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Estimates of Structural Relationships for the World's Rubber Market with Particular Emphasis on Thailand's Natural Rubber Industry

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ABSTRACT

This paper presents a simultaneous equation model of the world's rubber market which depicts the behavioral relationships among rubber prices, consumption, production, imports, exports and stocks on the global level with special emphasis on Thailand's role. This framework provides a basis for calculation of elasticities, and impact and dynamic multipliers analysis based on simulation results.

INTRODUCTION

This study is based on an econometric world rubber market model with a special emphasis on Thailand's role in the world rubber economy. The main objective of this paper is to present the structural framework of the simultaneous equation model. It depicts the behavioral relationships among rubber prices, consumption, production, imports, exports and stocks. Recent data have been used to study the structural relationships of the world rubber trade. These estimates are useful to provide a set of structural parameters which can be used for projection, policy evaluation and multiplier analysis based on a simulation approach.

The plan of the paper is as follows: In section II, model specification and theoretical equations are presented and discussed. The structural estimates, elasticities, and multiplier analysis are presented in section III. The final section contains conclusions of the study.

Model Specification, Theoretical Equations and Estimation Techniques

The framework for analyzing the world rubber market contains 13 behavioral equations and II identities as shown in Figure I and Tables 1 and 2. Within this analysis, we identify the particular supply and demand relationships for Thailand, the U.S. and rest of the world. The model design has been based on the following observations:

1. Thailand is one of the major expanding rubber producing countries.
2. The United States as the world's largest industrial country, is the most important rubber consuming country.
3. The estimation of model prices is based on Singapore natural rubber price, since it is the price targeted for the goal of price stabilization, as

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administered by International Rubber Organization (INRO).

Ordinary least squares (OLS) and two stage least squares (2SLS) estimators are applied to the data as a basis for model parameter estimation. Time series data for a 24 year period from 1954 to 1983 was used. Metric system measures, such as hectare and metric ton, have been used for area and weight measures. Local currency for price of natural rubber or GDP have been converted to U.S. dollars. All of the nominal prices have been deflated by consumer price indexes.

A description of the basic relationships in the model are explained as follows:

Supply Sector:

Development of a dynamic relationship in explaining the output of rubber can be traced to the work of Wharton. The tappable area response model relates to the economic forces that motivate rubber planters to plant, such as the lagged rubber prices and the untappable area. In addition, plantings are influenced also by subsidies for inputs. The rubber production model represents the relationship existing between the tappable area and the yield of the current year. A partial adjustment model was chosen for the estimation of the supply equations, since economic relationships are characterized by long lags and rigidities in the adjustment of production to prices.

Demand Sector:

The demand sector of the world rubber market is explained by relative prices, derived demand shifters and income. The real gross domestic product (real GDP) is used as the key exogenous variable in the demand model. Consumption, imports and exports are treated as the dependent variables. However, rubber price is the important variable on which rubber consumers ans rubber importers make their decisions. The changes in relative price of natural and synthetic rubbers affects the proportion in which they are used. Lags in adjustment are recognized since industrial processes using rubber can not necessarily be changed immediately in response to price or exogenous shocks.

The Singapore natural rubber price was chosen to represent the world rubber price. Major factors affect the short term level of the natural rubber price such as changes in the world rubber stocks, inflation rates and stockpile disposal of the U.S. natural rubber. But, the long term price level is determined dominantly, by the relationship between the synthetic and antural rubber prices.

Model Specification and Estimation

Block Model

The world rubber market model used in this study consists of 4 blocks as follows:

1. Supply Block: This includes Thai natural rubber tappable area, Thai natural rubber untappable area, the rest of the world natural rubber production, Thai and the world natural rubber production, Thai natural rubber export supply.

2. Demand Block: This contains the following endogenous variables: Thai natural rubber consumption, the consumption demand of the natural rubber in the U.S., import demand of natural rubber in the U.S., the rest of the world and the world natural rubber consumption, and the world natural rubber ending stock.

3. Price Linkages: This block is shown as a linkage of the Singapore natural rubber price, Thai natural rubber domestic price, Thai natural rubber gazetted price, Thai natural rubber import price, the U.S. synthetic rubber price and Japanese synthetic rubber price. Prices were deflated by consumer price index.

