# TOTAL ELASTICITY OF DEMAND FOR INDONESIAN NATURAL RUBBER : THE USE OF EXTENDED ARMINGTON MODEL

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**Abstrak**

Pengetahuan tentang total elastisitas permintaan karet alam Indonesia sangat penting untuk menilai kebijaksanaan pemerintah Indonesia di sektor karet. Penelitian ini menggunakan model Armington yang telah dikembangkan oleh Duffy *et al.* (1990). Prosedur pendugaan yang digunakan adalah model penyesuaian parsial dalam bentuk fungsi logaritma dan diduga dengan "Ordinary Least Square". Data yang digunakan mulai tahun 1968 sampai tahun 1989 dan dikelompokkan kedalam negara pengimpor dan pengekspor. Dalam jangka pendek maupun jangka panjang, total elastisitas permintaan karet alam Indonesia tidak elastis. Hal ini berarti kebijaksanaan pemerintah yang ada sekarang tidak akan menghasilkan kenaikan penerimaan ekspor, kecuali dibarengi oleh usaha-usaha untuk meningkatkan daya saing dan pangsa pasar. Usaha-usaha ini dapat berupa peningkatan mutu dan efisiensi produksi karet alam yang diekspor.

## INTRODUCTION

### Background

An agricultural commodity which has an important position in the economic development of Indonesia is natural rubber. Rubber is significant to the Indonesian economy because of the role it plays in foreign exchange earnings, income for farmers, employment opportunities and regional development.

Since the early 1970s, several major government initiatives, such as the Nucleus Estate Smallholders'Project (NES), Smallholders' Rubber Development Project (SRDP) and others, have been directed towards improving the Indonesian rubber sector. According to Barlow and Muharminto (1982), low-cost loans were provided for developing and rehabilitating estates. In addition, smallholders were provided with expanded credit facilities. The aim of these measures is to enhance the export supply of Indonesian rubber, thus resulting in increased export returns.

According to Dillon (1987), developments in the rubber industry are based on the principle of comparative advantage. The existing natural and human

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resources, along with the technology involved in production, result in the lower cost of producing rubber in Indonesia than in other producing countries. This, in turn, results in an increase in the bargaining position of Indonesian rubber in the world market.

Despite the importance of the rubber sector to the Indonesian economy, the government initiatives have been introduced implicitly under the assumption that total export demand for Indonesian rubber is perfectly responsive to price changes and that rubber is a homogeneous product in international trade. This assumption seems to be unrealistic.

The question addressed in this study is concerned with determining the total elasticity of export demand for Indonesian natural rubber. This parameter is important in assessing the degree of price responsiveness of Indonesian natural rubber in the world market. Answer to this question will be useful in examining the impact of current, as well as future development strategies in the rubber sector. The present study should also provide information on the key parameters which influence the size of the total elasticity of export demand for Indonesian rubber.

### Objectives

This study focuses on the variation of demand for Indonesian rubber in response to variations in rubber prices. More specifically the objectives of this study are to:

a) assess the degree of competitiveness of Indonesian natural rubber in the world market;
b) examine the price responsiveness of import demand for natural rubber in the world market;
c) evaluate the price responsiveness of import demand for Indonesian natural rubber in the world market; and
d) to analyse the policy implications of price changes in the world market for Indonesian natural rubber.

## METHODOLOGY

### Theoretical Framework : Armington Demand Theory

Previous studies, which assumed that rubber is a homogeneous product, found that the import demand for Indonesian rubber is inelastic (Teken, 1971). This result is open to question as the assumption of a homogeneous product is heroic.

In fact, natural rubber is a differentiated product in international trade. Hence, there is a need to use an approach which allows for the heterogenity of the product.

Armington (1969) proposed a theory which allowed for products to be differentiated by quality and origin.

Armington (1969) hypothesised that commodities in international trade are differentiated not only by the place of origin but also by quality of the product produced. In other words, foreign consumers view the same 'good' from different places of origin as different kinds of 'products'.

On the basis of Armington's theory, the difference between a good and a product can be clarified. A good is defined as a commodity differentiated by kind (e.g. natural versus synthetic rubber). A product is a commodity identified by both kind and place of origin (e.g. Malaysian versus Indonesian natural rubber).

