Pertanika 13(2), 283-288 (1990)

Composite Models for Short Term Forecasting for Natural Rubber Prices

MAD NASIR SHAMSUDIN and FATIMAH MOHD. ARSHAD

Department of Agricultural Economics
Universiti Pertanian Malaysia
43400 UPM Serdang, Selangor Darul Ehsan, Malaysia

Key words: composite models, short term forecasting, natural rubber prices

ABSTRAK

Teknik ekonometrik dan kaedah satu pembolehubah Box-Jenkins telah digunakan untuk meramal harga getah asli. Kajian ini membentuk satu model peramalan jangka pendek dengan menggabungkan model ekonometrik dan model satu pembolehubah atau dikenali sebagai model komposit. Penemuan kajian menunjukkan model komposit dapat meramal harga getah asli lebih cekap daripada model ekonometrik dan model satu pembolehubah.

ABSTRACT

The econometric technique and Box-Jenkins univariate method have been applied in forecasting natural rubber prices. This study developed a short term forecasting model known as the composite model, by combining the econometric and univariate models. The results indicate that the composite model produces more efficient forecasts than the econometric and univariate models.

INTRODUCTION

Despite the dire need for better forecast of natural rubber prices, few attempts have been made to do so. Some of the pioneer work on Malaysia natural rubber price forecasting were carried out by A. Halim (1978), Mohd. Napi (1984) and Mohd. Napi and Mohd. Yusof (1988). They have adopted both econometric and Box-Jenkins univariate methods and found that the two techniques were capable of producing reliable forecasts. The studies, however, did not compare the relative performance of each model. Previous studies that compared the relative efficiency of various forecasting techniques indicate inconclusive results. Studies by Cooper (1972), Bourke (1979) and Brandt and Bessler (1981) indicate the superiority of the Box-Jenkins univariate model over econometric models, while studies by Leuthold *et al.* (1970) and Gellatly (1979) indicate otherwise.

In view of the inconclusive findings of the relative ability of the forecasting techniques and the fact that each method has its own strengths, the composite model may well be a better alternative to reconcile the inconsistencies. This model combines the two approaches into a composite one; it retains the structural relationship extracted from the econometric method while using the time-series model to explain for the residual. Studies by Bates and Granger (1969), Granger and Newbold (1977) and Brandt and Bessler (1981) illustrated that the composite forecasts outperformed the individual forecasts. They further demonstrated that the composite forecasts have an error variance not greater than the smallest error variance of the individual forecasts. This paper attempts to forecasts monthly rubber prices (RSS1) in Kuala Lumpur market using the composite model and to compare its forecasting predictability with each individual model (i.e., econometric and univariate). The following paragraphs provide briefly the description of the methodology. This is followed by the analysis of the results and conclusion.

METHODOLOGY

Econometric Model

The price equation of natural rubber can be specified as follows:

$$PR_t = f\ (SCC_{t-1},\ WCN_{t-1},\ PR_{t-1},\ E) \qquad (1)$$

where

PR_t = price of natural rubber (RSS1) in Kuala Lumpur

SCC_{t-1} = stock of natural rubber in the consuming countries lagged one period

WCN_{t-1} = total consumption of natural rubber lagged one period

PR_{t-1} = price of natural rubber (RSS1) in Kuala Lumpur lagged one period

E = random error term

The price is expected to have positive relationships with consumption and one period lagged price and negative relationship with stock.

Equation (1) was estimated using ordinary least squares (OLS). The sample period was from January 1978 to March 1988. The data was obtained from the MRRDB "Malaysian Rubber Review" and IRSG "Rubber Statistical Bulletin".

Box-Jenkins Model

The Box-Jenkins technique, or autoregressive-integrated-moving average (ARIMA) model, is well documented, in particular, by Box and Jenkins (1976), Nelson (1973) and O'Donovan (1983). Briefly, this technique is a univariate approach which is built on the premise that knowledge of past values of a time series is sufficient to make forecasts of the variable in question. In other words, the models are void of economic theory and this characteristic has been critisized as an inherent weakness of the time series application.

Box and Jenkins (1976) set forth four steps for this approach: model indentification, parameter estimation, diagnostic checking and forecasting. The identification step involves the comparisons of estimated autocorrelation and partial autocorrelation functions of the series of interest with the theoretical autocorrelation and partial autocorrelation functions of known ARIMA processes. Given a class of ARIMA models from the first step, their parameter values can be estimated from the historical series using nonlinear least squares. Diagnostic checks are then applied to determine any possible inadequacies in the model, and the process is repeated if any are found. Finally, having arrived at an adequate model, "optimal" forecasts are generated by recursive calculation.

