrated nature of the tyre industry appearing in developed countries.

Policy implications

The magnitudes of the estimated short-run supply and demand elasticities were both inelastic. This implies that the future prices for NR will continue to fluctuate. Hence, it is important to take necessary steps to accommodate this situation. Further research is therefore needed to find ways and means to stabilize the future rubber prices. Theoretically, there are two basic approaches to minimize the fluctuations in rubber prices. Firstly at the international level, buffer stock policies may be used to mitigate the explosive nature of price fluctuations. However, past experience indicates that the buffer stock policies which have been in operation since 1981 under the International Natural Rubber Agreement (INRA) have not performed up to expectations and are generally biased towards the rubber consuming countries. Hence, further in-depth research is needed to identify the necessary changes with regard to the existing buffer stock policies and to assess their likely effects. Secondly, at the domestic level many options are available to increase the elasticities for NR. One such way is to introduce proper marketing strategies especially with respect to marketing of crepe rubber. It is well known that Sri Lanka produces the best quality crepe in the world. In fact many experts in marketing believe that the country has lost a remarkable portion of crepe market due to inadequate attention paid on marketing aspects. Another way to expand the elasticities is to move away from the conventional types of rubber and to produce speciality rubbers *viz.* De-Proteinized Natural Rubber (DPNR), Thermo Plastic Natural Rubber (TPNR), Cyclised Rubber, Liquid Rubber *etc.* which have their specific applications. Promoting the value added product sector is yet another option available for policy makers. For instance, in 1992 Sri Lanka produced nearly 100,000 MT of rubber of which only above 25 percent was used domestically to produce vale added products for both local and export markets. It is worthwhile to note that the amount of foreign exchange earned by exporting the value added products (Rs. 3300 million)

is higher than the amount of total foreign exchange that the country has earned by exporting the remaining 75 percent (Rs. 2800 million) of the production as raw rubber. This clearly signifies the importance of producing more value added products particularly by taking into consideration Sri Lanka's meagre market share in the world market which does not enable it to influence prices in consumer markets. Hence, it can be argued that Sri Lanka's long-term vision should be to produce more value added products and transform Sri Lanka into a rubber product manufacturing centre in the region. This particular policy would not only minimize the fluctuations in rubber prices but also provides a better profit margin for both producers and product manufacturers.

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APPENDIX I

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