The basic assumptions underlying the Armington frame work are :

(1) the marginal rate of substitution between any two products (e.g., Malaysian and Indonesian natural rubber) is independent of the quantity of any other product;
(2) the elasticity of substitution between any two products in a given market is constant; and
(3) the elasticity of substitution between two products in one market equals the elasticity of substitution between any other products in the same market.

Under these assumptions, Armington (1969) derived the demand function for internationally traded goods from a utility function, where utility is defined to be a function of the product consumed in importing countries.

Duffy *et al.* (1990) extended Armington's framework by suggesting that the import demand facing a particular country supplying the good, say Indonesia, can be obtained by horizontally summing all product demand curves facing this country. Hence, the own-price elasticity of demand for exports from the jth country (Nj) is the share weighted sum of the own-price elasticities of demand in all importing countries as :

$$N_j = \Sigma_i ( X_{ij}/X_j ) * N_{ijj} \quad \ldots\ldots (1)$$

where :

$N_{ijj}$ = the direct price elasticity of demand for a product from country j with respect to its price in country i;
$X_j$ = total export from country j (Indonesia); and
$X_{ij}$ = the quantity of product X from country j consumed by country i.

Duffy *et al.* (1990) also derived the total own-price elasticity of demand for exports from the jth country ($N_j$*) in a similar manner to that suggested by Buse

(1958).In the context of the Armington framework, this elasticity was formulated as follows :

$$N_j^* = N_j + N_{jk} (\Delta PX_{ik}/\Delta PX_{ij}) \quad \ldots\ldots (2)$$

where :

$N_j$ = as defined in (1);

$N_{jk}$ = the average cross-price elasticity between a product from country j with respect to the price of a product from country k in country i;

$\Delta PX_{ik}$ = a change in price of product from country k in country i; and

$\Delta PX_{ij}$ = a change in price of product from country j in country i.

Tomek and Robinson (1981) make the point that the total elasticity coefficient is negative and smaller in absolute value than $N_j$, since the cross-price elasticity and the percentage change in price are positive. According to Duffy *et al.* (1990), this specification assumes that the price of goods other than the good being considered and incomes in importing countries are independent of changes in export prices of the product from country j. Equation (1) also reveals that the demand curve facing country j can shift in response to a change in the price of the product.

**Estimation Approach**

In this study, import demand elasticities for Indonesian natural rubber will be estimated using both equations (1) and (2) in order to assertain the significance of the indirect effects, i.e., the cross-price elasticity of Indonesian rubber with respect to the price of other country's rubber and the ratio of the percentage change of both Indonesian and other countries' natural rubber prices. Equation (2) is considered to be the 'extended' model as the export supply equation is endogenous and not infinitely elastic. Following Duffy *et al.* (1990), a simple static equilibrium model will be used to determine the change in competing product prices with respect to a change in the Indonesian rubber price. In subsequent parts, estimation elasticities of demand for Indonesian natural rubber will be presented.

**First Stage Estimation of Import Demand**

In the first stage of the estimation process, the total import demand by a consuming country is determined. In this stage, the aim is to obtain the short- and long-run direct price elasticities of demand for natural rubber in importing countries.

Following Grilli *et al.* (1980), a market share approach is used to derive the demand for natural rubber from that of all rubber (called elastomer). Using Nerlove's partial adjustment principle, a double-log functional form of this equation is expressed as :

$$\ln MSX_{i(t)} = \ln \delta_1 + \delta_1 \beta_1 \ln (PX_i/PS_i)_{(t)} + (1 - \delta_1) \ln MSX_{(t-1)} + \delta_1 \gamma_1 \ln T + \epsilon_1 \quad \ldots\ldots (3)$$

where :

| | | |
|---|---|---|
| $MSX_i$ | = | the market share for natural rubber in country i; |
| $PX_i$ | = | the price of natural rubber in country i; |
| $PS_i$ | = | the price of synthetic rubber in country i; |
| $C_i$ | = | the consumption of elastomer; and |
| T | = | a time trend. |
| $\delta_1$ | = | the coefficient of adjustment; |
| $\delta_1 \beta_1 = \omega_i$ | = | short-run price elasticity of demand; |
| $\beta_1 = \omega_i^*$ | = | the long-run price elasticity of demand; |
| $\delta_1 \gamma_i$ | = | the coefficient of trend; |
| t | = | the time period; and |
| $\epsilon_1$ | = | an error term. |

**Second Stage Estimation of Import Demand**

In the second stage of estimation, the total import demand for natural rubber in importing countries is allocated among competing suppliers. The aim of undertaking this stage of the estimation procedure is to derive the short-and long-run elasticities of substitution of Indonesian rubber in importing countries.