4. Performance and Policy Equations: This block includes relationships such as Thai natural rubber export duty, Thai natural rubber export duty revenue, Thai natural rubber cess tax, Thai natural rubber cess tax revenue, Thai natural rubber production earnings, and Thai natural rubber export earnings.

All prices, and gross domestic product are deflated by consumer price index. For example, Thai natural rubber real price is deflated by Thai CPI, the U.S. real GDP is deflated by U.S. CPI, the Singapore natural rubber real price is deflated by Singapore CPI, etc.

Estimation Results & Multiplier Experiments

1. Estimation Results of the Models

All coefficients of the supply equations are significant and have expected signs as shown in Table 1 and 2. The demand and price equations have similarly strong explanatory power, and are statistically significant at the 10 percent level. Table 3 reports estimates of structural relationships in the form of elasticities.

The estimates of structural relationships, in the form of elasticities indicate that the long run price elasticity of production is 0.56 for Thailand, 0.01 for rest of the world and 0.07 for the world total. In this study, however, the area and yield price effects were estimated separately. It was found that the price elasticity of Thai rubber yield is significantly inelastic in the short run, i.e. 0.18. The long run effect was slightly larger, i.e. 0.25.

The price elasticity of area tapped for Thai rubber was estimated at a very low 0.03 in the short run and at 0.31 in the long run. Thus, the Thai aggregate rubber production elasticity was calculated at 0.21 of which 0.18 was contributed by yield response and 0.03 by tappable area response. The long run Thai rubber production elasticity estimate of 0.56 is based upon a long run response of tappable area at 0.31 plus the long run yield response at 0.25. The price elasticity of the supply for Thai natural rubber untappable area is also inelastic in both the short and long run, i.e. 0.04 and 0.46. The price elasticity for Thai natural rubber export supply is 0.19 in the short run and 0.46 in the long run.

On the demand side, the long run price elasticities for natural rubber consumption are −0.45 for Thailand, −0.36 for th U.S., −0.82 for the rest of the world, and −0.73 for the world total. Estimates of the long run income elasticities are 1.74 for Thailand, 0.44 for the U.S., 1.49 for the rest of the world and 1.28 for the world total. The estimated price elasticity for U.S. natural rubber imports is −0.28 and income the elasticity is 0.30.

2. Dynamic Multiplier Simulations Experiments.

In this section, the dynamic multipliers are presented based on the assumption in Table 4 and alternative simulations. Tables 5 and 6 report the results of these multipliers for two major variables. The two alternative assumptions used for simulation to generate the dynamic multipliers are:

1. A one time (1986) increase of 1 percent in the U.S. real GDP.
2. A decrease in world crude oil real price by 50 percent, beginning in 1986 and maintained throughout the simulation period trough 1995.

Results of Multiplier Simulations

Experiment 1:

The multiplier simulation results of major variables is given in Table 5. A one-time increase of 1 percent in the U.S. real GDP will increase the Singapore natural rubber price by 0.15 percent in 1986, while the world natural rubber stock increases by 0.50 precent. However the INRO buffer stocks decrease by 10.53 percent. There are similar increases for the U.S. natural rubber consumption by 0.41 percent, and U.S. natural rubber imports also increase by 0.31 percent. While, the world rubber production is constant, the Thai natural rubber export price increases by 0.12 percent, the Thai export duty revenue increases by 0.10 percent and the Thai natural rubber export earnings increase by 0.01 percent in 1986. The U.S. synthetic rubber price rises by 0.02 percent.

Table 1
Estimates of the World Rubber Market Model

Tappable Area:

(1) $RTA_t^{TH} = -19.1218 + 0.8009\,RTA_{t-1}^{TH} + 0.2871\,RUTA_{t-6}^{TH} + 0.0302\,P_{t-1}^{TH}$
*(23.6384) (0.0202) (0.0423) (0.0142)
$R^2 = 0.99$ C.V. = 1% D.H. = −0.68

Untappable Area:

(2) $RUTA_t^{TH} = 96.3127 + 0.7830\,RUTA_{t-1}^{TH} + 0.0416P_t^{TH} + 0.0300\,RPS_t^{TH}$
*(57.7619) (0.0824) (0.0210) (0.0103)
$R^2 = 0.95$ C.V. = 1.5% D.H. = 0.15

Production:

