A PRINCIPAL COMPONENTS ANALYSIS OF NATURAL RUBBER PRICES

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ABSTRACT

Principal components analysis was used to analyse four series of natural rubber prices. Four components were extracted using accepted techniques. The first component explained a substantial proportion of total variation and indicated that the four series generally move very closely together annually. The second, third and the fourth components explained a smaller proportion of total variation. Regression of the first component with production and consumption gave statistically significant results with some policy insights.

INTRODUCTION

Rubber is an important primary commodity produced mostly in South and South East Asia for export to the industrialized countries. The prices of natural rubber have shown wide fluctuations in the past. These fluctuations affect the incomes of producer nations as well as rubber producers with undesirable consequences for their welfare. Rubber is an important raw material particularly for the motor car industry. Industrial activity in the developed countries can have a significant influence on natural rubber prices. An understanding of the nature and causes of the fluctuations in rubber prices both in consumer and producer nations is thus of great importance. In this paper, principal components analysis is used to study the natural rubber price series of Sri Lanka (producer country), Singapore, New York and London (consumer markets).

METHODOLOGY

In principal components analysis, linear transformations of the following type are sought.

$$(1) \quad \zeta_i = \sum_{i=1}^{p} a_{ij}X_j \ , \ i = 1,2, , \ldots p$$

where p variates X_1, X_2,.........X_P are observed on n individuals. The coefficients a_{ij} are chosen, so that the new variate has as large a variance as possible; the second is then chosen to be uncorrelated with the first and to have as large a variance as possible. The X variates are thus transformed to new uncorrelated variates which account for as much of the variation as possible in descending order.

This separation of the total variation into orthogonal subsets is an aid to understanding the nature of fluctuations present in the several series of prices. The principal components provide measures of the amount of common variation as well as the magnitude and nature of the divergencies in the series. Regression analysis on the components can be used to determine the nature and causes of the fluctuation. This technique also overcomes the effects of multicollinearity and economises in the number of variates. The theoretical development of component analysis and its illustrative applications have been discussed by several authors (Anderson 1953. Kloek and Mennes 1960, Malinvaud. 1966 Morrison 1967). Doll and Chin (1970) applied this to the analysis of shrimp prices and Nieuwoudt (1972) applied it in production function analysis.

THE ANALYSIS AND RESULTS

The four series of annual natural rubber prices for New York, Sri Lanka, London and Singapore are depicted in Figure 1. The prices are those of RSS 1 in local currency. All prices were converted to equivalent U.S. dollars prior to the analysis[1]. The correlation matrix for the four series of prices over the 28 year period is given in Table 1. A study of the graph and the correlation matrix indicates the presence of a high common variance among the four price series. Before principal components are extracted, it is necessary to test whether there is a significant inte-rela-