In the context of Armington framework, the import demand equation for Indonesian natural rubber can be expressed in the same manner as in Duffy *et al.* (1990) as :

$$X_{ij}/X_i = b_{ij}^{\sigma_{ij}} ( PX_{ij}/PX_i )^{-\sigma_{ij}} \quad \ldots\ldots (4)$$

According to Duffy *et al.* (1990), the intercept, $b_{ij}$, is a function of time, so that :

$$b_{ij} = A_{ij} T_{ij}^{\beta 2}$$

where :

$A_{ij}$ is a constant term; and all other variables are defined as above.

A partial adjustment equation can finally be derived as follows :

$$\ln (MSX_{ij(t)}) = \delta_2 \sigma_{ij} \ln A_{ij} - \delta_2 \sigma_{ij} \ln (PX_{ij}/PX_i) + (1 - \delta_2) \ln (MSX_{ij(t-1)}) + \delta_2 \beta_2 \ln T_{ij} + \epsilon_2 \quad \ldots\ldots (5)$$

where :

$MSX_{ij}$ = the market share of natural rubber imports from country j (e.g. Indonesia) in country i; and all other variables were as defined earlier.
$\delta_2$ = the coefficient of adjustment;
$\delta_2 \sigma_{ij}$ = the short-run elasicity of substitution;
$\sigma_{ij}$ = the long-run elasticity of substitution;
$\delta_2 \beta_2$ = the coefficient of the time trend; and
$\epsilon_2$ = an error term.

**Extended Armington Framework**

Following Duffy *et al.* (1990), a simple static equilibrium model will be used to derive the total elasticity of import demand for Indonesian natural rubber. This model can be seen as follows :

$$\text{dln } XI^d = e_{11} \text{ dln } PX_{ij} + e_{12} \text{ dln } PX_i \quad \ldots\ldots (6)$$

$$\text{dln } XROW^d = e_{21} \text{ dln } PX_{ij} + e_{22} \text{ dln } PX_{ik} \quad \ldots\ldots (7)$$

$$\text{dln } XROW^s = E_s \text{ dln } PX_{ik} \quad \ldots\ldots (8)$$

where :

$XI^d$ = the import demand for Indonesian rubber;
$XROW^d$ = the import demand for the ROW rubber;
$XROW^s$ = the export supply of natural rubber from ROW;
$PX_{ij}$ = the price of Indonesian natural rubber; and
$PX_{ik}$ = the price of rubber in importing countries.
$e_{11}$ = the direct-price elasticity of import demand for Indonesian rubber;
$e_{22}$ = the direct-price elasticity of import demand for rubber from ROW;
$e_{12}$ = the cross-price elasticity of import demand for Indonesian rubber with respect to price changes in ROW rubber;
$e_{21}$ = the cross-price elasticity of import demand for ROW rubber with respect price changes in Indonesian rubber; and
$E_s$ = the export supply elasticity from the rest of the world's exporting countries.

The short-run and the long-run total elasticity of import demand for Indonesian natural rubber can be expressed as :

$$\text{dln } QXI/\text{dln } PX_{ij} = e_{11} + e_{12} * e_{21}/(E_s - e_{22}) \quad \ldots\ldots (9)$$

Using equation (2), equation (9) can be expressed as :

$$N_j^* = N_j + N_{jk} * N_{kj} / (E_s - N_k) \quad \text{..... (10)}$$

where :

$$e_{11} = Nj = -\sigma_{ij} (1 - S_{ij}) + \omega_i S_{ij} \quad \text{..... (11)}$$

$$e_{12} = N_{jk} = \sigma_{ij} (1 - S_{ij}) + \omega_i (1 - S_{ij}) \quad \text{..... (12)}$$

$$e_{22} = N_k = -\sigma_{ij} S_{ij} + \omega_i (1 - S_{ij}) \quad \text{..... (13)}$$

$$e_{21} = N_{kj} = \sigma_{ij} S_{ij} + \omega_i S_{ij} \quad \text{..... (14)}$$

where :

$\sigma_{ij}$ = the elasticity of substitution of Indonesian natural rubber with other countries' rubber;
$S_{ij}$ = the expenditure share of Indonesian rubber in country i;
$\omega_i$ = the elasticity of import demand for natural rubber in country i; and
$E_s$ = as defined in (8).

