4. Research Methods and Model Specification

4.1 Introduction

Three main points are presented in this chapter. First, attention is given to the procedure of decomposition analysis, that is, the method to be used to ascertain the sources of Indonesian natural rubber price instability. Implementation of the procedure, as well as its limitations, are included in this section. Second, attention is given to explaining the sources of price instability. Initially, an econometric model of the supply and demand for Indonesian natural rubber is presented. This model comprises three behavioural equations and an identity representing a market clearing in the context of static equilibrium. To obtain the price of Indonesian natural rubber as a dependent variable, a reduced form is derived from this model in two ways. Initially, the three structural equations are solved to provide a full reduced form model which can then be estimated. Alternatively, a restricted reduced form model is derived from the significant coefficients of the estimated structural equations. As another comparison, a directly estimated natural rubber price equation is specified based on previous research. Estimated coefficients resulting from all approaches will be used in the decomposition analysis of the sources of Indonesian natural rubber price variations. Third, data definitions, the time period of observations and data sources are also presented this chapter.

4.2 Decomposition Procedure

The rationale of the decomposition procedure is that the sources of revenue instability of a particular commodity can be traced back into price and quantity components. A number of analysts using this procedure to examine the sources of revenue instability have been mentioned previously in Chapter 3. Piggott (1978), however, criticised this decomposition procedure in that it provides a weak informational base for designing policies to counter the effects of instability. In addition to that, the pattern of price-quantity variability could be due to more than the pattern of demand and supply variability. Alternatively, Piggott developed an analysis of the causes of instability in gross revenue in a competitive market. This method is based on the argument that in competitive markets, gross revenue instability can be traced back into the supply and demand components that contribute most to revenue variability. In a subsequent paper, Piggott (1981) indicated that a similar procedure could be used for analysing the causes of instability in prices and quantities traded.

Due to the requirement of a knowledge of the relative importance of supply and demand shifts in causing price instability, the method proposed by Piggott (1981) is adopted in this study. The procedure of the decomposition analysis is described in the following part.

4.2.1 The case of simultaneous price and quantity determination

Under a purely competitive market, the underlying demand and supply functions can be represented by:

$$Q_t^d = a_t + k_1 P_t \tag{4.1}$$

and

$$Q_t^s = c_t + k_2 P_t \tag{4.2}$$

where:

Q_t^d = the quantity demanded in period t;

Q_t^s = the quantity supplied in period t;

a_t = net demand intercept in period t;

c_t = net supply intercept in period t $(c_t < a_t)$;

k_1 = non-stochastic demand slope $(k_1 < 0)$;

k_2 = non-stochastic supply slope $(k_2 > 0)$; and

P_t = price in period t.

The equilibrium price in period t , P_t^e, is obtained by equating demand and supply, that is :

$$P_t^e = (a_t - c_t)/(k_2 - k_1) \tag{4.3}$$

Price variability is defined as the price variance given by:

$$\mathrm{var}\left(P^e\right) = \pi\,\mathrm{var}(a) + \pi\,\mathrm{var}(c) - 2\pi\,\mathrm{cov}(a,c) \tag{4.4}$$

where:

$\pi \quad = \left[1/\left(k_2 - k_1\right)^2\right]$;

var( ) = variance operator;

cov ( ) = covariance operator; and

All other variables are as defined previously.

The direct contribution of variability in the demand intercept to the variance in price can be seen in the first term on the right-hand-side (R.H.S.) of equation (4.4). Similarly, the second term measures the direct contribution of variability in the supply intercept, while the third term is the contribution of interactions between demand and supply variability. The relative importance of these components of price variability can be obtained by normalising each R.H.S. term on the variance of price or one of the R.H.S. terms.

The net intercepts, a_t and c_t, measure the joint influence of all demand shifters and all supply shifters, respectively. The net intercept can be written as a linear combination of the various individual shift variables, that is:

$$a_t = \alpha_1 a_{1t} + \alpha_2 a_{2t} + \ldots + \alpha_n a_{nt} \tag{4.5}$$

and

$$c_t = \beta_1 c_{1t} + \beta_2 c_{2t} + \ldots + \beta_m c_{mt} \tag{4.6}$$

where:

$a_{it} = (i = 1,\ldots,n)$ = the value of demand shifter i in period t;

$c_{it} = (i = 1,\ldots,m)$ = the value of supply shifter i in period t;

$\alpha_i(i = 1,\ldots,n)$ = the coefficient associated with demand shifter i; and

$\beta_i = (i = 1,\ldots,m)$ = the coefficient associated with supply shifter i.

Decomposition of these sources of price variability can be carried a step further by expressing the variance of a_t and c_t as functions of the variances and covariances of the individual shift variables, as follows:

$$\operatorname{var}(a) = \sum_{i=1}^{n} \alpha_i^2 \operatorname{var}(a_i) + 2\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \alpha_i \alpha_j \operatorname{cov}(a_i, a_j) \tag{4.7}$$

and

$$\operatorname{var}(c) = \sum_{i=1}^{m} \beta_i^2 \operatorname{var}(c_i) + 2\sum_{i=1}^{m-1} \sum_{j=i+1}^{m} \beta_i \beta_j \operatorname{cov}(c_i, c_j) \tag{4.8}$$

Each of the terms on the R.H.S. of equation (4.7) can be normalised on, say, var(a) to measure the relative importance in causing variability in the net demand intercept. Similarly, the terms on the R.H.S. of equation (4.8) can be normalised on, say, var(c). By doing this, a more complete breakdown of the causes of price instability is obtainable.

4.2.2 Implementation of the procedure

As proposed by Piggott (1981), implementation of the decomposition procedure requires coefficients associated with the various demand and supply shifters, as well as the slope of the demand and supply equations. These coefficients are usually estimated from an econometric model of demand and supply for a particular commodity. Myers and Runge (1985), alternatively, demonstrated the computation of the various demand and supply elasticities at the point of means. Then by using observations on prices, quantities, and the demand and supply shifters, the implied coefficients of the demand and supply functions can be calculated. Another alternative suggested by Piggott (1981) is that the values for demand and supply elasticities could be based on the results of previous research and/or *a priori* reasoning.

A decision has been made in this study to specify and estimate an econometric model in order to obtain the necessary coefficients. This is because the existing econometric models for the Indonesian natural rubber market (Teken 1971; Muslim 1990), seem inappropriate for the analysis undertaken in this study. Moreover, it is considered that *a priori* reasoning alone might not present the estimates sufficiently.

The specification of the econometric model for Indonesian natural rubber market is outlined in part 4.3.

It should be noticed that an econometric model only results in an estimate of the price relationship represented by equation (4.3). The actual price in period t can be written in the following equation :

$$P_t^e = \hat{P}_t^e + \mu_t \tag{4.9}$$

where:

P_t^e = the actual price;

$\hat{P}_t^e$ = an estimate of P_t^e obtained from the econometric model; and

μ_t = error term.

The variance of P_t^e follows that:

$$\operatorname{var}\left(P^e\right) = \operatorname{var}\left(\hat{P}^e\right) + \operatorname{var}(\mu) + 2\operatorname{cov}\left(\hat{P}^e, \mu\right) \tag{4.10}$$

The decomposition procedure will be applied to the term $\operatorname{var}\left(\hat{P}^e\right)$, that is, the variance of the estimated price. The value of the multiple coefficient of determination $\left(R^2\right)$ obtained from an ordinary least square estimate of equation (4.3) will indicate the proportion of the variance of actual price explained by the econometric estimate.

4.2.3 Some limitations of the procedure

Limitations of the decomposition variance procedure have been discussed by Piggott (1978, 1981) and Myers and Runge (1985). The application of variance techniques to measure variability is the first shortcoming of this procedure. Offutt and Blandford (1983) argued that the use of variance as a measure of variability is subject to the common criticism levelled against this statistic. This is that the variance decision has nothing more to contribute by way of explanation since it is not able to provide information of the causes of instability. However, since Offutt and Blandford indicated that using the variance as the measure of instability does not encompass an explicit forecasting procedure, this limitation seems unimportant. In addition, Wong

(1986) pointed out that the coefficient of variation has an advantage of being decomposable into components, so this first shortcoming can be neglected.

Another limitation is the assumption of linear demand and supply functions which shift in parallel fashion. With these linear forms, analysis of the causes of variability through decomposition procedures is straightforward. In the context of the present study, one problem might be the outcome regarding some effects of shocks, such as the sharp rise of synthetic rubber prices during the oil crisis period, on the natural rubber market. However, the choice of linear forms is sufficient to indicate the source of price variability, and thus is important in determining possible government intervention in the natural rubber market.

4.3 An Econometric Model of the Indonesian Natural Rubber Market

The econometric model of the Indonesian natural rubber market used in this study is constructed under linear and static assumptions. This means that no lagged dependent variables are incorporated in the model. This choice follows the requirement of the decomposition procedure to ascertain the sources of natural rubber price instability. In constructing the model, structural forms of supply and demand for Indonesian natural rubber are firstly described. Then a reduced form is derived from the supply and demand functions in two ways to obtain the Indonesian natural rubber price as a dependent variable. Previous empirical models of the Indonesian natural rubber market are taken into account when constructing the model, including Teken (1971), Muslim (1990), and Surjoputranto (1991).

As previously mentioned, a directly estimated natural rubber price equation is also provided. This equation is more closely related to previous works that have been done by other analysts. The reason underlying this choice is to compare different price equations in explaining the sources of price instability of Indonesian natural rubber.

4.3.1 Structural model of the Indonesian natural rubber market

There are three behavioural equations in the structural model, that is, supply, export demand, and domestic consumption, of Indonesian natural rubber. In addition, an identity representing a market clearing condition is presented to close the model. All *a priori* equations are presented in the following parts:

(i) Supply equation

It is hypothesised that total natural rubber production is a linear and static function of domestic natural rubber price, domestic price of palm oil, cost of labour, government support for natural rubber, and a time trend variable. The functional form of natural rubber supply can be specified as follows:

$$QP_t = \alpha_0 + \alpha_1 PR_t + \alpha_2 PO_t + \alpha_3 CL_t + \alpha_4 D_t + \alpha_5 T + \mu_1 \quad (4.11)$$

where:

QP_t = total natural rubber production in year t, measured in 1000 tonnes of the dry content weight of latex;

PR_t = Indonesian natural rubber price in year t, expressed in Rp/kg, represented by the Jakarta f.o.b. price of RSS1, deflated by the Indonesian consumer price index (CPI);

PO_t = domestic price of palm oil in year t, expressed in Rp/kg, represented by the average domestic price of palm oil, deflated by the Indonesian CPI;

CL_t = cost of labour in year t, represented by the average labour wage per day paid on natural rubber activities, expressed in Rp/day, deflated by the Indonesian CPI;

D_t = policy dummy variable in year t, representing the introduction of the NESS program in 1977 (1: government policy; 0: otherwise);

T = a linear time trend representing technological progress in the natural rubber industry, denoted consecutively by the numbers 1 to 27 for the years 1966-1992;

$\alpha_0,\ldots,\alpha_5$ = parameters to be estimated; and

μ_1 = error disturbance.