(3) $RPD_t^{ROW} = 856.0966 + 0.561\,RPD_{t-1}^{ROW} + 0.4918\,\Delta_t^{P^{SP}} + 30.0217\,TT$
*(218.8757) (0.1247) (0.0984) (0.4836)
$R^2 = 0.98$ C.V. = 3% D.H. = 0.39

Export:

(4) $RE_t^{TH} = -238.1687 + 523.3178\,IPI_t^{JAP} + 0.5061\,RWP_t^{TH} + 0.4466\,RED_t^{TH}$
*(52.8564) (42.8502) (0.0903) (0.1529)
$R^2 = 0.97$ C.V. = 6% D.W. = 2.06

Consumptions:

(5) $RC_t^{TH} = -2.1058 + 0.3372\,RC_{t-1}^{TH} + 1.2682\,RGDP_t^{TH} - 7.7268\,\{P_{t-1}^{TH}/SRRP_{t-1}^{JAP}\}$
*(1.5116) (0.1271) (0.2303) (2.2650)
$R^2 = 0.99$ C.V. = 8% D.W. = 1.60

(6) $RC_t^{US} = 418.8193 + 0.1624\,RC_{t-1}^{US} + 0.1589\,RGDP_t^{US} - 149.6006\,\{P_{t-2}^{SP}/SRRP_{t-2}^{US}\}$
$+ 94.0735\,DV1$ [1]
(32.9136)
$R^2 = 0.91$ C.V. = 5.7% D.H. = −1.60

Table 1 Continued

(7) $RC_t^{ROW} = 166.8538 + 0.8659\, RC_{t-1}^{ROW} + 0.3697\, RGDP_{t-2}^{US} - 356.9601\, \{P_{t-2}^{SP}/SRRP_{t-2}^{JAP}\}$

*(54.0448) (0.1794) (0.3103) (88.3511)

$R^2 = 0.99$ C.V. = 2.16% D.H. = −0.15

Import:

(8) $RI_t^{US} = 565.0906 + 0.1192\, RGDP_t^{US} + 0.1762\, P_{t-2}^{SP} - 1.091\, RGSD_t^{US} + 70.729\, DV1$

*(116.0264) (0.0651) (0.0401) (0.241) (28.537)

$R^2 = 0.94$ C.V. = 6.39% D.W. = 2.5406

Price Linkages:

(9) $P_t^{SP} = 282.4074 + 0.4454\, RGDP_t^{US} - 2.6615\, RGSD_{t-1}^{US} + 2.5933\, SRRP_t^{US}$

*(721.9801) (0.1794) (0.5220) (0.3550)

$- 3935.65\, \{RST_t^{W}/RC_t^{W}\} + 439.252\, DV2 - 232.6170\, DV3$

(975.8034) (107.1796) (57.4792)

$R^2 = 0.88$ C.V. = 10.97% D.W. = 1.40

(10) $P_t^{TH} = 51.6094 + 0.2897\, P_{t-1}^{TH} + 0.4511 P_t^{SP} - 173.4454\, DV4$

*(64.1569) (0.1085) (0.0969) (46.3987)

$R^2 = 0.84$ C.V. = 13% D.W. = 0.44

(11) $GP_t^{TH} = -46.5764 + 0.0703\, GP_{t-1}^{TH} + 1.0146\, P_t^{TH}$

*(27.2623) (0.0578) (0.0704)

$R^2 = 0.97$ C.V. = 6.39% D.W. = 0.22

(12) $SRRP_t^{US} = -19.8055 + 0.9170\, SRRP_{t-1}^{US} - 10.7423\, \Delta OP_t^{W} + 0.0697\, P_t^{SP}$

*(59.6583) (0.0851) (4.0265) (0.0522)

$R^2 = 0.89$ C.V. = 6.58% D.H. = 0.06

Table 1 Continued

(13) $SRRP_t^{JAP} = 57.0964 + 0.6675\ SRRP_{t-1}^{JAP} + 0.3434\ P_t^{SP}$

*(79.7444) (0.0646) (0.1073)

$R^2 = 0.92$ C.V. = 8.2% D.H. = −2.20

Identities:

(14) $RPD_t^{TH} = RTA_t^{TH} * RAY_t^{TH}$

(15) $RPD_t^{W} = RPD_t^{TH} + RPD_t^{ROW}$

(16) $RC_t^{W} = RC_t^{T} + RC_t^{US} + RC_t^{ROW}$

(17) $RST_t^{W} = RST_{t-1}^{W} + RPD_t^{W} - RC_t^{W} + \Delta GST_t^{W} - \Delta BS$