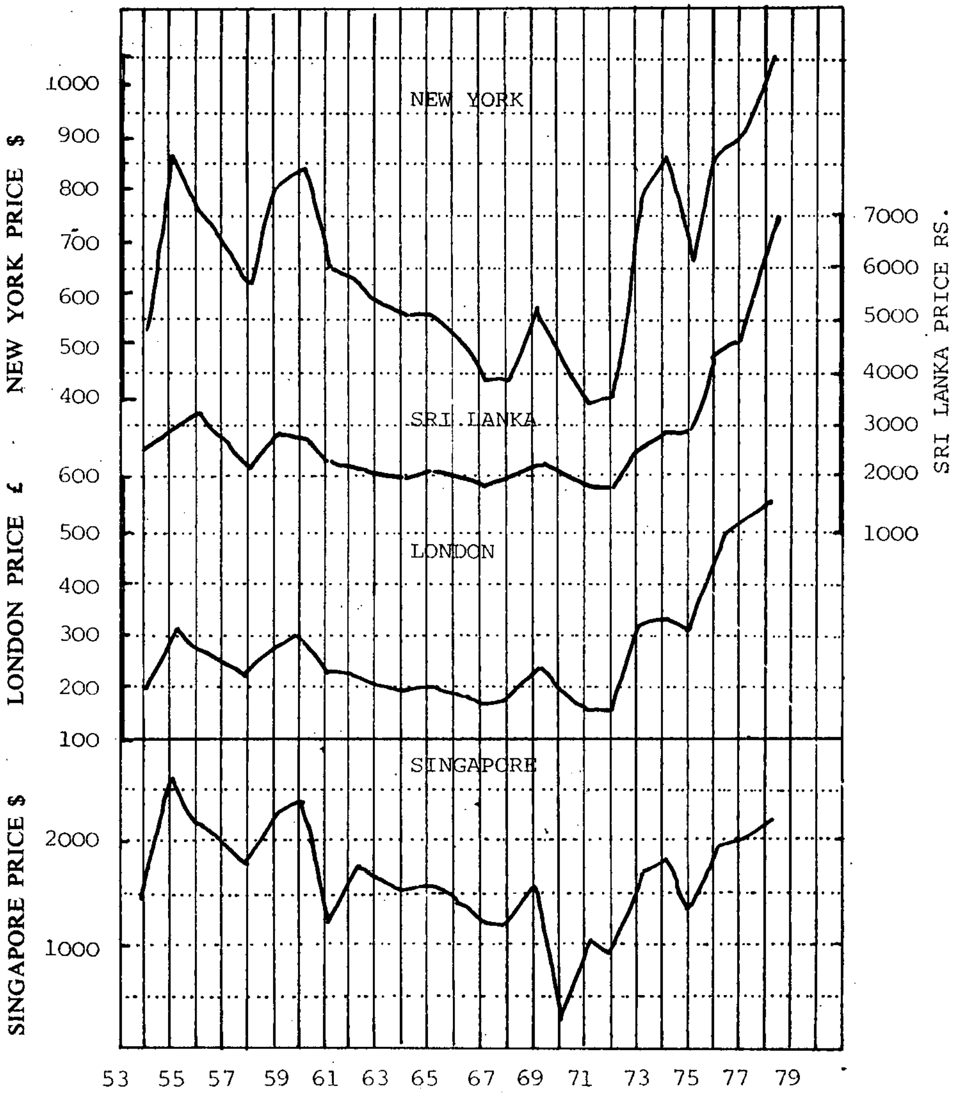

Fig. 1 THE TRENDS IN FLUCTUATIONS OF NATURAL RUBBER PRICES IN THE DIFFERENT MARKETS

tionship among the four variables. Bartlett's (1950) test of sphericity was used for this purpose which indcated a high multicollinearity among the variables[2]. Thus independent vectors were extracted from the correlation matrix using principal components analysis. Four eigen values were computed along with their respective eigen vectors (Seal, 1966).

The eigen values calculated are $\lambda_1 = 3.313$, $\lambda_2 = 0.552$, $\lambda_3 = 0.094$, and $\lambda_4 = 0.041$. The related matrix of four normalized vectors was then computed from which the partial correlation matrix was obtained using the relation $S = L^{\frac{1}{2}} V$ where S is the partial correlation matrix, $L^{\frac{1}{2}}$ is a diagonal matrix whose diagonal elements are the square roots of the eigen values of the correlation matrix and V is a matrix containing the normalized vectors[4] (Seal, 1966). The matrix B given in Table 2 containing the coefficients of the components extracted from the correlation matrix was computed by standardising the normalized vectors from their respective latent roots. The first root accounts for 82.2 percent of the summed variation while the second, third and fourth roots accounted for 13.8, 2.35 and 1.02 percent of the variation respectively. The effective dimensions of the variation can thus be reduced from four to almost two variables. The first component according to B is

$$(2) \quad \zeta_1 = 0.2939 \ NY + 0.2764 \ SL + 0.2857 \ LO + 0.239 \ SI$$

The coefficients of the first component for all four variables are approximately equal and the signs are the same. It can thus be inferred that the prices in the four series generally move very closely together annually. Any factor, such as world production or consumption which may affect prices in one market will have a similar effect in the other markets. This is apparent from Figure 1 where prices of the four series appear to move more or less in unison. This phenomenon suggests a common underlying force affecting rubber prices. It could be surmised that fluctuations in industrial countries are transmitted to producer countries rather than the revenue and that producer countries may not be able to mitigate price fluctuations on their own.[5].