The expected signs for each parameter are

$$\alpha_1 > 0; \quad \alpha_2 < 0; \quad \alpha_3 < 0; \quad \alpha_4 > 0; \quad \alpha_5 > 0.$$

(ii) Export demand

It is hypothesised that export demand for Indonesian natural rubber is a linear and static function of the Indonesian exchange rate, the world price of natural rubber, the world price of synthetic rubber, and income per capita of OECD members. The statistical model of the export demand can be expressed as follows:

$$XD_t = \beta_0 + \beta_1 EXR_t + \beta_2 WPR_t + \beta_3 WPS_t + \beta_4 GNP_t + \mu_2 \qquad (4.12)$$

where:

XD_t = quantity exported of Indonesian natural rubber in year t; measured in 1000 tonnes of the dry content weight of latex;

EXR_t = the Indonesian exchange rate in year t, expressed in Rp/US$, deflated by the ratio of the US CPI to the Indonesian CPI;

WPR_t = the world natural rubber price in year t; expressed in US cents/kg, represented by the New York c.i.f. price of RSS1, deflated by the US CPI;

WPS_t = the world synthetic rubber price in year t, expressed in US cents/kg, represented by the price of styrene-butadiene and deflated by the the US CPI;

GNP_t = income per capita of OECD members in year t, expressed in US$, deflated by the OECD CPI;

$\beta_0,\ldots,\beta_4$ = parameters to be estimated; and

μ_2 = error disturbance.

The *a priori* parameter signs are as follows:

$\beta_1 > 0; \quad \beta_2 < 0; \quad \beta_3 > 0; \quad \beta_4 > 0.$

(iii) Domestic consumption

Domestic consumption of natural rubber is hypothesised to be a linear and static function of domestic natural rubber price and domestic income per capita. It can be represented in the following equation:

$$DU_t = \gamma_0 + \gamma_1 PR_t + \gamma_2 Y_t + \mu_3 \qquad (4.13)$$

where:

DU_t = domestic consumption of natural rubber in year t; measured in 1000 tonnes of the dry content weight of latex;

PR_t = as previously defined in the supply equation;

Y_t = domestic income per capita in year t, expressed in Rp, deflated by the Indonesian CPI;

$\gamma_0, \ldots, \gamma_2$ = parameters to be estimated; and

μ_3 = error disturbance.

The expected signs of the parameters are

$\gamma_1 < 0; \qquad \gamma_2 > 0.$

(iv) Market clearing condition

$$\textit{Supply} = \textit{export demand} + \textit{domestic consumption} + \textit{residual} \tag{4.14}$$

A residual variable is included in the equation (4.14) to obtain the balance between quantity supplied and quantity demanded of Indonesian natural rubber. This variable measures changes in stocks as well as errors in measurement. A stock variable is not included explicitly in this equation because there is a lack of data on stocks over the whole data period and for all categories of stocks.

(v) Full reduced form of price equation

A full reduced form price equation can be obtained by equating equation (4.11) to the equations (4.12), (4.13), and the residual variable, as follows:

$$\begin{aligned}\alpha_0 + \alpha_1 PR_t + \alpha_2 PO_t + \alpha_3 CL_t + \alpha_4 D_t + \alpha_5 T + \mu_1 &= \beta_0 + \beta_1 EXR_t + \beta_2 WPR_t \\ &+ \beta_3 WPS_t + \beta_4 GNP_t + \mu_2 + \gamma_0 + \gamma_1 PR_t + \gamma_2 Y_t + \mu_3 + \delta_1 RSD_t\end{aligned} \tag{4.15}$$

where: RSD_t refers to the residual variable.

Then, the Indonesian natural rubber price variable can be expressed in all predetermined variables as follows:

$$(\alpha_1 - \gamma_1)PR_t = (\beta_0 + \gamma_0 - \alpha_0) + \beta_1 EXR_t + \beta_2 WPR_t + \beta_3 WPS_t + \beta_4 GNP_t + \gamma_2 Y_t - \alpha_2 PO_t - \alpha_3 CL_t - \alpha_4 D_t - \alpha_5 T + \delta_1 RSD_t + (\mu_2 + \mu_3 - \mu_1) \tag{4.16}$$

Equation (4.16) can be rewritten as:

$$\begin{aligned} PR_t = {} & \frac{\beta_0 + \gamma_0 - \alpha_0}{\alpha_1 - \gamma_1} + \frac{\beta_1}{\alpha_1 - \gamma_1} EXR_t + \frac{\beta_2}{\alpha_1 - \gamma_1} WPR_t + \frac{\beta_3}{\alpha_1 - \gamma_1} WPS_t \\ & + \frac{\beta_4}{\alpha_1 - \gamma_1} GNP_t + \frac{\gamma_2}{\alpha_1 - \gamma_1} Y_t + \frac{(-\alpha_2)}{\alpha_1 - \gamma_1} PO_t + \frac{(-\alpha_3)}{\alpha_1 - \gamma_1} CL_t + \frac{(-\alpha_4)}{\alpha_1 - \gamma_1} D_t \\ & + \frac{(-\alpha_5)}{\alpha_1 - \gamma_1} T + \frac{\delta_1}{\alpha_1 - \gamma_1} RSD_t + \frac{(\mu_2 + \mu_3 - \mu_1)}{\alpha_1 - \gamma_1} \end{aligned} \tag{4.17}$$

Equation (4.17) can be simplified as:

$$\begin{aligned} PR_t = {} & \pi_{20} + \pi_{21} EXR_t + \pi_{22} WPR_t + \pi_{23} WPS_t + \pi_{24} GNP_t + \pi_{25} Y_t \\ & + \pi_{26} PO_t + \pi_{27} CL_t + \pi_{28} D_t + \pi_{29} T + \pi_{30} RSD_t + v_1 \end{aligned} \tag{4.18}$$

where:

$$\pi_{20} = \frac{\beta_0 + \gamma_0 - \alpha_0}{\alpha_1 - \gamma_1}; \quad \pi_{21} = \frac{\beta_1}{\alpha_1 - \gamma_1}; \quad \pi_{22} = \frac{\beta_2}{\alpha_1 - \gamma_1}; \quad \pi_{23} = \frac{\beta_3}{\alpha_1 - \gamma_1};$$

$$\pi_{24} = \frac{\beta_4}{\alpha_1 - \gamma_1}; \quad \pi_{25} = \frac{\gamma_2}{\alpha_1 - \gamma_1}; \quad \pi_{26} = \frac{(-\alpha_2)}{\alpha_1 - \gamma_1}; \quad \pi_{27} = \frac{(-\alpha_3)}{\alpha_1 - \gamma_1};$$

$$\pi_{28} = \frac{(-\alpha_4)}{\alpha_1 - \gamma_1}; \quad \pi_{29} = \frac{(-\alpha_5)}{\alpha_1 - \gamma_1}; \quad \pi_{30} = \frac{\delta_1}{\alpha_1 - \gamma_1}; \quad v_1 = \frac{(\mu_2 + \mu_3 - \mu_1)}{\alpha_1 - \gamma_1}.$$

Equation (4.18) is then estimated by OLS.

(vi) Restricted reduced form price equation

A restricted reduced form price equation can be obtained by first estimating equation (4.11), (4.12), and (4.13) using a simultaneous equation estimator, omitting non significant variables, and by deriving a reduced form like equation (4.18) from the preferred structural equations. Thus the reduced form is restricted in that only those variables significant in the structural equations are allowed to enter the reduced form.

4.3.2 A directly estimated price equation

This price equation follows previous works, namely Piggott (1981), Watkins (1986), and Lestari (1994), where there is no structural model specified and the quantity variable is treated as an exogenous variable in the model. Hence, domestic natural rubber price is the only endogenous variable. The model is specified below:

$$\begin{aligned} PR_t = {} & \chi_0 + \chi_1 QP_t + \chi_2 EXR_t + \chi_3 WPR_t + \chi_4 WPS_t + \chi_5 GNP_t \\ & + \chi_6 PO_t + \chi_7 CL_t + \chi_8 D_t + \chi_9 T + v_2 \end{aligned} \tag{4.19}$$

where:

v_2 = error term.

All other variables are as defined previously.

To obtain the necessary coefficients for the purpose of decomposition procedure, OLS is applied to equation (4.19). In the next chapter, all the estimation results will be compared to explain the sources of natural rubber price instability in Indonesia.

4.4 Description of Variables Used

4.4.1 Domestic natural rubber price (*PR*)

This study is concerned with the analysis of the causes of natural rubber price instability, hence the Indonesian natural rubber price is treated as the dependent variable in the reduced form model. The Indonesian natural rubber price is represented by the price of Ribbed Smoked Sheet 1 (RSS1), the most preferred quality in the natural rubber market, at the Jakarta f.o.b. price. To reduce the effect of inflation, this price is deflated by the Indonesian Consumer Price Index (CPI), base year 1985.

The reason for choosing this domestic price in the supply equation is that producers will respond to this price rather than to the world price. On the other hand, wholesalers or exporters will respond to the changing price in the world market. Moreover, natural rubber is a storable commodity, hence, the wholesalers, that are assumed to have more storage facilities can adjust their quantity traded in relation to the changing price. Another reason for using the domestic price is to capture the response of domestic consumption of natural rubber to the unstable domestic price.

4.4.2 Palm oil price (*PO*)

The price of palm oil is included in the supply and price equation models because this commodity is grown under relatively similar environmental conditions as natural rubber. Therefore, it is assumed that natural rubber and palm oil are competing in resource use. In the very short-run, natural rubber producers might not respond quickly to the farm price of palm oil. However, it could be taken into consideration for the natural rubber producers to shift from natural rubber to palm oil in the longer period.