(18) $EP_t^{TH} = P_t^{TH} + RED_t^{TH} + RCT_t^{TH} + TC_t^{TH}$

(19) If $GP_t^{TH} < \$172.53 \rightarrow RED_t^{TH} = 0$

If $GP_t^{TH} < \$176.99 \rightarrow RED_t^{TH} = 0.01 * GP_t^{TH}$

If $GP_t^{TH} \geqslant \$176.99 \rightarrow RED_t^{TH} = 0.40 * \{GP_t^{TH} - \$172.53\} - RES_t^{TH}$

(20) $RER_t^{TH} = RE_t^{TH} * RED_t^{TH}$

(21) If $GP_t^{TH} \leqslant \$297.46 \rightarrow RCT_t^{TH} = \$14.87$

If $GP_t^{TH} > \$297.46 \rightarrow RCT_t^{TH} = 0.10 * \{GP_t^{TH} - \$297.46\} + \$14.87$

(22) $RCR_t^{TH} = RE_t^{TH} * RCT_t^{TH}$

(23) $RPDE_t^{TH} = RPD_t^{TH} * P_t^{TH}$

(24) $REE_t^{TH} = RE_t^{TH} * EP_t^{TH}$

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*The value in parenthesis under the estimated coefficient is the standard error.

Table 2

Definition of Variables

Endogenous Variables :

EP_t^{TH}: Thai natural rubber export real price, U.S. $/metric ton, deflated by Thai CPI (1975 = 100)

GP_t^{TH}: Thai natural rubber gazetted real price, U.S. $/metric ton, deflated by Thai CPI (1975 = 100)

P_t^{SP}: Singapore natural rubber real price, U.S. $/metric ton, deflated by Singapore CPI (1975 = 100)

P_t^{TH}: Thai natural rubber domestic real price, U.S. $/metric ton, deflated by Thai CPI (1975 = 100)

RC_t^{ROW}: Rest of the world natural rubber consumption, thousand metric tons

RC_t^{US}: The consumption demand of natural rubber in the U.S., thousand metric tons

RC_t^{TH}: Thai natural rubber consumption, thousand metric tons

RC_t^{ROW}: Rest of the world natural rubber consumption, thousand metric tons

RC_t^{W}: The world natural rubber consumption, thousand metric tons

RCR_t^{TH}: Thai natural rubber real replanting cess tax revenue, thousand dollars, deflated by Thai CPI (1975 = 100)

RCT_t^{TH}: Thai natural rubber real replanting cess tax deflated by Thai CPI, U.S. $/metric ton.

RE_t^{TH}: Thai natural rubber export supply, thousand metric tons

RED_t^{TH}: Thai natural rubber real export duty deflated by Thai CPI, U.S. $/metric ton

REE_t^{TH}: Thai natural rubber real export earnings, thousand dollars, deflated by Thai CPI (1975 = 100)

Table 2 Continued

RER_t^{TH}: Thai natural rubber real export revenue, thousand dollars, deflated by Thai CPI (1975 = 100)

RES_t^{TH}: Thai natural rubber export subsidy, U.S. $/metric ton

RI_t^{US}: The import demand of natural rubber in the U.S., thousand metric tons

RPD_t^{ROW}: Rest of the world natural rubber production, thousand metric tons

RPD_t^{TH}: Thai natural rubber production, thousand metric tons

RPD_t^{W}: The world natural rubber production, thousand metric tons

$RPDE_t^{TH}$: Thai natural rubber real producer earnings, thousand dollars, deflated by Thai CPI (1975 = 100)

RST_t^{W}: The world natural rubber ending stock, thousand metric tons

RTA_t^{TH}: Thai natural rubber tappable area, thousand hectares

$RUTA_t^{TH}$: Thai natural rubber untappable area, thousand hectares

$SRRP_t^{US}$: The U.S. synthetic rubber (SBR) real price, U.S. $/metric ton, deflated by the U.S. CPI (1975 = 100)

$SRRP_t^{JAP}$: Japanese synthetic rubber (SBR) real price, U.S. $/metric ton, deflated by Japanese CPI (1975 = 100)