In this study, the estimate of elasticity of export supply from the rest of the world's exporting countries used was obtained from Grilli *et al.* (1981). As Malaysia is the Indonesia's main competitor, the values of its export elasticity would be used in this study. The short- run and long- run elasticities of export supply for this country were found to be 0.19 and 0.33, respectively. In addition, the unitary value of this elasticity would also be used to analyse its effect on the demand for Indonesian rubber.

**Sources of the Data**

The data are composed of 22 annual observations from 1968 to 1989. Most data relevant to the study are available from various issues of the Indonesian Statistics Pocketbook (Biro Pusat Statistik 1990 and earlier issues), the World Rubber Statistics Handbook (International Rubber Study Group, 1986), the Rubber Statistical Bulletin (International Rubber Study Group, 1990), the International Trade Statistics Yearbook (United Nations, 1987a and earlier issues), the Commodity Trade Statistics (United Nations, 1990b and earlier issues) and the International Financial Statistics (International Monetary Fund, 1990 and earlier issues).

There are two methods of forming the groups of importing countries. First, importing countries are grouped into six regions based on the countries of destination of imported natural rubber. These groups consist of Western European Nations, Eastern Europe, United States, Japan, Singapore and the Rest of the World's importing countries. Second, Singapore can be excluded from the list of importing countries as it is a natural rubber re-exporting country. In terms of supply, the

exporting countries are grouped into two exporters, i.e., Indonesia and the Rest of the World's exporting countries. The list of importing and exporting countries is specified in Appendix 1.

Two different techniques were adopted in estimating the second-stage of the import demand for Indonesian rubber. The first technique accounts for the inclusion of Singapore and the second technique excludes Singapore in the model. The two techniques described above can be seen in Appendix 2.

## DIRECT-PRICE ELASTICITIES OFF DEMAND FOR NATURAL RUBBER IN IMPORTING COUNTRIES

As implied in the first stage estimation approach, the demand for natural rubber in importing countries are treated as a homogeneous product. In other words, no differentiation was initially made between the kind and the origin of natural rubber demanded, in importing countries. The results of estimating the demand for natural rubber in importing countries using the first-stage process are presented in Appendix 3.

The short-run elasticities were found to be inelastic ranging from $-0.04$ to $-0.47$ (Table 1). These values were consistent with economic theory which suggests that in the short-run the adjustment process of demand to changes in price is not instantaneous. Further, the estimated elasticities from three regions, i.e., US, Western Europe and the rest of the world's importing countries, were found to be in the same range as those obtained by Grilli, *et al.* (1981). However, Grilli, *et al.* (1981) estimated lower values of these elasticities in Japan and higher in the rest of the world's importing country and Singapore, than those obtained in this study.

As in the short-run, the values of the long-run elasticities for each of the importing countries, with the exception of Japan, were quite reasonable. In the Japanese equation, this result might be attributed to an inappropriate size of the

Table 1. Price elasticity of demand for natural rubber in importing countries.

| Countries | Coefficient of adjustment | Elasticities | |
|---|---|---|---|
| | | Short-run | Long-run |
| Japan | 0.347 | −0.474 | −1.365 |
| U.S.A. | 0.688 | −0.117 | −0.170 |
| Western Europe | 0.626 | −0.170 | −0.272 |
| Eastern Europe | 0.695 | −0.040 | −0.057 |
| ROW | 0.545 | −0.116 | −0.212 |
| Singapore | 0.202 | −0.081 | −0.402 |

adjustment coefficient. The value of the adjustment coefficient for the Japanese equation could be considered to be too low, given that Japan is an industrialised country. The values of these long-run elasticity estimates were mostly different from the values derived by Grilli *et al.* (1981).