The palm oil price in this study is represented by the domestic price, since palm oil production is primarily concerned with the increasing domestic demand for cooking oil (DGEC 1994). This palm oil price is deflated by the Indonesian CPI (base year 1985) to reduce the effect of inflation. In the price equations, it is expected that the coefficient for the palm oil price is positive. The reason is that if the palm oil price increases due to the expanding demand, the palm oil producers tend to increase their production. On the other hand, the natural rubber producers tend to shift from natural rubber to palm oil production. Consequently, there will be less supply of natural rubber and in turn the scarcity of natural rubber will bring an increase of natural rubber price.

4.4.3 Cost of labour (*CL*)

Among variable production costs, labour wages for tapping is the most important component. Based on the agricultural census done by the Central Bureau of Statistics of Indonesia in 1983, labour wages comprise about 52 per cent of the total variable cost of natural rubber production (Mubyarto and Dewanta 1991). The cost of labour in this study is represented by the average labour wage per day paid on the natural rubber production activities. It is expressed in Rp/day and deflated by the Indonesian CPI to obtain the real wage for labour. The expected sign for the coefficient of labour wages in the price equations is positive which means that the increase of labour wages will result in less profitability to produce natural rubber and in turn will rise the price of natural rubber.

4.4.4 Government support (*D*)

Rubber supply, and thus the dependent price variable, to some extent, has been affected by the impact of government intervention in the natural rubber industry. Hence, government policy is included in this study in relation to the increase of product quality through the incorporation of the NESS scheme.

Government policy in this study is represented by a dummy variable, which takes the value 0 from 1966 to 1977 for the period without government policy and the value 1 for the presence of government intervention. The expected sign for the coefficient of government policy in the price equations is positive, denoting the presence of government intervention will bring about a better quality of the product and in turn a better price received by the producers.

4.4.5 Technological progress (*T*)

The inclusion of a time trend in the supply and price equation models is to approximate technical progress achieved by the natural rubber producers. The use of a time trend to represent technological changes has been criticised by some analysts, however, many studies have used this variable as a proxy of technological changes in the natural rubber industry, such as Muslim (1990) and Bogahawatte and Samaruppuli (1995). This time trend is denoted consecutively by the numbers 1 to 27 for the years 1966 to 1992. It is expected that the sign for this coefficient is negative, reflecting improvement in technology will increase natural rubber production and in turn will depress the natural rubber price.

4.4.6 Indonesian exchange rate (*EXR*)

Exchange rate policy may cause changes in export demand and hence the domestic price of natural rubber either directly or indirectly. As the Indonesian government has often devalued the local currency (*rupiah*) with respect to the US dollar, it is expected that the exporters will be interested to enhance natural rubber exports, whilst the consuming countries will buy more natural rubber from Indonesia. It is also expected that the gains from the exchange rate policy will trickle down to the natural rubber producers. The expected sign for the coefficient of the Indonesian exchange rate is positive in the price equations, assuming that the exchange rate policy will increase the export demand for Indonesian natural rubber as well as increase the price of Indonesian natural rubber. This exchange rate variable is expressed in Rp/US$, deflated by the ratio of the US CPI to the Indonesian CPI.

4.4.7 The world price of natural rubber (*WPR*)

As a large percentage of Indonesian natural rubber is exported, it is assumed that the world price will also affect export demand and the domestic price. The world natural rubber price is represented by the New York c.i.f. price of RSS1 in US cents/kg, deflated by the US CPI (base year 1985). In the price equations, the expected sign for the coefficient of the world price of natural rubber is positive, assuming that a rise in price in the world market due to increasing demand will be passed on to the Indonesian price as well.

4.4.8 The world price of synthetic rubber (*WPS*)

The world rubber market consists two types of rubber, that is, natural and synthetic (Grilli *et al.* 1980; Barlow *et al.* 1994). According to many analysts, synthetic rubber in not necessarily a substitute of natural rubber. Some analysts however, assume that synthetic rubber is a competitive product for natural rubber in the world rubber market. To capture the impact of synthetic rubber in the world rubber market, the world synthetic rubber price is included in this study. The aim is to examine if there is any effect of this price on export demand and on the Indonesian natural rubber price. The world synthetic rubber price is represented by the price of styrene-butadiene (SBR) type, expressed in US cents/kg and deflated by the US CPI (base year 1985). The expected sign for the coefficient of world synthetic rubber price in the price equations is negative. This follows the assumption that the increased demand for synthetic rubber will increase its price, owing to the inability of natural rubber supply to fill the growing demand of rubber in general. Hence, the effect of reduced natural rubber demand can be expected and in turn will depress the world natural rubber price as well as the Indonesian price.

4.4.9 Income per capita of OECD members (*GNP*)

Grilli *et al.* (1980) noted that the demand for natural rubber in the world market is largely dependent on the growth of the automobile industry. Historically, the automotive sector is closely related to the growth of real income and the production and use of motor vehicles. It is expected that this relationship remains strong in the future. Therefore, an income variable is considered to be likely a demand shifter in the Indonesian natural rubber export market, and hence in the price equation.

The income per capita of OECD members, as major consuming countries of natural rubber, is expressed in US dollar per head per year, deflated by the OECD CPI (base year 1985). The expected sign for the coefficient of this variable in the price equations is positive, assuming that an increased income per capita will expand the demand for automotive products, and in turn the demand for natural rubber. The rise in natural rubber demand is expected to influence a rise in the price of Indonesian natural rubber as well.

4.4.10 Indonesian income per capita (*Y*)

To capture shifts in the domestic consumption for natural rubber, domestic income per capita is included in this study. It is assumed that the higher income per capita, causes more demand for automotive products, and hence more demand for natural rubber. Although vehicles are considered as luxurious goods to the average population, the demand for two-wheel vehicles can be expected from the middle-class income earners (Mubyarto and Dewanta 1991; UNIDO 1993).

The income per capita is expressed in *rupiah* per head per year, deflated by the Indonesian CPI (base year 1985). In the price equations, the expected sign for the coefficient of Indonesian income per capita is positive, assuming that the increased income will expand the demand for vehicles, and the demand for natural rubber. The expected impact is a rise in the price of domestic price of natural rubber.

4.4.11 Quantity supplied variable (*QP*)

In the directly estimated price function, a quantity supplied variable is included as one measure of quantity. This variable measures the total production of natural rubber and is considered to affect domestic price. Hence, the quantity supplied is treated as an exogenous variable and is anticipated that the sign for this coefficient is negative. This is in line with the a priori beliefs about the relationship between price and quantity available.

4.5 Data Sources

Most data in this study were obtained from the Central Bureau of Statistics of Indonesia (CBSI) publications in the form of yearly time series data from 1966 to 1992. This included, data on natural rubber prices (domestic and the world prices), production, exports, and labour wages. Data on the Indonesian exchange rate, the Indonesian CPI, and the US CPI were collected from the International Monetary Fund (IMF) publications in various issues. Another source of data was from selected issues of Food and Agriculture Organisation (FAO) publications. A complete listing of data sources is provided in the Appendix A2.

4.6 Summary

The research method for analysing the sources of Indonesian natural rubber price instability has been presented in this chapter. Also included was the model specification and the variables which are considered to influence the supply and demand for the Indonesian natural rubber market. It is realised that a criticism of this study is in the context of linear and static supply and demand functions. Therefore, the policy implications of this study have to be interpreted cautiously. The results of this study, however, will be still useful as a tool in providing information of the causes of price instability in relation to the supply and demand variations. For further research, an alternative method should be developed to capture the non-linearity effect of the supply and demand functions. This suggestion will be presented in more detail in the final chapter.

Another problem which can be raised in this study is the nature of the data. Errors in measurement, for example in the quantity supplied, exports, and domestic use of natural rubber, should be taken into consideration. It was found that different data sources have different figures, meaning that different results can be expected from different sources of data.

5. Estimation Results and the Decomposition of Natural Rubber Price Instability

5.1 Introduction

In this chapter, the estimation results from three different ways of constructing the Indonesian natural rubber price equation are presented. In reporting the estimation results from the econometric model of the Indonesian natural rubber market, the sequence is followed that was proposed in Chapter 4. Initially, estimation of the structural model is presented, followed by estimates of a full reduced form price equation and then a directly estimated price equation. Selected variables are deleted in each model to attain alternative models. By examining these alternatives, it is expected that preferred models with the most appropriate combination of variables can be obtained. The decomposition results of the sources of instability of Indonesian natural rubber price are reported and discussed as the main part of this chapter. This decomposition analysis is segregated into supply, demand and interaction components. Comparison with previous studies are made. Finally, the three hypotheses postulated in Chapter 1 are tested.

5.2 Estimation Results

Estimation results of the econometric model in this section include the estimated coefficients of the explanatory variables, the standard errors of the estimated coefficients (in parentheses), the adjusted coefficient of determination ($\overline{R}^2$), and the Durbin-Watson (*d*-) statistic.

In selecting preferred variables, a combination of knowledge of economic theory and statistical principles is taken into consideration. This includes the sign and magnitude of the parameter estimates, as well as the significance of coefficients from a statistical point of view. However, it is not easy to choose a preferred model. Griffiths *et al.* (1993, p.342) noted that 'selecting the appropriate set of regressors and an appropriate model are difficult problems for which no satisfactory solution exists'. In addition to that, Tomek and Robinson (1990) indicated that since there is no clear definitive guidance to obtain the best set of variables, the inclusion of some subjective combination follows the judgement of the analyst. Griffiths *et al.* (1993) pointed out that it may be useful to describe some of the variables and model selection criteria that can be used and the possibility of the statistical consequences. A decision has been made in this study to take into account the economic theory and logic and compatibility with *a priori* expectation, together with an indication of statistical considerations.

5.2.1 Estimation of the structural model

- **Estimates using all variables**

Equations (4.11), (4.12), and (4.13) are estimated using the OLS estimator and the results are presented as follows:

(i) Supply

$$\underset{(47.695)}{QP = 378.65} + \underset{(3.4366)}{13.816PR} + \underset{(4.1194)}{16.794PO} - \underset{(3.2489)}{9.8911CL} - \underset{(33.053)}{14.596D} + \underset{(3.1129)}{36.397T} \tag{5.1}$$

$$\overline{R}^2=0.9620 \qquad D.W.=1.17$$

As can be seen from equation (5.1), the adjusted coefficient of determination ($\overline{R}^2$) is high, 0.9620, indicating that 96.20 per cent of the variation of quantity supplied of natural rubber is explained by the explanatory variables. Almost all the coefficients of explanatory variables are significant, except for the government policy variable (*D*). The signs of the coefficients on the price of palm oil (*PO*) and government policy (*D*), however, do not conform with *a priori* expectations. One possible explanation of this matter is the existence of multicollinearity among explanatory variables (Greene 1993). In this case, it is found that the trend variable (*T*) has a high correlation with the price of palm oil (*PO*) and labour wages (*CL*). This could affect the magnitude and sign of other estimated coefficients in the supply equation.