Explanatory Variables

ΔBS: Change in the INRO buffer stock, thousand metric tons

ΔOP_t^{W}: Change in the world crude oil real price, U.S. $/barrel, deflated by the U.S. CPI (1975 = 100)

ΔP_t^{SP}: Change in Singapore natural rubber real price, U.S. $/metric ton, deflated by Singapore CPI (1975 = 100)

CPI_t^{SP}: Singapore commodity price index

Table 2 Continued

ΔGST_t^W: Change in the world natural rubber strategic stockpile, thousand metric tons

DV1: Dummy variable for the U.S steel belted radial tire innovation (set 1 after 1972 and to 0 for all other years)

DV2: Dummy variable for energy crisis (set 1 for 1973, to 0 for all other years)

DV3: Dummy variable for recession (set 1 for 1968, 1981, 1982 and 1983 to 0 for all other years)

DV4: Dummy variable for for Japanese recession (set 1 for 1980, 1981, 1982 and 1983, to 0 for all other years)

GP_t^{TH}: Thai natural rubber gazetted real price, lagged one year, U.S. $/per metric ton, deflated by Thai CPI (1975 = 100)

IPI_t^{JAP}: Japanese industrial production index (1975 = 100)

P_{t-1}^{SP}: Singapore natural rubber real price, lagged one year, U.S. $/metric ton, deflated by Singapore CPI (1975 = 100)

P_{t-2}^{SP}: Singapore natural rubber real price, lagged two years, U.S. $/metric ton, deflated by Singapore CPI (1975 = 100)

P_{t-1}^{TH}: Thai natural rubber real price, lagged one year, U.S. $/metric ton, deflated by Thai CPI (1975 = 100)

RAY_t^{TH}: Thai natural rubber average yield, metric ton/hectare

RC_{t-1}^{ROW}: Rest of the world natural rubber consumption, lagged one year, thousand metric tons

RC_{t-1}^{US}: The consumption demand of natural rubber in the U.S., lagged one year, thousand metric tons

RC_{t-1}^{TH}: Thai natural rubber consumption, lagged one year, thousand metric tons.

RCT_t^{TH}: Thai natural rubber real replanting cess tone, U.S. $/metric ton, deflated by Thai CPI (1975 = 100)

RED_t^{TH}: Thai natural rubber real export duty, U.S. $/metric ton, deflated by Thai CPI (1975 = 100)

$RGDP_t^{US}$: The U.S. real GDP, deflated by the U.S. CPI (1975 = 100)

Table 2 Continued

$RGDP^{US}_{t-2}$: The U.S. real GDP, lagged two years, deflated by the U.S. CPI (1975 = 100)

$RGDP^{TH}_{t}$: Thai real GDP, deflated by Thai CPI (1975 = 100)

$RGSD^{US}_{t}$: The U.S. natural rubber government stockpile disposal, thousand metric tons

$RGSD^{US}_{t-1}$: The U.S. natural rubber government stockpile disposal, thousand metric tons, lagged two years

RPD^{ROW}_{t-1}: Rest of the world natural rubber production, lagged one year, thousand metric tons

RPS^{TH}_{t}: Thai natural rubber production subsidy, U.S. \$/hectare

RST^{W}_{t-1}: The world natural rubber beginning stock, thousand metric tons

RTA^{TH}_{t-1}: Thai natural rubber untappable area, lagged one year, thousand hectares

RTA^{TH}_{t-6}: Thai natural rubber untappable area, lagged six years, thousand hectares

RWP^{TH}_{t}: Thai natural rubber trade weighted exchange value of Thai natural rubber export real price, U.S. \$/metric ton, deflated by Thai CPI (1975 = 100)

$SRRP^{JAP}_{t-1}$: Japanese synthetic rubber (SBR) real price, U.S. \$/metric ton, deflated by Japanese CPI (1975 = 100), lagged one year

$SRRP^{JAP}_{t-2}$: Japanese synthetic rubber (SBR) real price, U.S. \$/metric ton, deflated by Japanese CPI (1975 = 100), lagged two years

$SRRP^{US}_{t-1}$: The U.S. synthetic rubber (SBR) real price, U.S. \$/metric ton, lagged one year, deflated by the U.S. CPI (1975 = 100)

$SRRP^{US}_{t-2}$: The U.S. synthetic rubber (SBR) real price, U.S. \$/metric ton, lagged two years, deflated by the U.S. CPI (1975 = 100)