## ELASTICITIES OF SUBSTITUTION OF INDONESIAN NATURAL RUBBER IN IMPORTING COUNTRIES

As implied in the second stage approach, the natural rubber in importing countries is differentiated on the basis of its kind and origin. This means that natural rubber is treated as a heterogeneous product from the buyers' view point. The estimated equations of the demand for Indonesian natural rubber, each with and without the inclusion of Singapore in the models are presented in Appendix 4 and 5. The respective elasticities of substitution of Indonesian rubber from both types of equations are presented in Table 2 and Table 3.

Table 2. Elasticity of substitution of Indonesian natural rubber in importing countries with the inclusion of Singapore.

| Countries | Coefficient of adjustment | Elasticities | |
|---|---|---|---|
| | | Short-run | Long-run |
| Japan | 0.7441 | 0.3475 | 0.4805 |
| U.S.A | 0.5925 | 0.6410 | 1.0970 |
| Western Europe | 0.3607 | 1.0472 | 2.9034 |
| Eastern Europe | 0.5306 | 1.0203 | 1.9230 |
| ROW | 0.4018 | 0.5984 | 1.4895 |
| Singapore | 0.6733 | 1.2385 | 1.8394 |

The values of the short-run elasticity of substitution of Indonesian natural rubber were found to be inelastic in most countries, implying that Indonesian rubber was not competitive in those countries. Using the model which included Singapore, the elasticity of substitution was found to be inelastic in the US, Japan and the rest of the world's importing countries. However, it was found to be elastic in Western Europe, Eastern Europe and Singapore (Table 2). The results in Western and Eastern Europe seemed to be inappropriate, as both regions are not the main markets for Indonesian rubber. These results might be due to the inappropriate use of a representative price and (or a proxy price) of natural rubber in these regions.

Malaysia and Vietnam are the main exporters to Western Europe and Eastern Europe, respectively. However, given the standard error values of the estimated elasticities in both Western and Eastern Europe equations, there is a possibility that the magnitude of the elasticities in both countries is less than one, implying inelastic values. Hence, the estimates of the elasticities derived in this study could be said to be reasonable.

The problems of estimating the short-run elasticity also occured in the model which excluded Singapore. However, the estimated elasticities of substitution seemed to be more reasonable than those derived from the model which included Singapore (Table 3). The problems associated with estimating these eleasticities might be due to the use of an inappropriate assumption regarding the allocation of natural rubber exported from Singapore to groups of importing countries.

The magnitude of the estimated long-run elasticity of substitution of Indonesian rubber in importing countries could be said to be more reasonable than the short-run estimates in both models. In the long-run, Indonesian rubber was found mostly to be competitive in importing countries. It must be noted that Indonesian rubber was found to be competitive in all markets, with the exception of Japan and in the model with the inclusion of Singapore. These results are related to the size of the adjustment coefficient. In the model without the inclusion of Singapore, the magnitude of that coefficient in the Japanese and Eastern Europe equations may be too large. A similar assessment may also apply for Eastern Europe and the rest of importing countries equations in the model which exclude Singapore.

Table 3. Elasticity of substitution of Indonesian natural rubber in importing countries without the inclusion of Singapore.

| Countries | Coefficient of adjustment | Elasticities | |
|---|---|---|---|
| | | Short-run | Long-run |
| Japan | 0.441 | 0.580 | 1.316 |
| U.S.A. | 0.375 | 0.759 | 2.027 |
| Western Europe | 0.481 | 0.920 | 1.912 |
| Eastern Europe | 0.664 | 1.137 | 1.712 |
| ROW | 0.608 | 0.112 | 0.183 |

## TOTAL ELASTICITY OF IMPORT DEMAND FOR INDONESIAN NATURAL RUBBER

Using the elasticities presented in previous sections, the total elasticities of import demand for Indonesian natural rubber, using the extended Armington

frameworks in both models with and without the inclusion of Singapore were estimated. The estimated total elasticities mentioned above were presented in Table 4. Using the extended Armington framework, the total elasticity of import demand for Indonesian rubber was found to be in the range from $-0.42$ to $-0.50$ in the short-run and between $-0.86$ and $-1.02$ in the long-run, both without and with the inclusion of Singapore, respectively. The above values indicate that the total short-run elasticity of import demand for Indonesian rubber is, in general, inelastic. While in the long-run, the value was found to be inelastic and close to unitary.