The Durbin-Watson value (*d*-statistic) shows the presence of autocorrelation. Thus the autocorrelation correction is applied to the supply function and the result is presented in equation (5.2):

$$QP = \underset{(58.736)}{451.48} + \underset{(3.0288)}{11.544}PR + \underset{(5.1253)}{10.104}PO - \underset{(4.2165)}{5.9365}CL - \underset{(37.087)}{13.336}D + \underset{(4.3062)}{31.698}T \qquad (5.2)$$

$$\bar{R}^2 = 0.8781$$

(ii) Export demand

$$XD = \underset{(223.83)}{333.68} + \underset{(0.0831)}{0.0805}EXR + \underset{(61.423)}{61.875}WPR - \underset{(14.801)}{27.468}WPS + \underset{(0.7561)}{5.4212}GNP \qquad (5.3)$$

$$\bar{R}^2 = 0.8344 \qquad D.W. = 1.0411$$

From the export demand estimation, it is found that the $\bar{R}^2$ is relatively high. Unfortunately, only the coefficient of income per capita of OECD members (*GNP*) is significantly different from zero and the sign is as expected. Although the world natural rubber price (*WPR*) and the world price of synthetic rubber (*WPS*) are significantly different from zero, their signs do not appear as *a priori* expectations. The unexpected signs of those two variables again could be due to multicollinearity. The correlation coefficient between the Indonesian exchange rate (*EXR*) and world synthetic rubber price (*WPS*) is relatively high, 0.73, and this would affect other coefficients estimates. The sign for the Indonesian exchange rate conforms with expectation, however, it does not affect significantly the quantity of export demanded.

The *d*-statistic shows the presence of autocorrelation. Alternatively, an autocorrelation correction is applied to the export demand equation and the result is reported in equation (5.4):

$$XD = \underset{(249.13)}{373.44} + \underset{(0.0991)}{0.0848}EXR + \underset{(50.285)}{78.350}WPR - \underset{(13.798)}{29.741}WPS + \underset{(1.0635)}{5.1119}GNP \qquad (5.4)$$

$$\bar{R}^2 = 0.8781$$

(iii) Domestic consumption

$$DU = -\,24.876 - 0.1209PR + 0.0234Y$$
$$\quad\;(15.339)\quad(1.633)\qquad(0.002)$$

$$\bar{R}^2 = 0.8488 \qquad D.W. = 0.1965 \tag{5.5}$$

The estimation result of domestic consumption shows that the $\bar{R}^2$ is relatively high and the signs of all parameters are as expected. The coefficient of Indonesian income per capita (Y), however, is the only significant coefficient affecting domestic consumption. The d-statistic reveals a low value, indicating that autocorrelation exists. Reestimating the model after correcting the autocorrelation, the result is presented in the following equation:

$$\mathrm{DU} = 21.486 - 0.3551\mathrm{PR} + 0.0187\mathrm{Y} \tag{5.6}$$
$$\quad\;(44.38)\quad(0.6088)\qquad(0.0468)$$

$$\bar{R}^2 = 0.9720$$

(iv) Derivation of price equation from the structural model

A price equation from the structural model is derived using all the estimated coefficients from equations (5.2), (5.4), (5.6) and a residual variable, regardless of their signs and significance. Hence, the steps from equation (4.14) to equation (4.18) are followed to attain the price equation of domestic natural rubber. From the statistical point of view, this equation may include imprecise results, however this price equation is reported for comparison purposes. The result is presented in equation (5.7).

$$\begin{aligned} PR = \; & -8.1211 + 0.0068EXR + 5.20WPR - 2.3084\mathrm{WPS} + 0.4556GNP \\ & + 0.0016Y - 0.8491PO + 0.4989CL + 1.1209D \\ & -2.6639T + 0.084RSD \end{aligned} \tag{5.7}$$

It should be noted here that a method for estimating the standard errors of this derived price equation could not be found. Thus the decomposition analysis, which relies on coefficient variances, cannot be undertaken on this equation.

- **Estimates using selected variables**

Selected variables are deleted from the structural model to obtain significant variables and/or expected signs. In this sense, the economic theory, logic, and compatibility with *a priori* expectations still hold. As stated by Griffiths *et al.* (1993), if the signs of parameters do not agree with expectations, the model should be reestimated. Wallace (1977) pointed out that one way of dealing with this problem is to drop the intercorrelated variables, although this decision may result in omitting relevant variables from the model. The estimation results of using selected variables in the structural model are reported in the following part:

(i) Supply

$$\underset{(116.98)}{QP = 794.99} + \underset{(10.642)}{7.1966PR} - \underset{(3.3131)}{3.9753PO} + \underset{(59.811)}{243.78D} \tag{5.8}$$

$$\bar{R}^2 = 0.6285 \quad D.W. = 0.3361$$

Equation (5.8) represents the preferable choice among several options. As can be seen, all signs of the parameters agree with the *a priori* expectations, although government policy (D) is the only significant variable. Moreover, only 62.85 per cent of the variation in quantity supplied is explained by the variation of the explanatory variables. The d-statistic is very small, indicating the presence of autocorrelation. An attempt was made by reestimating the model using an autocorrelation correction, however the result was unsatisfactory where the coefficient of the palm oil price becomes positive. Hence, the decision is made to use equation (5.8) as the preferred model for the supply function.

(ii) Export demand

$$XD = 929.70 + 0.2532EXR - 4.2758WPR - 26.447WPS \quad (5.9)$$
$$\quad\quad (379.22) \quad\quad (0.1381) \quad\quad (10.951) \quad\quad (23.097)$$

$$\overline{R}^2 = 0.4591 \quad D.W. = 0.5041$$

Equation (5.9) shows that only the Indonesian exchange rate (*EXR*) is significantly different from zero at 10 per cent level of significance. The adjusted coefficient of determination is relatively low, implying that less than 50 per cent of the variation in the quantity demanded for export can be explained by the variation of the explanatory variables. In addition, the sign for the parameter of world price of synthetic rubber (*WPS*) does not conform with expectations. However, since Barlow *et al.* (1994) indicated that synthetic rubber does not necessarily compete with natural rubber, then the negative sign for the parameter of world synthetic rubber price is acceptable.

The *d*-statistic is a relatively low value, suggesting the presence of autocorrelation. Reestimating the model by using an autocorrelation correction results in an unsatisfactory outcome, because none of the independent variables are significant. Moreover, the sign for the world natural rubber price is positive, which is not the logical relationship between quantity export demanded and its price. Since equation (5.9) reveals the best possible choice among other options, this equation will be used to estimate a restricted reduced form price equation from the structural model.

(iii) Domestic consumption

The explanatory variables used in the domestic use of natural rubber are not restricted as their signs agree with the expectations. Hence, the equation (5.6) is used for estimating the restricted reduced form of price equation.

(iv) Derivation of price equation from the structural model

As previously proposed, a restricted reduced form price equation is obtained by deriving a reduced form like equation (4.18). Hence, a similar procedure to obtain equation (5.7) is conducted to ascertain the price equation using the modified structural model. In this restricted reduced form, only those significant variables and/or having expected signs are allowed to enter the equation. Thus, the equations (5.8), (5.9), (5.6) and a residual variable are reconstructed to get the price equation and the result is presented in equation (5.10).

$$PR = 20.6836 + 0.0335EXR - 0.5662WPR - 3.5021\mathrm{WPS} + 0.0025Y$$

$$+0.5264PO - 32.8215D + 0.1324RSD \qquad (5.10)$$

The estimation result from equation (5.10) seems to be unsatisfactory in explaining price equation since two explanatory variables, the world natural rubber price (*WPR*) and the government support (*D*), have opposite signs than expected. However, this approach is still reported for comparison purposes, even though, like equation (5.7), it cannot be used in the decomposition analysis.

5.2.2 Estimation of reduced form price equation

- **Estimate using all variables**

In this section, equation (4.18) is estimated directly using the OLS estimation procedure and the result is written as follows:

$$PR = \underset{(3.9126)}{-1.4964} + \underset{(0.0019)}{0.0084EXR} + \underset{(1.2068)}{6.3767WPR} - \underset{(0.3044)}{0.3791WPS} + \underset{(0.0432)}{0.0413GNP}$$

$$- \underset{(0.0009)}{0.0003Y} - \underset{(0.2048)}{0.4334PO} + \underset{(0.9422)}{0.1622CL} + \underset{(1.1803)}{0.4428D}$$

$$- \underset{(0.3039)}{0.4202T} + \underset{(0.0045)}{0.0032\mathrm{RSD}} \qquad (5.11)$$

$$\overline{R}^2 = 0.7722 \qquad D.W. = 1.8472$$

The value of $\overline{R}^2$ is 0.7722, implying that 77.22 per cent of the variation in Indonesian natural rubber price is explained by the explanatory variables. The *d*-statistic lies between the lower and upper bounds ($d_L = 0.601$ and $d_U = 2.470$ at 5 per cent significance level), meaning that the presence of autocorrelation is inconclusive.

The result from equation (5.11) shows that almost all parameters have signs consistent with *a priori* expectations, except for the coefficients of Indonesian income per capita (*Y*) and price of palm oil (*PO*). Also, the Indonesian income per capita is not significant in affecting the domestic natural rubber price, although this variable is significant in influencing the quantity of domestic consumption. Observing the correlation matrix of coefficients, the figures show that the price of palm oil is highly correlated with the trend variable (*T*), cost of labour (*CL*), and income per capita of OECD members (*GNP*). The existence of these highly correlated variables may have affected the least squares estimator. The residual variable (*RSD*) is not significant if included in the directly estimated reduced form equation.