TC^{TH}_{t}: Thai transportation real cost, U.S. \$/metric ton, deflated by Thai CPI (1975 = 100)

TT: Time trend

Table 3
Summary of the Estimated Supply & Demand of Price Elasticities & Income Elasticities

Variables	Short Run	Long Run
Supply Price Elasticities:		
Thai natural rubber average yield	0.18	0.25
Thai natural rubber tappable area	0.03	0.31
Thai natural rubber untappable area	0.04	0.18
Thai natural rubber production	0.21	0.56
The rest to the world production	0.004	0.01
The world rubber production	0.03	0.07
The natural rubber export	0.19	0.46
Demand Price Elasticities:		
Thai natural rubber consumption	−0.30	−0.45
The U.S. natural rubber consumption	−0.30	−0.36
Rest of the world natural rubber consumption	−0.11	−0.82
The world natural rubber consumption	−0.68	−0.73
The U.S. natural rubber import	−0.28	−0.82
Income Elasticities:		
Thai natural rubber consumption	1.15	1.74
The U.S. natural rubber consumption	0.37	0.44
Rest of the world natural rubber consumption	0.20	1.49
The world natural rubber consumption	0.24	1.28
The U.S. natural rubber import	0.30	0.30

Over the simulation period, the Singapore natural rubber price increased in the range of −0.72 to 1.07 percent. As a result, the U.S. synthetic rubber price ranged from −0.04 to 0.37 percent in the long run. No further decrease in the INRO buffer stocks was generated past the first year. The world rubber ending stocks ranged from −0.24 to 0.11 percent. The Thai natural rubber export price ranged from −0.51 to 0.76, which in turn raised the Thai natural rubber export duty revenue from 1.69 to 3.39 percent at the peak in 1991 and have a positive income effect on Thai natural rubber producer earnings ranging from 0.32 to 0.54 percent at the peak of 1991. Thai natural rubber export earnings also range from 0.37 to 1.14 percent at the peak of 1991. The world rubber production is quite stable in the long run while the rest-of-the-world natural rubber consumption fluctuates from −0.04 to 0.18 at the peak of 1989. The U.S. natural rubber consumption has a range of −0.33 to 0.19 at the peak of 1989.

Table 4
Base Assumptions: 1984-1995

Exogenous	Base Assumptions											
Variables	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RPS^{TH}_{t}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TT	26	27	27	28	29	30	31	32	33	34	35	36
$*RGDP^{US}_{t}$	.06	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
$*RGDP^{TH}_{t}$	.01	.035	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
RWE^{TH}_{t}	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
RAY^{TH}_{o}	.694	.744	.794	.862	.919	.938	.987	1.038	1.088	1.138	1.188	1.234
ΔGST^{W}_{t}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$RGSD^{US}_{t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ER^{TH}_{t}	27.15	26.45	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50	26.50
RST^{TH}_{t}	225.93	225.93	128.30	128.30	128.30	128.30	128.30	128.30	128.30	128.30	128.30	128.30
$*IPI^{JAP}_{t}$	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
$*TC^{TH}_{t}$	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
$*OP^{W}_{t}$	19.82	19.01	18.93	18.99	19.74	20.09	21.25	21.53	21.97	22.22	22.44	23.11
$*CPI^{SP}$	1.168	1.173	1.220	1.269	1.319	1.372	1.427	1.489	1.544	1.665	1.670	1.736

*the base year in 1980 which is equal to 100.00

Table 5

Multiplier Simulations: A One-Time (1986) Increase of : Percent in the U.S. Real GDP