Following Piggott (1990, p 34-39), the inelastic nature of the demand equation in the short-run suggests that the time period allowed for adjustments to quantity demanded from a change in price was relatively short. This implies the time available for searching for substitute products was limited. In addition, the budget share of raw material, i.e., Indonesian rubber, in the finished products was small.

As suggested by Duffy, *et al.* (1990), the resulting values of the total elasticity of demand derived from the extended framework are realistic in assessing the effects of policy changes. The above values suggest that the feedback response of own-price changes, relative to other exporting countries' rubber price had a significant impact on the estimated total export demand elasticity.

Table 4. Total elasticity of export demand for Indonesian natural rubber.

| Type of Model | Total Elasticity | |
|---|---|---|
| | Short-run | Long-run |
| Model with Singapore | | |
| Es = 0.19 (short-run) | −0.5 | – |
| Es = 0.33 (long-run) | – | −0.86 |
| Es = 1.0 (short-and long-run) | −0.64 | −0.98 |
| Model without Singapore | | |
| Es = 0.19 (short-run) | −0.42 | – |
| Es = 0.33 (long-run) | – | −0.94 |
| Es = 1 (short-and long-run) | −0.49 | −1.02 |

The inelastic export demand for Indonesian natural rubber means that the price effect is stronger than the quantity effect. Hence, total revenue over the period of analyses move in the same direction as the price effect. As the price of natural rubber has tended to decline in recent years, the results confirm the view that decreasing foreign exchange earnings have occured and thus farmers' incomes have declined as well.

As implied in equation (10), the competitiveness of Indonesian rubber has important role in determining the size of the total elasticity of export demand for Indonesian natural rubber. The greater the elasticity of substitution, the greater the share of Indonesian rubber in importing countries, therefore, the greater the total elasticity of demand for Indonesian rubber will be. In accordance with the result of this study, the Indonesian rubber should become more competitive, both in the short-run and in the long-run, in order to maximise its foreign exchange earnings.

To increase competitiveness of Indonesian rubber, the increased export supply of Indonesian rubber should be followed by the improved quality of Indonesian rubber and supported with the relatively low price of Indonesian rubber compared to other countries' rubber. As Indonesia has a comparative advantage than other producing countries, this implication confirms the view that several major government initiatives will finally result in increased export returns of Indonesia.

## CONCLUSION AND POLICY IMPLICATIONS

From the proceeding analysis, the Indonesian rubber can be considered to be incompetitive in the short-run and competitive in the long-run. Further, both its short- run and long-run total demand response were relatively inelastic to changes in price. These results have implications for assessing the government initiatives as outlined in the background.

The results suggest that the government initiatives to expand the supply of Indonesian rubber will not result in an increase in the foreign exchange earnings from natural rubber. Over the period of analyses, the inelastic import demand curve for Indonesian rubber means that total revenue has moved in the same direction as the price effect. As the price of natural rubber has tended to decline in recent years, the results confirm the view that decreasing foreign exchange earnings have occured and thus farmers' incomes have declined as well.

However, this implication does not confirm the view that the government of Indonesia should act in a contrary manner and restrict the supply of natural rubber. In order to maximise its foreign exchange earninges, the Indonesian supply sector should become more competitive, both in the short-run and long-run. As indicated in the second-stage model, the competitiveness of Indonesian rubber was principally determined by the ratio of its price to the average price of rubber in the importing countries. This implies that factors related to price of Indonesian rubber, such as efficiency of production, expanded export supply supported with improved quality of Indonesia rubber, should be considered in future policy formulation.

## REFERENCES


Armington, P.S. (1969), 'A theory of demand for products distinguished by place of production', International Monetary Fund Staff Papers, 26 (1), 159-178.

Barlow, C. and Muharminto (1982), 'The rubber smallholder economy', Bulletin of Indonesian Economic Studies, 18, 86-119.

Biro Pusat Statistik (1990 and earlier issues), 'Indonesian Statistics Pocketbook, Jakarta.

Buse, R.C. (1958), 'Total elasticities - a predictive device', Journal of Farm Economics, 40 (4), 881-891.