- **Estimate using selected variables**

Similar to the previous equations, selected variables are omitted in this reduced form price equation because of incorrect signs or insignificance. The preferred version of the equation is shown in equation (5.12):

$$PR = \underset{(4.7841)}{4.8721} + \underset{(0.0018)}{0.0028}EXR + \underset{(1.4109)}{6.1022}WPR - \underset{(0.3456)}{0.9393}WPS + \underset{(0.0363)}{0.0393}GNP$$

$$+ \underset{(1.3946)}{0.9385}D - \underset{(0.1783)}{0.1313}T \qquad (5.12)$$

$\overline{R}^2$=0.5365 $\quad$ $D.W.$= 1.1170

The result indicates that the coefficients of world natural rubber price (*WPR*) and world synthetic rubber price (*WPS*) are significantly different from zero and other variables are insignificant in affecting the domestic natural rubber price. Also, all regressors have expected signs. The value of $\overline{R}^2$ is relatively low, indicating that only 53.65 per cent of the variation in domestic natural rubber price can be explained by the explanatory variables. The *d*-statistic lies between the bounds (d_L =0.925 and d_U =1.974 at 5 per cent significance level), implying the presence of autocorrelation is inconclusive.

Reestimating the model with an autocorrelation correction, the outcome yields no improvement, since the sign for government policy (*D*) and trend variable (*T*) change. Hence, the decision is made to use equation (5.12) for the decomposition analysis.

5.2.3 A directly estimated price equation

- **Estimate using all variables**

Equation (4.19) is estimated using the OLS estimation procedure and the result is shown in equation (5.13). Recall that this equation is not based on a structural model and contains a quantity variable. As can be seen from this equation, almost all parameters have expected signs, except for the price of palm oil (*PO*). The coefficients of Indonesian exchange rate (*EXR*) and world natural rubber price (*WPR*) are significantly different from zero, meaning that those variables are significantly influencing the Indonesian natural rubber price. The quantity variable (*QP*), however, is insignificant.

$$\begin{aligned} PR = \; & \underset{(4.5175)}{-0.1014} - \underset{(0.0077)}{0.0012\,QP} + \underset{(0.0022)}{0.0083\,EXR} + \underset{(1.3441)}{6.2527\,WPR} - \underset{(0.2918)}{0.3911\,WPS} \\ & + \underset{(0.0397)}{0.0428\,GNP} - \underset{(0.2082)}{0.4341\,PO} + \underset{(0.1604)}{0.1487\,CL} + \underset{(0.9827)}{0.5399\,D} - \underset{(0.2918)}{0.4938\,T} \end{aligned} \tag{5.13}$$

$$\bar{R}^2 = 0.7860 \qquad D.W. = 1.8195$$

The value of $\bar{R}^2$ is relatively high, implying that almost 80 per cent of the variation of the dependent variable can be explained by the explanatory variables. The *d*-statistic, however, falls between the bounds (d_L=0.691 and d_U=2.342) which means that the presence of autocorrelation is inconclusive.

Comparing the results between the equation (5.11) and (5.13), both equations show that Indonesian exchange rate (*EXR*) and world natural rubber price (*WPR*) are strongly affecting the domestic natural rubber price (*PR*). Moreover, the magnitude of coefficient *WPR* is relatively large, indicating that there is a strong relationship between *PR* and *WPR*.

- **Estimate using selected variables**

Omitting selected variables from the directly estimated price equation, the result is presented as follows:

$$PR = \underset{(6.4193)}{7.1358} - \underset{(0.0107)}{0.0058QP} + \underset{(0.2428)}{0.0036EXR} + \underset{(1.5818)}{6.4607WPR} - \underset{(0.3665)}{0.9948WPS}$$

$$+ \underset{(0.0422)}{0.0505GNP} + \underset{(1.4247)}{0.8755D} - \underset{(0.2378)}{0.0481T} \qquad (5.14)$$

$$\overline{R}^2 = 0.5195 \qquad D.W. = 1.1453$$

As can be seen from equation (5.14), again the quantity supplied (*QP*) is insignificant in affecting the domestic natural rubber price. The omission of the variable palm oil price (*PO*) results in the $\overline{R}^2$ falling to 0.5195. An autocorrelation correction for equation (5.14) does not yield a satisfactory outcome, as the signs for government policy (*D*) and trend variable (*T*) change. Hence, the equation (5.14) will be used for the decomposition procedure.

Similar conclusions can be drawn by comparing equations (5.12) and (5.14) where the coefficients of world natural price (*WPR*) and world synthetic rubber price (*WPS*) significantly affect the Indonesian natural rubber price.

5.2.4 Responsiveness of domestic natural rubber price to selected variables

The response of the Indonesian natural rubber market to market conditions is measured in term of its related price elasticity of supply and demand, as well as its flexibility to selected variables in different price equations. Using the results from the preferred (although still poorly estimated) equations in the structural model, the elasticities of supply and demand of Indonesian natural rubber can be computed (the formula are presented in Appendix A5). It is found that the price elasticity of supply of Indonesian natural rubber is 0.07, indicative of inelastic response of the quantity supplied to the domestic price changes. Similarly, the price elasticity of demand is 0.0035, approaching almost perfect nonresponse of quantity demanded to changes in domestic price. The results in this study agree with previous studies (Teken 1971; Muslim 1990; Bogahawatte and Samaruppuli 1995) on elasticity estimates of natural rubber from the main producing countries.

The price elasticity of supply is slightly higher than that of demand. This seems reasonable since production of natural rubber can be adjusted by the tapping system, following the assumption stated by Bogahawatte and Samaruppuli (1995), that the current rubber trees are mostly in mature stages. On the other hand, the unresponsiveness of quantity demanded to the domestic price could be mainly due to the large percentage of Indonesian rubber exported. As shown is equations (5.5) and (5.6), price is not significant. Hence, the quantity demanded is not necessarily affected by domestic natural rubber price.

Natural rubber price flexibility to selected variables in this study measures the percentage change in domestic natural rubber price associated with one per cent change in relevant variables, computed at the means (Tomek and Robinson 1990; White 1993). The formulae is presented in Appendix A6. In Table 5.1 is provided a summary of the flexibility of Indonesian natural rubber price to selected variables.

Table 5.1: Price flexibility of Indonesian natural rubber to selected variables, 1966-1992

Price flexibility with respect to	Equation (5.12)	Equation (5.14)
Exchange rate	0.2870	-
World natural rubber price	0.9147	0.9685
World synthetic rubber price	-1.2111	-1.1874
Income per cap. of OECD members	0.5315	0.6809

Note: Price flexibility is computed based on the preferred model of price equation only

Source: Computed from equations (5.12) and (5.14)

Based on Table 5.1, it can be said that the Indonesian natural rubber price is more responsive to the world natural rubber price and the world synthetic rubber price than other regressors. In addition, the influence of the Indonesian exchange rate and income per capita of OECD members could have been taken into account in the relationship between domestic natural rubber price, world natural rubber price and world synthetic rubber price. Owing to the close relationship between domestic natural rubber price and world natural rubber price, Indonesian natural rubber price variation could be expected to be more affected by demand forces than supply forces in the world rubber market. Later this will be checked in the decomposition analysis.

5.2.5 Evaluation of the estimation results

Evaluating the results from the price equations, it is found that some variables are consistently insignificant in affecting the domestic natural rubber price. These include government policy (*D*), trend variable (*T*) and to a lesser extent income per capita of OECD members (*GNP*) This result suggests that those variables do not significantly contribute to the fluctuation of Indonesian natural rubber price. According to Tomek and Robinson (1990), proxy variables, such as zero-one variables and trends, could be misused and an alternative specification of proxy variables can have a profound effect on the coefficients of other variables in the equation. They also noted that proxy variables should not be inserted into equations in a casual manner.

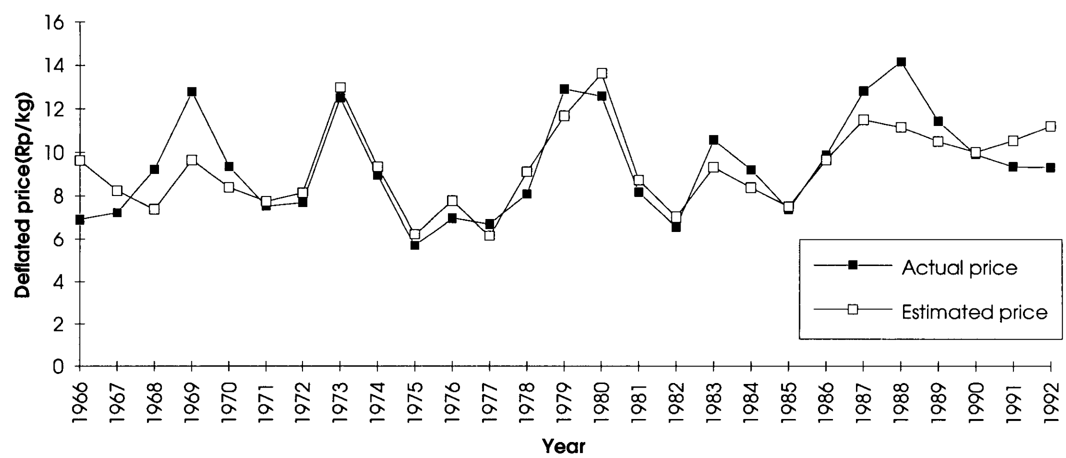
Uncertainty about the number of regressors has been proposed by a number of authors, notably Ramanathan (1989), Tomek and Robinson (1990) and Griffiths *et al.* (1993). The presence of multicollinearity can be a common problem in model specification. As Tomek and Robinson (1990) pointed out the inclusion of irrelevant or the omission of relevant explanatory variables can lead to the term 'specification error'.