YEAR	$^{1}RC_t^{US}$	$^{2}RC_t^{ROW}$	$^{3}RI_t^{US}$	$^{4}RST_t^{W}$	$^{5}RST_t^{INRO}$	$^{6}RPD_t^{W}$	$^{7}NP_t^{SP}$	$^{8}NEP_t^{SP}$	$^{9}SRP_t^{US}$	$^{10}FDR_t^{TH}$	$^{11}RPE_t^{TH}$	$^{12}REE_t^{TH}$
1986	100.41	100.00	100.31	100.50	89.47	100.00	100.15	100.12	100.02	100.27	100.10	100.01
1987	100.06	100.00	100.00	100.30	89.47	99.92	99.28	99.49	99.99	98.34	99.59	99.51
1988	99.96	100.17	99.96	100.05	89.47	100.03	100.13	99.93	99.96	99.77	99.95	99.94
1989	100.19	100.18	100.00	99.83	89.47	100.08	100.93	100.70	100.05	101.79	100.55	100.67
1990	99.77	100.14	99.97	99.74	89.47	100.07	100.18	101.14	100.17	103.07	100.90	101.09
1991	99.74	100.07	99.98	99.77	89.47	100.03	101.07	101.18	100.26	103.39	100.94	101.14
1992	99.67	100.01	99.78	99.87	89.47	100.00	100.81	101.01	100.32	103.14	100.80	100.97
1993	99.72	99.97	99.81	99.97	89.47	99.99	100.57	100.76	100.36	102.68	100.61	100.74
1994	99.82	99.96	99.98	100.06	89.47	99.98	100.39	100.54	100.37	102.19	100.44	100.53
1995	99.92	99.97	99.91	100.11	89.47	99.99	100.27	100.38	100.37	101.69	100.31	100.37

Note : Data are (Multiplier/Control Solution) × 100.00

$^{1}RC_t^{US}$ = The consumption demand of natural rubber in the U.S.

$^{2}RC_t^{ROW}$ = The rest of the world natural rubber consumption

$^{3}RI_T^{US}$ = The import of natural rubber consumption in the U.S.

$^{4}RST_t^{W}$ = The world natural rubber ending stock

$^{5}RST_t^{INRO}$ = The INRO natural rubber production

$^{6}RPD_t^{W}$ = The world natural rubber production

$^{7}NP_t^{SP}$ = Singapore natural rubber norminal price

$^{8}NEP_t^{TH}$ = Thai natural rubber export norminal price

$^{9}SRP_t^{US}$ = The U.S. synthetic rubber norminal price

$^{10}EDR_t^{TH}$ = Thai natural rubber export duty revenue

$^{11}RPE_t^{TH}$ = Thai natural rubber producer earnings

$^{12}REE_t^{TH}$ = Thai natural rubber export earnings

Table 6

Multiplier Simulations: A One-Time (1986-1995) Decrease of 50 Percent in the World Crude Oil Price

YEAR	$^{1}RC_t^{US}$	$^{2}RC_t^{ROW}$	$^{3}RPD_t^{TH}$	$^{4}RPD_t^{W}$	$^{5}RST_t^{W}$	$^{6}BS_t$	$^{7}NP_t^{SP}$	$^{8}NP_t^{TH}$	$^{9}NEP_t^{TH}$	$^{10}SRP_t^{US}$	$^{11}SRP_t^{JAP}$	$^{12}EDR_t^{TH}$	$^{13}RPE_t^{TH}$	$^{14}REE_t^{TH}$
1986	100.00	100.00	100.00	97.89	93.77	122.81	77.98	85.99	82.73	79.28	93.87	60.96	85.98	83.46
1987	100.00	100.00	99.71	99.09	91.91	122.81	80.40	83.72	79.46	78.55	90.57	50.46	83.48	80.31
1988	100.54	101.27	99.45	99.93	89.60	122.81	85.54	86.27	82.37	77.32	89.77	53.98	85.80	83.08
1989	99.36	101.87	99.30	100.38	87.61	122.81	91.32	90.60	87.75	77.35	90.75	65.80	89.97	88.24
1990	96.80	101.90	99.27	100.21	86.17	122.81	92.14	92.41	90.15	76.22	91.65	72.39	91.73	90.52
1991	94.36	101.56	99.29	100.09	85.90	122.81	92.44	93.13	91.07	76.37	92.34	74.18	92.47	91.32
1992	93.22	101.28	99.21	99.95	86.19	122.81	91.96	93.07	90.95	76.45	92.69	71.91	92.34	91.22
1993	93.14	101.07	99.05	99.87	86.64	122.81	91.65	92.90	90.62	76.58	92.81	67.53	92.02	90.88
1994	93.55	100.95	98.88	99.82	87.02	122.81	91.87	93.10	90.65	76.72	93.06	63.10	91.97	90.88
1995	93.99	100.87	98.74	99.72	87.12	122.81	91.01	92.54	89.96	75.99	92.99	56.82	91.37	91.19

Note: Data are (Multiplier/Control Solution) × 100.00

$^{1}RC_t^{US}$ = The consumption demand of natural rubber in the U.S.