Dillon, H.S. (1987), Prospek perdagangan komoditi pertanian strategis di pasaran internasional (kasus komoditi karet), Paper disampaikan pada seminar di jurusan Sosial Ekonomi Pertanian, Institute Pertanian Bogor.

Duffy, P.A., Wohlgenant, M.K. and Richardson, J.W. (1990), 'The elasticity of export demand for U.S. cotton', American Journal of Agricultural Economics, 61 (1), 468-474.

Grilli, E.R., Agostini, B.B. and Welvaars, M.J.H. (1980), The World Rubber Economy : Structure, Changes and Prospects, John Hopkins, London.

Grilli, E.R., Helterline, R. and Pollak, P. (1981), 'An econometric model of the world rubber economy', World Bank Staff Commodity Working Paper, 6, 1-38.

International Rubber Study Group (1985), World Rubber Statistics Handbook, 3, 1965-1985, London.

_____ (1990), Rubber Statistical Bulletin, 45, 1, London.

International Monetary Fund (1990 and earlier issues), International Financial Statistics, Washington.

Piggot, R.R. (1990), Book of Supplementary Notes on Price Theory, The University of New England, Armidale.

Teken, I.B. (1971), The Supply of and Demand for Indonesian Rubber, Ph.D. thesis, Purdue University, Purdue.

Tomek, W.G. and Robinson, K.L. (1981), Agricultural Product Prices 2nd edn., Cornell University Press, Ithaca.

United Nations (1987a and earlier issues), International Trade Statistics Yearbook, New York.

_____ (1990b and earlier issues), Commodity Trade Statistics, New York.

Appendix 1. List of importing and exporting countries.

| Group | Countries |
|---|---|
| **Importing Countries** | |
| – Western Europe | Belgium, Luxemburg, France, Federal Republic of Germany, Italy, Netherlands, United Kingdom. |
| – Eastern Europe | Czechoslovakia, Yugoslavia, Poland, Soviet Union. |
| **Exporting Countries** | |
| – Rest of the World's Exporting Countries | Malaysia, Thailand, Sri Lanka Vietnam, Kampuchea, Burma, India, China, Philippines, Liberia, Nigeria, Zaire, Cameroon, Ivory Coast, Brazil and Other Latin America. |

Appendix 2. The direct and indirect calculation of quantity demanded for Indonesian rubber.

**1. Direct Calculation**

Indonesian rubber exports to :

| | |
|---|---|
| – US | $= e_1$ |
| – Western Europe | $= e_2$ |
| – Eastern Europe | $= e_3$ |
| – Japan | $= e_4$ |
| – Rest of the World's Importing Countries | $= e_5$ |
| – Singapore | $= e_6$ |
| | $\Sigma e_i = E$ |

**2. Indirect Calculation**

Unknown Singaporean re-exports of Indonesian rubber to :

| | |
|---|---|
| – US | $= Se_1$ |
| – Western Europe | $= Se_2$ |
| – Eastern Europe | $= Se_3$ |
| – Japan | $= Se_4$ |
| – Rest of the World's Exporting Countries | $= Se_5$ |
| | $\Sigma Se_i = SE$ |

**Assumptions :**

(i) $SE = e_6$, i.e all Indonesian rubber re-exported in the same year.

(ii) proportions going to different parts of the world from Singapore are the same as the proportion going directly from Indonesia.

i.e., $\frac{Se_i}{SE} = \frac{e_i}{E - e_6}$

$Se_i = e_i * SE / (E - SE)$

Therefore, the final trade Indonesian rubber into "country" i is :

$$fe_i = e_i + \frac{e_i SE}{E - SE} = \frac{e_i E}{E - SE}$$

Appendix 3. The results of estimating the import demand for natural rubber in importing countries.