Table 1—CORRELATION MATRIX OF RUBBER PRICES

	NY	*SL*	*LO*	*SI*
NY	1.0	0.834	0.899	0.803
SL		1.0	0.926	0.542
LO			1.0	0.587
SI				1.0

N.B. NY, SL, LO and SI stand for New York, Sri Lanka, London and Singapore respectively.

Table 2—COEFFICIENTS OF THE PRINCIPAL COMPONENTS

$$B = \begin{Bmatrix} 0.2939 & 0.1596 & 1.7621 & 3.2166 \\ 0.2764 & -0.6097 & -2.2560 & 1.0520 \\ 0.2857 & -0.4845 & 1.1986 & -3.3450 \\ 0.2390 & 1.0768 & -0.9868 & -1.2817 \end{Bmatrix}$$

The second component may be mostly due to the Singapore price series. The second component contains positive coefficients for New York and Singapore prices and negative coefficients for London and Sri Lanka prices. This component is primarily correlated with Singapore price and to a lesser extent with New York and

London prices and measures the variation in the series that occur when Singapore price moves in an opposite direction to that of New York and London. Figure 1 reveals this phenomenon for 1967 and 1968. The effect of New York price is not prominent during this period. This is confirmed by the lower coefficient of New York price in the second component and the lower partial correlation of the second component for New York price in matrix S. Hence the second component could be written as

$$(3)\ \zeta_2 = -\ 0.6097\ SL - 0.4845\ LO - 1.0768\ SI$$

In the third component, the coefficients are positive for New York and London and negative for Sri Lanka and Singapore. The prices of the first two markets move in an opposite direction to the prices of the other two markets. This is observed during 1955–56, 1959–60 and 1974–75. However, due to the low partial correlation and the small proportion of summed variation, the contribution of this component to total fluctuations is low. This applies to the fourth component as well. A test due to Bartlett (1950) was employed for testing the significance of the difference between the third and fourth components confirmed them to be the same.[6]. The first three components can thus explain the nature of fluctuations in all four price series.

The principal components when regressed upon production or consumption variables can provide useful information. Thus the first component was regressed with world production and consumption of natural rubber, synthetic rubber and total rubber.[7] The results of the regression of the first component with production presented in Table 3 indicate world production of natural, synthetic and total rubber to be negatively related to price. This confirms that all four price series (producers and consumers) are affected similarly by production increases. The regression of the first component with consumption gave a negative relationship for all three types of rubber (Table 4). This result is usually unexpected. The most plausible argument is that consumption may be a function of price rather than the reverse.

The results in Tables 3 and 4 indicate that the regression coefficients for production and consumption are quite similar for synthetic and total rubber. However, for natural rubber the regression coefficient for consumption is less than that of production. A spontaneous increase in production can lower prices which may call forth a large increase in consumption which can force the price up. The magni-

Table 3—RESULTS OF REGRESSION OF FIRST COMPONENT WITH RUBBER PRODUCTION

Type of Rubber			*Constant*	*Coefficient*	R^2
Natural rubber	...	...	791	–69.8	0.63
Synthetic rubber	...	...	678	–85.9	0.63
Total rubber	...	...	1234	–350.5	0.64

N.B. All coefficients are significant at the 5 percent significance level.