$^{2}RC_t^{ROW}$ = The rest of the world natural rubber consumption

$^{3}RPD_t^{TH}$ = Thai natural rubber production

$^{4}RPD_t^{W}$ = The world natural rubber production

$^{5}RST_t^{W}$ = The world natural rubber production

$^{6}BS_t$ = The INRO buffer stock

$^{7}NP_t^{SP}$ = The Singapore natural rubber norminal price

$^{8}NP_t^{TH}$ = Thai natural rubber domestic norminal price

$^{9}NEP_t^{TH}$ = Thai natural rubber export norminal price

$^{10}SRP_t^{US}$ = The U.S. synthetic rubber norminal price

$^{11}SRP_t^{JAP}$ = The Japanese synthetic rubber norminal price

$^{12}EDR_t^{TH}$ = Thai natural rubber export duty revenues

$^{13}RPE_t^{TH}$ = Thai natural rubber producer earnings

$^{14}REE_t^{TH}$ = Thai natural rubber export earnings

Generally, the rubber market seems to be stable relative to supply with demand showing minor fluctuation. The important observation is that demand shocks on the world rubber economy imply immediate adjustment in the form of prices and stocks. These adjustments bring about further consumption adjustments in the interim. In the longer run, supply effects are important in sustaining the adjustment dynamics. However, full adjustment is not attained even up to the end of the simulation time period.

Experiment 2:

In the second case, which is shown in Table 6, the world crude oil real price is assumed to decrease by 50 percent during 1986-1995. As a result of the reduction of world crude oil price, the U.S. synthetic rubber price decreases by 20.82 percent in 1986. The Japanese synthetic rubber price declines by 6.13 percent. Since the cost of synthetic rubber production is cheaper, most of the industry will use more synthetic rubber relative to natural rubber. The Singapore natural rubber price is affected by the decline in the world crude oil price both in the short run and the long run. The range of the Singapore rubber price decrease in from 7.56 to 22.02 percent. The Thai natural rubber domestic price decreases from 7.46 to 14.01 percent, while the range for the Thai natural rubber export price is a decrease of 8.93 to 20.54 percent. However, the U.S. natural rubber consumption is constant form 1986 to 1987, and increases by 0.54 percent in 1988. Afterward, it decreases with a stable decline from 0.64 to 6.86 percent at the bottom in 1993 as the results of the reduction of U.S. synthetic rubber prices. Nevertheless, the rest of the world natural rubber consumption increases in response to lower rubber prices form 0.87 to 1.90 at the peak of 1990. The world natural rubber production begins to decrease in 1986 to 1988, with a range from 2.11 to 0.07 percent, but will increase during 1989-1991 from 0.90 to 0.38 percent. Finally, it will decline from 0.05 to 0.28 percent from 1992 to 1995. The Thai natural rubber prices decrease from 0.55 to 1.24 percent in the long run. The world rubber stocks are declining both in the short run and long run, in part this is due to the INRO buffer stocks which increase by 22.81 percent in the short run and are maintained over the longer run, because of the reduced Singapore rubber price.

The Thai natural rubber export duty revenue declines by 25.82 to 49.54 percent during 1986-1995. Thai natural rubber producer earnings decrease from 7.66 to 16.52 percent and Thai natural rubber export earnings decline fom 8.68 to 16.54 percent. This indicates that the reduction of the world crude oil prices can have serious sustained consequences for the Thai rubber industry. The price declines in rubber as a result of the oil price impact, interact with inelastic demand to bring about declines in earnings to the rubber producing sector. Price stabilization through INRO buffer stocks are inadequate to prevent substantial declines in earnings.

CONCLUSIONS

This paper presents a simultaneous equation model of the world rubber market which shows the behavioral relationships among the rubber prices, consumptions, productions, imports, exports and stocks on a global level with special emphasis on Thailand's role. The empirical model traces the movement of the endogenous variables well. This study also reported elasticity estimates. The close relationship between crude oil price and the price of synthetic rubber are important links in the natural rubber industry particularly since the energy crisis of 1973. Important dynamic multipliers are reported for major endogenous variables in response to changes in U.S. GDP and world crude oil price. A one percent, one time increase in the U.S. GDP has a positive effect on the Singapore rubber price. A world crude oil price decline shock has a negative effect on rubber prices and revenues in both the short run and the long run.

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