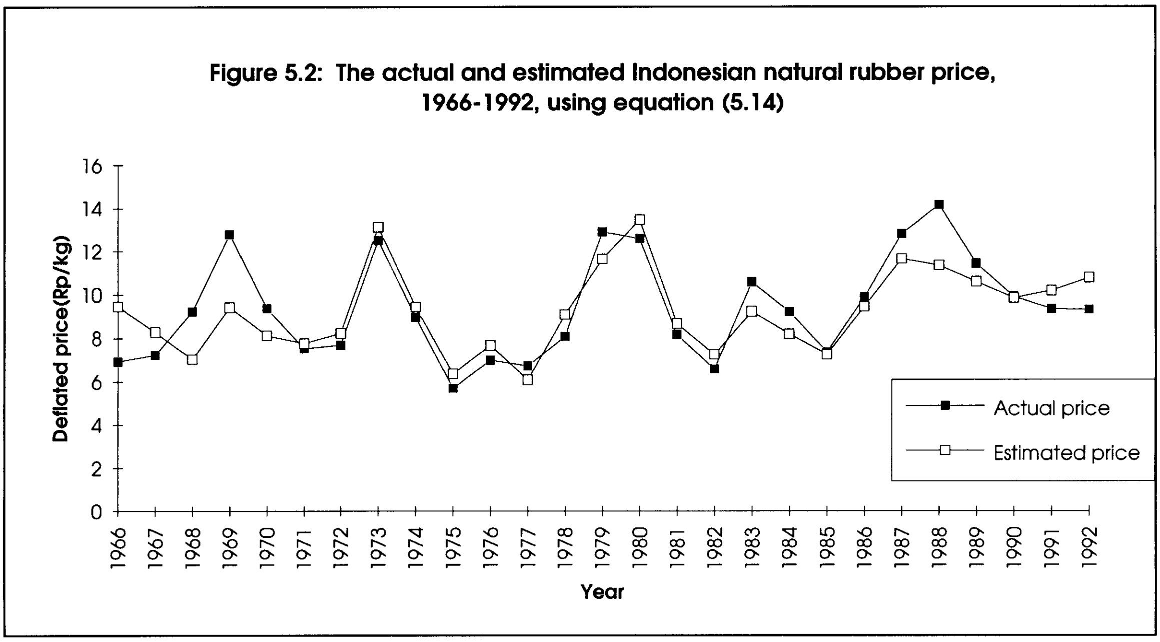
Another problem found in this study is that the bounds test for autocorrelation is inconclusive. Although the presence of autocorrelation is commonly found in time-series data analysis (Ramanathan 1989), still the inconclusive nature of the Durbin-Watson test could affect the least squares estimator. According to Judge *et al.* (1980), an inconclusive test region is not satisfactory and the authors suggest deriving an alternative test such as including the fitting of a beta distribution. To sum up, specifying a model with certain regressors is always a trade-off between economic theory, logic and compatibility on one hand, while considering the significance of estimates on the other hand.

This study does not take into account choosing preferred functional forms, although some literature, such as Griffiths *et al.* (1993) and Greene (1993), provides a choice between two functional forms. The Box-Cox test, for instance, is one way of dealing with the choice between the linear and the log-linear functions. Another approach is by comparing their maximum likelihood. If a log-linear functional form is chosen in the structural model, different decomposition procedures should be developed. Piggott's method (1981) on decomposition procedure is concerned with linear and static condition assumptions. An attempt to estimate a log-linear price equation was made to compare the significance and expected signs of the parameters, however the results do not show a satisfactory outcome (see Appendices A7 and A8).

To validate the price equation models, the root mean square percentage error (RMSPE) is applied to equations (5.12) and (5.14), models which have significant variables and/or expected signs According to Tomek and Robinson (1990), the RMSPE represents the percentage deviation of the predicted values of price from its actual path. The RMSPE formulae is provided in the Appendix A9. The actual and estimated price graphs are presented in Figure 5.1 and Figure 5.2 respectively for equation (5.12) and equation (5.14). Computation of RMSPE for equation (5.12) and equation (5.14) are 13.61 per cent and 13.82 per cent of error respectively, implying a relatively low error for prediction. These results suggest that both equations are acceptable.

Figure 5.1: The actual and estimated Indonesian natural rubber price, 1966-1992, using equation (5.12)





5.3 Decomposition Analysis of Natural Rubber Price

5.3.1 Components of the variance of estimated natural rubber price

A summary of the decomposition analysis of natural rubber price is shown in Table 5.2. Recall that this relates only to the estimated price equations. The interpretation of this result can be explained in this way. The demand effect from omitting selected variables in the reduced form price equation is 132.08. This indicates that if the supply intercept had been stable and if the slope parameters and the time path of demand intercept had been unchanged, then the variance of natural rubber price would have increased by 32.08 per cent (132.08 - 100). Similarly, the supply effect of 0.47 per cent suggests that the variance of natural rubber price from the supply side would not have been affected since its value is less than 100 per cent, assuming other factors held constant. Other results in Table 5.2 can be interpreted analogously.

The results in Table 5.2 show that, regardless of the different approaches applied to the price equation, the demand component is obviously a dominant source of Indonesian natural rubber price instability. The supply component, however, only contributes a small influence to the domestic natural rubber price fluctuation, as does the interaction of demand-supply component.

A negative sign of the interaction effect of supply-demand component indicates that there is a positive relationship between supply and demand intercepts which could have a dampening effect on the price variability. On the other hand, a positive sign of interaction suggests there is some tendency of demand and supply shifts to have offsetting influence upon the variance of estimated domestic natural rubber price. A positive interaction effect is found using the reduced form price equation and this implies that the demand forces could offset the supply forces.

Important contributors of the demand effect can be traced further by looking at the percentage of the variance components of the net intercept on the demand side. The contribution of different factors to the net intercept variance of the demand side for full reduced form and directly estimated price equations is presented in Table 5.3 and Table 5.4 respectively.

Table 5.2: Decomposition results of the variance of Indonesian natural rubber price

Analysis from	Component (%)		
	Supply effect	Demand effect	Interaction
1. Full reduced form price equation			
• All variables[a]	0.47	103.26	6.54
• Selected variables[b]	3.06	132.08	15.04
2. A directly estimated price equation			
• All variables[c]	0.50	123.06	- 7.65
• Selected variables[d]	2.75	186.91	-127.90

Source: [a]Computed from equation (5.11)
[b]Computed from equation (5.12)
[c]Computed from equation (5.13)
[d]Computed from equation (5.14)

Viewing the results from Table 5.3, it is obvious that the variance of world natural rubber price (*WPR*) dominates other factors in contributing to the variance of the net intercept from the demand side. It is not surprising, since the estimated coefficient of the world natural rubber price significantly affects the domestic price (equations 5.11 and 5.12). The contribution of world synthetic rubber price (*WPS*), however, does not appear to have a large effect although its estimated coefficient significantly influences the domestic natural rubber price. Of the covariability components, the Indonesian exchange rate (*EXR*) and the income of OECD members (*GNP*) have larger contributions than other covariability relationships, meaning that those two variables have a strong relationship despite their insignificant estimated coefficients in the price equations.

Table 5.3: Percentage components of the variance of the net intercept from demand side using full reduced form price equation

Components	Percentage of net intercept variance	
	All variables[1]	Selected variables[2]
var (EXR)	4.39E-01	2.82E-11
var (WPR)	99.60	83.20
var (WPS)	0.22	0.12
var (GNP)	5.45E-06	2.27
var (Y)	1.24E-13	-
var (RSD)	3.44E-10	-
2 cov (EXR,WPR)	1.80E-04	3.45
2 cov (EXR,WPS)	4.50E-06	2.11
2 cov (EXR,GNP)	4.90E-08	7.42
2 cov (EXR,Y)	2.20E-12	-
2 cov (EXR,RSD)	6.69E-11	-
2 cov (WPR,WPS)	0.35	1.40
2 cov (WPR,GNP)	2.56E-02	8.0E-03
2 cov (WPR,Y)	1.35E-06	-
2 cov (WPR,RSD)	4.19E-05	-
2 cov (WPS,GNP)	4.10E-04	4.65E-04
2 cov (WPS,Y)	9.94E-09	-
2 cov (WPS,RSD)	3.63E-07	-
2 cov (GNP,Y)	3.63E-10	-
2 cov (GNP,RSD)	1.82E-08	-
2 cov (Y,RSD)	1.58E-12	-
Total	100.00	100.00

Note: var = variance
cov = covariance
All symbols refer to the previous section

Source: [1]Equation (5.11)
[2]Equation (5.12)

The percentage components attributable to the variance of the net intercept of the supply side is discussed briefly, although its contribution is relatively small to the variance of domestic natural rubber price. In the full reduced form price equation using all variables (equation 5.11), the variance of government policy (*D*) has the highest percentage among other independent variables in the supply side, accounting for about 90 per cent to the net intercept variance of supply schedule. Of the covariability supply-demand interaction component, it stems largely from the relationship between government policy (*D*) and the world natural rubber price (*WPR*), amounting to 52.22 per cent. A similar result is obtained using selected variables (equation 5.12). These findings are consistent with previous results, where there is a strong relationship between the domestic natural rubber price and the world price.

Table 5.4: Percentage components of the variance of the net intercept from demand side using a directly estimated price equation

Components	Percentage of net intercept variance	
	All variables[1]	Selected variables[2]
var (EXR)	4.87E-10	7.27E-11
var (WPR)	99.90	97.52
var (WPS)	0.02	0.12
var (GNP)	4.15E-06	4.29E-06
2 cov (EXR,WPR)	2.0E-04	8.69E-05
2 cov (EXR,WPS)	3.03E-06	1.34E-05
2 cov (EXR,GNP)	3.62E-08	6.46E-10
2 cov (WPR,WPS)	0.02	2.17
2 cov (WPR,GNP)	0.02	1.30E-03
2 cov (WPS,GNP)	3.0E-04	7.40E-04
Total	100.00	100.00

Source: [1]Equation (5.13)
[2]Equation (5.14)

The result in Table 5.4 indicates that the variance of the Indonesian exchange rate does not appear to have a strong influence on the net intercept variance of the demand side, although its estimated coefficient significantly contributes to the fluctuation of domestic natural rubber price (equation 5.13). Similar to the results shown in Table 5.3, the variance of world natural rubber price surpasses other factors on the net intercept variance of the demand side. Again, this follows the significant effect of the estimated coefficient of the world natural rubber price on the domestic price. The variance of world synthetic rubber price does not contribute significantly to the net intercept, although its estimated coefficient is significant in the price equations. Hence, it should be questioned about the relative importance of Indonesian natural rubber to the world synthetic rubber production. Of the covariability factors, the world natural rubber price and the world synthetic rubber price have the higher percentage of contribution to the net intercept variance.

On the supply side, the variance of the government policy has the highest contribution to the net intercept variance, accounting for 84.85 per cent (equation 5.13). Using selected variables (equation 5.14), a similar conclusion can be drawn for the variance of government support. This result indicates that the variance of government policy variable to a large extent has affected the net intercept variance of the supply side.