| Countries | Constant | $MS_{(t-1)}$ | Price ratio | Elastomer consumption | Trend |
|---|---|---|---|---|---|
| Japan | 0.287 | 0.653 | -0.474 | -0.160 | -0.037 |
| | (0.518) | (6.070) | (-6.156) | (-3.626) | (-0.563) |
| | | | $R^2$ = 0.651 DW = 1.129 | | |
| U.S.A. | 0.283 | 0.312 | -0.117 | -0.220 | -0.073 |
| | (1.209) | (2.032) | (-3.044) | (-3.086) | (-2.959) |
| | | | $R^2$ = 0.847 DW = 1.679 | | |
| W. Europe | 0.086 | 0.374 | -0.170 | -0.051 | -0.092 |
| | (0.121) | (2.290) | (-2.617) | (-0.235) | (-2.130) |
| | | | $R^2$ = 0.744 DW = 2.257 | | |
| E. Europe | 1.161 | 0.305 | -0.040 | -0.173 | -0.415 |
| | (4.180) | (17.771) | (-0.476) | (-13.616) | (-24.520) |
| | | | $R^2$ = 0.972 DW = 2.168 | | |
| ROW | -1.002 | 0.455 | -0.116 | 0.138 | -0.140 |
| | (-0.949) | (2.866) | (-1.822) | (0.870) | (-1.319) |
| | | | $R^2$ = 0.791 DW = 1.892 | | |
| Singapore | 2.137 | 0.796 | -0.128 | | 0.062 |
| | (1.448) | (3.765) | (-1.235) | | (0.793) |
| | | | $R^2$ = 0.382 DW = 1.892 | | |

Note: – t(0.05, 17) = 2.110
– numbers in the parantheses are t-statisticsTable 5.3

Appendix 4. The results of estimating the import demand for Indonesian natural rubber in importing countries with the inclusion of Singapore.

| Countrives | Constant | MS(t-1) | Price ratio | Trend |
|---|---|---|---|---|
| Japan | -0.840 | 0.256 | -0.347 | -0.068 |
| | (-3.607) | (1.326) | (-1.980) | (-1.991) |
| | | $R^2$ = 0.233 DW = 1.8684 | | |
| U.S.A. | -0.500 | 0.408 | -0.641 | 0.303 |
| | (-2.268) | (3.103) | (-2.131) | (2.348) |
| | | $R^2$ = 0.956 DW = 2.36 | | |
| W. Europe | -0.145 | 0.639 | -1.047 | -0.181 |
| | (-0.271) | (3.513) | (-2.408) | (-1.623) |
| | | $R^2$ = 0.305 DW = 2.1123 | | |
| E. Europe | -0.597 | 0.469 | -1.020 | 0.212 |
| | (-2.461) | (2.461) | (-1.333) | (1.305) |
| | | $R^2$ = 0.612 DW = 1.8584 | | |
| ROW | -0.852 | 0.598 | -0.598 | 0.325 |
| | (-1.584) | (3.650) | (-1.041) | (1.200) |
| | | $R^2$ = 0.936 DW = 1.992 | | |
| Singapore | 0.088 | 0.327 | -1.239 | -0.284 |
| | (0.285) | (1.525) | (-2.949) | (-0.310) |
| | | $R^2$ = 0.500 DW = 1.214 | | |

Note: – t (0.05, 18) = 2.101
– numbers in parantheses are t-statistics.

Appendix 5. Demand for Indonesian natural rubber in importing countries without the inclusion of Singapore.

| Countries | Constant | MS(t-1) | Price ratio | Trend |
|---|---|---|---|---|
| Japan | -0.204 | 0.559 | -0.580 | -0.217 |
| | (-2.152) | (3.246) | (-2.285) | (-2.407) |
| | | $R^2$ = 0.903 DW = 1.841 | | |
| U.S.A. | -0.582 | 0.625 | -0.759 | 0.255 |
| | (-1.583) | (9.849) | (-2.967) | (2.411) |
| | | $R^2$ = 0.970 DW = 2.5070 | | |
| W. Europe | 0.151 | 0.519 | -0.920 | -0.347 |
| | (0.386) | (2.248) | (-1.995) | (-2.632) |
| | | $R^2$ = 0.557 DW = 1.803 | | |
| E. Europe | -0.412 | 0.336 | -1.137 | 0.640 |
| | (-1.732) | (1.566) | (-1.475) | (0.476) |
| | | $R^2$ = 0.306 DW = 1.695 | | |
| ROW | -2.839 | 0.392 | -0.112 | 0.477 |
| | (-3.148) | (2.144) | (-1.132) | (3.051) |
| | | $R^2$ = 0.902 DW = 1.975 | | |

Note: – t(0.05,18) = 2.101
– numbers in parantheses are t-statistics.