Table 4—RESULTS OF REGRESSION OF FIRST COMPONENT WITH RUBBER CONSUMPTION

Type of rubber			*Constant*	*Coefficient*	R^2
Natural rubber	...	...	1121.0	–288.5	0.59
Synthetic rubber	...	...	678.0	–87.9	0.64
Total rubber	...	...	784.9	–68.1	0.63

N.B. All coefficients are significant at the 5 percent significance level.

tude of the coefficients indicate that if the industry cannot respond very quickly to changes in price, a divergent cobweb type fluctuation in rubber prices is possible. Buffer stock manipulations may be used to mitigate the explosive nature of price fluctuations. However, further research is needed to assess the likely effects of buffer stocks policies in minimising price fluctuations in rubber.

CONCLUDING REMARKS

The analysis above of the bahaviour of natural rubber prices of both producer and consumer countries indicate that there are some common factors which influence rubber prices in the markets studied. The regression of the price components with production gave significant results for all four markets. The analysis also indicates that a divergent type of fluctuation in price is possible. This is suggestive of the potential of buffer stocks to mitigate wide fluctuations in rubber prices.

Notes

1. RSS refer to Ribbed Smoked Sheets which is the most widely processed type of rubber. These are classified into RSS 1, RSS 2 etc. on the basis of various characteristics. RSS 1 enjoys a premium in international markets.

2. Bartlett's sphericity test is as follows:

$$X^2_{0.5\ (P^2-P)} = [(N-1) - \tfrac{1}{6}(2.p - 5)] \ln |R|$$

where p is the number of variates (element vector variables). N is the number of elements in the element vector variable and R is the correlation matrix. In this study X^2 was 108.04 with 6 degrees of freedom which was found to be highly significant.

3. In extracting the principal components the following relationship was satisfied:

$$[K\hat{\Sigma}K - VI] = 0$$

where $\hat{\Sigma}$ is the variance-covariance matrix, $K\hat{\Sigma}K = R$ and K is a diagonal matrix of scale changes.

4. The normalized vector V is

$$V = \begin{bmatrix} 0.535 & 0.119 & 0.541 & 0.653 \\ 0.503 & -0.453 & -0.693 & 0.213 \\ 0.520 & -0.360 & 0.368 & -0.679 \\ 0.435 & 0.8 & -0.303 & -0.260 \end{bmatrix}$$

and the matrix S containing relative correlations with respect to each variable computed is

$$S = \begin{bmatrix} 0.973 & 0.080 & 0.166 & 0.132 \\ 0.915 & -0.330 & -0.213 & 0.043 \\ 0.940 & -0.267 & 0.113 & -0.137 \\ 0.790 & 0.590 & -0.090 & -0.052 \end{bmatrix}$$

5. The factors influencing rubber prices and the direction of its influence cannot be discovered from this study. However, the smaller share of Sri Lanka's rubber in the world market does not enable it to influence prices in consumer markets. Thus the most plausible direction appears to be from the industrial countries to the producer nations where the latter behaves as a price taker.

6. Bartlett's test modified by Lowly (1956) is given below:

$$X = [N - k - \frac{2(P-k)+7+2/(P-k)}{6} - \sum_{i=1}^{k}\left(\frac{\lambda}{\hat{\lambda}_j - \hat{\lambda}}\right)^2] \cdot [-\ln(\hat{\lambda}_{k+1} + \hat{\lambda}_{k+2} \ldots \hat{\lambda}_P) + (P-k)\ln\hat{\lambda}]$$

where $\lambda = (\lambda_{k+1} + \lambda_{k+2} + \ldots \lambda_p)/(P-k)$ is approximately distributed Chi-square with (P–K–1) (P–K+2)/2 degrees of freedom, N is the number of elements of the P component vector, K is the first eigen value considered to be significantly different from each other. For the hypotheses

$$\lambda_2 = \lambda_3 = \lambda_4 \quad H_o; \qquad \lambda_2 \neq \lambda_3 \neq \lambda_4 \quad H_1,$$

X^2 for K=1, gave significant results with X^2 of 106.38 and degrees of freedom 5. Testing $\lambda_3 = \lambda_4$ was non significant. Thus λ_3 & λ_4 could be assumed to be the same.

7. Total rubber comprises the total of natural and synthetic rubber.

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