Of the covariability components of supply-demand interaction, the covariance of the trend variable and the world natural rubber price contribute about 47 per cent in the full reduced form price equation using all variables. Moreover, the covariance of government policy and world natural rubber price is the second largest, 24 per cent. The covariance between government policy and world natural rubber price in a directly estimated price equation using selected variables surpasses all other contributors, accounting for about 90 per cent.

5.3.2 Discussion of the decomposition results

Although different approaches are used to estimate a price equation for Indonesian natural rubber, the decomposition analysis results in similar outcomes. The variance of world natural rubber price is obviously a dominant source on the variance of the net intercept of the demand side. This can be explained by the high significance of this independent variable in affecting the domestic price. On the other hand, the government policy variable contributes a high proportion to the variance of the net intercept of the supply side. On the basis of the structural model, this government policy variable is significant in affecting the quantity of production (equation 5.8), however it does not significantly impact the domestic natural rubber price. This finding suggests the need for more investigation of the government's role in the domestic natural price. Another important finding in this study is the contribution of the covariance between the government policy variable and the world natural rubber price to the supply-demand component. Hence, there would be a strong relationship between government policy and the world natural rubber price. In other words, despite the dominant demand effect to the price instability, the supply component should not be neglected.

The decomposition analysis undertaken in this study suggests that the demand component is the dominant factor in affecting Indonesian natural rubber price instability. This follows the statement by Campbell and Fisher (1982), that for an exported commodity, price fluctuation stems largely from the demand side. In addition to that, the nature of perfect competition in the natural rubber market has forced the producers to be 'price takers' (Tomek and Robinson 1990). Although Indonesia was the second largest producer during the past three decades, the price of natural rubber could not be influenced by Indonesia's position in the world natural rubber market.

This study comes to the same conclusion as previous research. Findings from Watkins (1986) and Myers and Runge (1985) suggest that since the commodity concerned is primarily for export, then the impact from the demand side seems to offset the supply impact on the nature of price instability. However, it is different from Lestari's finding on the source of milk price instability in Indonesia where the supply component is more attributable to price fluctuation. This could be due to the large proportion of milk imported.

5.4 Assessing the Validity of the Hypotheses

Based on the results obtained in this study, the validity of the null hypotheses is assessed as follows:

- The first null hypothesis that supply variability and demand variability are of equal importance in affecting domestic natural rubber price instability is rejected, since the decomposition analysis shows that the demand effect surpasses other components in contributing to the variance domestic natural rubber price.

- The second null hypothesis that government policy is no more important than other supply shifters in causing the shift of natural rubber supply, can also be rejected. The *t*-statistic, the ratio between estimated coefficient and standard error

(Griffiths *et al.* 1993), in the structural model (equation 5.8) reveals government policy to be a highly significant factor in affecting the quantity supplied. Also, the high proportion of variance of the government policy variable to the supply component strengthens the argument to reject this second hypothesis.

- The third null hypothesis that exchange rate policy is no more important than other demand shifters in causing the shift for natural rubber export demand, is rejected as well. The result from estimating the export demand function (equation 5.9) shows that the exchange rate variable is statistically significant in affecting the quantity of natural rubber demanded at the 10 per cent level of significance.

5.5 Summary

This chapter was concerned with the estimation results of the econometric model that was proposed in Chapter 4, as well as the decomposition analysis of different models of price equation. Some problems can be raised in estimating the econometric model. An initial problem comes from the interpretation of the estimation results because some parameters did not have the expected signs. There is often a trade-off between choosing significant variables and expected signs. One possible explanation is the nature of linear and static conditions of the econometric model used in this study. The number of observations could be another possibility for the insignificant and unexpected signs of the parameters.

Determining a source of instability in a particular market involves a choice of technique which obviously impacts the way in which instability is described. Although there are some limitations in the procedure, a decomposition analysis provides information of the sources of instability of the commodity concerned. In this study, the decomposition analysis suggests the demand component as the major cause to the instability of Indonesian natural rubber price. This finding will have important implications for policy, which will be described in the next chapter.

Another finding was that deriving a reduced form price equation from an estimated structural model cannot contribute to decomposition analysis until a method is worked out to calculate the standard errors from the structural equations.

6. Summary and Policy Implications

6.1 Introduction

A summary of this study is presented in this chapter, including the objective, the analytical framework and the results. Some limitations of the study are discussed, followed by a description of the policy implications of the study that can be raised based on the finding of this study. Finally, suggestions for further research are highlighted.

6.2 Summary of the Study

During the last three decades (1960 - 1990), Indonesia was the second largest producer of natural rubber in the international market. The quantity exported accounted for about 90 per cent of total production, and the remainder was consumed domestically. Although domestic consumption accounted for a small fraction of total production, it has shown a promising expansion since the Indonesian government promoted of rubber-product industries in the 1980s. Hence, the role of natural rubber in the economic development of Indonesia is not only as a source of foreign exchange earnings, but also as the source of income of the population who are concerned with natural rubber or rubber-based goods.

Government intervention in the natural rubber industry can be seen in the NESS scheme and the exchange rate policy, however the Indonesian natural rubber market still suffers from substantial instability. This is due to the condition of perfect competition in the natural rubber market. The impact of natural rubber market instability is reflected in the unstable world price, as well as the domestic price.

The objective of this study is to identify the sources of Indonesian natural rubber price instability over the period 1966 to 1992. The results of this study are then used to derive policy implications for the Indonesian natural rubber industry to overcome the impact of trade instability. To determine the sources of domestic natural rubber price fluctuation, the decomposition procedure proposed by Piggott

(1981) is adopted. This analysis includes explanation in terms of supply variability, demand variability and supply-demand interaction variability.

Estimates associated with the various supply and demand shifters are required prior to the decomposition analysis and these can be obtained from an econometric model specification. An econometric model of price determination has been developed in this study and is constructed from a structural model of the market. A directly estimated price equation, which is not based on the structural model, is also used as a comparison in explaining the sources of Indonesian natural rubber price instability.

Estimation of the structural model suggests that both supply and demand of Indonesian natural rubber are unresponsive to changes in domestic price, shown by inelastic figures of supply and demand schedules. Quantity of export demanded is also unresponsive to the world natural rubber price changes. However an important finding in estimating the price equations is the significant impacts of world natural rubber price and world synthetic rubber price on domestic price. Through the estimation of price flexibility of Indonesian natural rubber with respect to the world price, the result is consistent, shown by a figure of more than 0.90. Thus different implications for price instability are drawn depending on the approach followed (equations (5.10) vs (5.12) vs (5.14)).

The decomposition analysis results in the demand component being dominant in affecting the Indonesian natural rubber price instability. This implies that fluctuation in the domestic natural rubber price is largely due to fluctuations of the shift variables of the demand function. The contributions of the net intercept of supply shifters and interactions, however, are relatively small. The exception is in the equation which uses selected variables in the directly estimated price equation. It is found that the interaction effects between supply and demand shifters are quite large, reflecting a positive relationship between covariance supply and demand shifters in affecting domestic natural rubber price fluctuation. This domestic natural rubber price is likely to be more responsive to the variance of the world price. Other demand variables included in the econometric model, such as the Indonesian exchange rate and income per capita of OECD members, do not significantly contribute to the net intercept variance of demand factors.

On the supply side, the variance of government policy has the highest contribution to the net intercept variance of supply shifters. The covariability component of supply-demand interaction between the government policy and world natural rubber price is found to be the main interaction factor. To sum up, the two main variables which are closely related to the domestic natural rubber price are the government policy and the world natural rubber price. The world synthetic rubber price, however, does not seem to contribute the demand shifters since its contribution in the net intercept variance is negligible. This contradicts the significance of this variable in the price equation. A different approach should be developed to determine relationship between the Indonesian natural rubber and synthetic rubber.

6.3 Limitations of the Study

This study is limited by certain deficiencies regarding the model used to approximate the sources of Indonesian natural rubber price instability. Owing to the linear and static assumptions used in the econometric model of Indonesian natural rubber, the findings of this study seem to neglect the adjustment process of Indonesian rubber to changes in the market, especially to the world natural rubber price. In addition, the inclusion of some variables in the structural model may be inappropriate under linear and static conditions. These include the domestic price of palm oil, the government policy and the trend variable.

A proxy variable such as a zero-one variable may be unsuitable in measuring government intervention in term of improving quality and quantity of natural rubber production. Also the inclusion of the trend variable as a proxy for technological changes could be overcome by the relationship between domestic natural rubber price and the world price, resulting in an insignificant impact of this variable on the changes of domestic natural rubber price. Generally, the trend and income variables move upwards together following the movement of price, and this condition might affect the sign as well as estimates of those variables.

Measurement of the residual variable as a proxy for the stockpile can be another limitation of this study. In this study, the previous years stockpile is not taken into account in affecting the price of natural rubber. Again, this measurement may lead to an imprecise result.

As previously mentioned in Chapter 4, different sources of data have different figures and this condition is an indication of the uncertain quality of data used in this study.

Despite these limitations of this study, the decomposition analysis of Indonesian natural rubber fluctuation has been analysed and can be used as information for the government and related parties, such as exporters.

6.4 Policy Implications

The dominant impact of the demand side over the supply side as a source of Indonesian natural rubber price instability suggests that policy attention should be tailored to market needs. It seems inappropriate for the Indonesian government to apply a price stabilisation program within the country to reduce the impact of market instability because most production is exported. Hence, attention could be focused on how to minimise the impact of consuming countries decisions to buy Indonesian natural rubber as fluctuation in the world natural rubber price will be transmitted to the domestic price.

Two basic approaches can be developed to mitigate the fluctuation of the natural rubber price. First, at the international level, buffer stock policies may be still useful to follow, although perceptions of the benefits of stabilisation through this international agreement are now largely negative (Barlow *et al.* 1994). Further in-depth research is required to formulate changes to the existing buffer stock policies under INRA. Finding other marketing strategies by exporters could be another way of reducing price instability. Many surrounding countries in Asia have shown increasing income levels, hence assuming the growing need for automotive products, so marketing attention could be more on these countries. In addition to that, export to neighbouring countries can reduce transport costs and it would be easier to manage the flow of information of consumer needs. Also, producers and/or exporters could research the possibility of a futures market for natural rubber. As Morgan and Sapsford (1994) indicated, a futures market provides an opportunity to the producers and consumers to shift the risk of adverse price movement, as well as provide more accurate price information to both parties.

Second, at the domestic level, several options can be undertaken to minimise the impact of price fluctuation. One such way is the expansion of the Indonesian tyre industry. UNIDO (1993) pointed out that the widely expected persistence of economic growth rates in recent years would ensure a steady expansion of domestic demand. It is also recognised that investment interest in the tyre industry has remained strong, with several existing manufacturers announcing expansion. In 1991, Indonesia produced 8.5 million units of car tyres and 6.0 million units of motorcycles tyres, and about 20 per cent of these products were exported. Hence, it is worth encouraging the tyre manufacturers to expand tyre exports.

The outlook for the sport-shoe industry is also promising. Domestic demand for such shoes is likely to continue in response to the growing population, income levels and changing fashions. UNIDO (1993) noted that Indonesia has the capacity to purchase more than 43 million pairs per annum. Export demand for this product is likely to widen as well. Hence, the organisation structure of rubber-based goods industry can be a basic element of reducing fluctuation on the domestic side.

The dominant influence of demand factors on domestic natural rubber price fluctuation does not necessarily stand alone. It includes the reflection of other major factors, such as supply and supply-demand interaction forces. Although the government policy variable in this study was insignificant in affecting the domestic natural rubber price, government policies should not be restricted. Facilitating cost-reducing and quality-improving methods for producers, especially the smallholders, can be ways of reducing natural rubber price fluctuation.

It should finally be added that government intervention will certainly remain a key element on both supply and demand sides, although its future course is hard to predict.

6.5 Suggestions for Further Research

There are some options to improve this study. The decomposition analysis can be conducted by omitting unnecessary variables. In this study, the domestic price of palm oil is insignificant in capturing the competitiveness of natural rubber and palm oil. Therefore, the palm oil variable may be replaced by other variable. According to Tan (1984), for the land-abundant area and dominance of smallholder rubber producers, fluctuation in rubber price tends to lead to a shift from tapping rubber to the plantation of cash-crops which provide promising revenues. Hence, research can be done to look at the impact of other cash crops such as upland rice.

The main limitation encountered in undertaking this study is the assumption of linear and static supply and demand forces. To capture non-linearity effects of the demand and supply functions on price fluctuation, an alternative method should be developed. Another possible area of work could be in terms of accounting for the stockpile in consuming countries. Barlow *et al.* (1994) pointed out that perfect competition in the natural rubber market to some extent is reflected by the price formation in the consuming countries based on natural rubber stocks. Thus, research can concentrate on this area.

Since price variance is mostly explained by demand impacts, further research can be developed on a futures market, where the benefits to producers or related parties can be measured.

Finally, the success of research proposed above will be dependent upon data availability and the model building used to approximate the problems. Data availability and quality are crucial for ongoing research in the Indonesian natural rubber industry.

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Appendices

Appendix A1. The MacBean Index

The MacBean Index is also known as the Instability Index

$$IDX = (100 / n - 4)\sum_{t=3}^{n=2}\left(|X_t - MA_t| / MA_t\right)$$

where:

IDX = instability index;

MA_t = a five-year moving average of the X values (price, volume, or earnings) centered on year t;

$MA_t = 1/5\left(X_{t-2} + X_{t-1} + X_t + X_{t+1} + X_{t+2}\right)$;

X_t = values in year t; and

n = number of observations.

Source: [1]Murray 1978, (p.63)
[2]Athukorala and Huynh 1987, (p.67)

Appendix A2. Data sources for variables used in the price equations

Description	Symbol	Units	Sources
1. Production	*QP*	'000 tonnes	DGEC 1994
2. Export demand	*XD*	'000 tonnes	IRSG various issues
3. Domestic use	*DU*	'000 tonnes	EIU various issues; CBSI various issues.
4. Domestic natural rubber price	*PR*	Rp/kg	CBSI various issues
5. Domestic palm oil price	*PO*	Rp/kg	CBSI various issues
6. Cost of labour	*CL*	Rp/day	CBSI various issues
7. Indonesian income per capita	*Y*	Rp/cap./year	IMF various issues
8. Indonesian exchange rate	*EXR*	Rp/US$	IMF various issues
9. World natural rubber price	*WPR*	US cents/kg	CBSI various issues
10. World synthetic rubber price	*WPS*	US cents/kg	USDC various issues
11. Income per capita of OECD members	*GNP*	US$/cap./year	World Bank 1983; 1993.
12. Consumer Price Index	*CPI*	-	IMF various issues

Note: Rp denotes *rupiah* (Indonesian currency)

Appendix A3. **Time series data of production, exports, and domestic use of Indonesian natural rubber, 1966 - 1992**

Year	Quantity (thousand tonnes)		
	Production	Exports	Domestic use
1966	736.50	680.41	23.00
1967	709.25	651.16	24.00
1968	755.64	716.15	23.00
1969	773.43	657.31	23.00
1970	802.15	581.19	25.00
1971	780.95	580.23	30.00
1972	800.90	755.96	40.00
1973	844.26	841.50	45.00
1973	816.48	794.74	35.00
1975	789.85	788.29	37.50
1976	856.55	789.89	35.00
1977	853.98	781.97	35.00
1978	884.98	865.96	40.00
1979	963.94	865.32	45.00
1980	1020.00	976.13	46.00
1981	963.24	812.80	59.00
1982	899.21	797.61	66.00
1983	1006.98	938.03	68.00
1984	1032.60	1009.56	74.00
1985	1054.97	987.77	83.12
1986	1113.13	958.69	93.36
1987	1130.35	1092.53	104.86
1988	1173.30	1132.13	117.78
1989	1209.04	1151.41	132.29
1990	1275.30	1077.33	148.58
1991	1328.17	1220.02	166.89
1992	1371.80	1267.61	187.45

Appendix A4. The Indonesian and world natural rubber prices, 1966 - 1992

Year	Indonesian price (Rp/kg)	World price US cents/kg
1966	14.55	52.10
1967	43.83	43.83
1968	93.11	43.70
1969	148.09	58.48
1970	122.57	46.65
1971	102.38	39.90
1972	111.43	40.21
1973	237.32	78.51
1974	239.86	86.54
1975	181.64	65.89
1976	266.70	87.26
1977	286.46	91.69
1978	370.61	110.81
1979	687.26	142.33
1980	760.79	162.54
1981	575.56	125.19
1982	507.44	100.21
1983	912.63	123.85
1984	888.57	114.57
1985	741.70	123.85
1986	970.50	109.56
1987	1478.96	111.26
1988	1766.33	128.66
1989	1516.83	111.18
1990	1414.00	102.08
1991	1456.00	102.79
1992	1560.00	110.43

Note: Both prices are current prices

Appendix A5. Formula for own-price elasticity of supply and demand

Elasticity of supply :

$$E_s = \alpha_1 . \frac{\overline{PR}}{\overline{QP}}$$

Elasticity of demand:

$$E_d = \beta_1 . \frac{\overline{PR}}{\overline{QD}}$$

where:

α_1 = the estimated coefficient of natural rubber price in the supply function;

β_1 = the estimated coefficient of natural rubber price in the aggregated demand function;

$\overline{PR}$ = the mean of domestic natural rubber price;

$\overline{QP}$ = the mean of quantity supplied; and

$\overline{QD}$ = the mean of quantity demanded.

Source: Adapted from Tomek and Robinson 1990, (p.29; 59).

Appendix A6. Price flexibility with respect to certain variables

Price flexibility:

$$E_k = \hat{\beta}_k \left(\frac{\overline{X_k}}{\overline{Y_k}} \right)$$

where:

$\hat{\beta}_k$ = an estimated coefficient of certain variable;

$\overline{X}$ = the mean of $\overline{X}$ variable (independent variable)

$\overline{Y}$ = the mean of $\overline{Y}$ variable (dependent variable)

Source: White 1993 (p.11)

Appendix A7. Estimates of full reduced form price equation in the log-linear function

Component	All variables[1]	Selected variables[2]
Intercept	-2.8485	-2.2319
	(1.6002)	(2.4426)
EXR	0.7793	0.6746
	(0.1408)	(0.3854)
WPR	1.0960	1.0658
	(0.0971)	(0.2039)
WPS	-0.2842	-0.4946
	(0.2275)	(0.5102)
GNP	0.3806	0.0741
	(0.2183)	(0.4400)
Y	0.1343	-
	(0.2380)	
PO	-0.3441	-
	(0.0806)	
CL	-0.5025	-
	(0.1007)	
D	-0.0768	-0.0786
	(0.0832)	(0.1217)
T	-0.2786	0.1524
	(0.1217)	(0.1442)
RSD	0.0002	-
	(0.0003)	
$\overline{R}^2$	0.9166	0.5712
D.W.	2.0739	0.9062

Note: [1]Equation (5.11) in the log-linear form, except for dummy variable (D)

[2]Equation (5.12) in the log-linear function, except for dummy variable (D)

*Numbers in parentheses are the standard errors of the estimated coefficients

Appendix A8. Estimates of a directly estimated price equation in the log-linear function

Component	All variables[1]	Selected variables[2]
Intercept	-1.9724	-1.2686
	(2.0931)	(4.3317)
QP	-0.0091	-0.2953
	(0.4046)	(0.8793)
EXR	0.7755	0.7030
	(0.1422)	(0.3103)
WPR	1.0658	1.0757
	(0.0925)	(0.2119)
WPS	-0.2960	-0.5453
	(0.2476)	(0.5546)
GNP	0.4154	0.1933
	(0.2947)	(0.6282)
PO	-0.3415	-
	(0.0785)	
CL	-0.4820	-
	(0.0728)	
D	-0.0299	-0.0628
	(0.0664)	(0.1375)
T	-0.2407	0.1954
	(0.0878)	(0.1499)
$\bar{R}^2$	0.9156	0.5504
D.W.	2.0310	0.9308

Note: [1]Equation (5.13) in the log-linear form, except for dummy variable (D)

[2]Equation (5.14) in the log-linear function, except for dummy variable (D)

*Numbers in parentheses are the standard errors of the estimated coefficients

Appendix A9. The root mean square percentage error (RMSPE)

$$RMSPE = \left[1 \Big/ n \sum_{t=1}^{n} \left\{ (p_t - a_t) / a_t \right\}^2 \right]^{0.5} * 100$$

where:

$RMSPE$	=	the root mean square percentage error
p_t	=	predicted value in year t;
a_t	=	actual value in year t; and
n	=	number of observations.

Source: Adapted from Tomek and Robinson 1990, p.347