The general multiplicative seasonal autoregressive-intergrated-moving-average (ARIMA) model for a seasonal Z_t, t = 1, 2,.... ..T with a known period S can be written as

$$\phi_p(B)\ \Phi_p(B^s)\ (I - B)^d\ (I - B^s)^D\ Z_t = \theta_q(B)\ \Theta_Q(B^s)\ e_t \qquad (2)$$

where

e_t = a random disturbance assumed to be distributed as N $(0, \sigma^2)$

B = a backward shift operator such that $BZ_t = Z_{t-1}$ and $B^k\ Z_t = Z_{t-k}$

$\phi_p(B)$ = The regular autogregressive operator of order p, i.e., $\phi_p(B) = (I - \phi_1 B - \phi_2 B^2 - \ldots\ldots \phi_p B^p)$

$\Phi_p(B)$ = The seasonal autogregressive operator of order p

d = number of regular differences

D = number of seasonal differences

$\theta_q(B)$ = the regular moving average operator of order q, i.e., $\theta_q(B) = (I - \theta_1 B - \theta_2 B^2 - \ldots\ldots - \theta_q B^q)$

$\Theta_Q(B)$ = the seasonal moving average operator of order Q

s = the order of the seasonal difference

Equation (2) is an ARIMA model of order (p, d, q) $(P, D, Q)_s$.

Composite Model

The composite model refers to the combination of forecasts from econometric and Box-Jenkins models. The advantage of the composite model is that its forecasts, in most cases, outperforms any of the individual forecasts.

A basic problem underlying the generation of composite forecasts is what weight to apply to each individual forecasts. Bates and Granger (1969) and Granger and Newbold (1977) discuss several procedures for determining these weights. One of the methods which has been proven superior to other methods is the minimum variance (Brandt and Bessler (1981)) which can be expressed as follows:

$$K_1 = \frac{\sigma_2^2 - \rho_{12}\,\sigma_1\,\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho_{12}\,\sigma_1\,\sigma_2} \qquad (3)$$

$$K_2 = 1 - K_1 \qquad (4)$$

where K_i is the weight assigned to forecast method i, σ_i^2 is the sample period forecast error variance associated with method i, and ρ_{ij} is the correlation coefficient between the errors of forecasts i and j.

Forecast Evaluation

Evaluation of the forecasts is based on the absolute accuracy and turning points. Three measures of absolute accurancy are used. They are root mean square error (RMSE), root mean square percent error (RMSPE) and Theil inequality coefficient.

Turning points evaluation can be categorised into statistical and cyclical turning points. The statistical turning points refer to an error which relates to any forecast direction of change that does not agree with the actual direction of movement. The cyclical turning points refer to a turning point in the economic sense of a reversal of current trend.

In evaluating cyclical turning points two types of errors are involved: (i) a turning point may be incorrectly predicted (Type I error) or (ii) none predicted when one actually occurs (Type II error).

Quantitative measures of these errors can be expressed as:

$$f_1 = b/(a+b);\; f_2 = c(c+d)$$

where f_1 and f_2 refer to type I and type II errors, respectively while a, b, c and d are types of turning point (Table 1).

Generally, the lower f_1 the better, but both must be considered in association since Type I errors may be avoided by never prediciting a turning point, and similarly for Type II errors.

TABLE 1
Types of turning point

Actual	Prediction	
	Turn	No turn
Turn	a	b
No turn	b	d

RESULTS AND DISCUSSION

Econometric Model

The estimated equation of the price of natural rubber is as follows:

$$PR_t = 70.048 - \underset{(-3.337)}{0.0698}\, SCC_{t-1} + \underset{(1.289)}{0.040}\, WCN_{t-1} + \underset{(24.667)}{0.893}\, PR_{t-1} \qquad (5)$$

$R^2 = 0.935$ SER = 10.687 h = 0.191

where PR_t is the price of natural rubber (RSS1) in Kuala Lumpur, SCC_{t-1} is the stock of natural rubber in the consuming countries lagged one period and WCN_{t-1} is total consumption of natural rubber lagged one period. The figures in parentheses are the t-values of the coefficients.

The estimated equation appears to fit the data well, as evidenced by the R^2 and t-values. All the estimated coefficients have the expected signs, although the estimate for lagged total consumption is insignificant. The results suggest that the price of natural rubber is determined by the stock levels and the price in the previous periods where they are significant at five percent level.

The estimated coefficients in equation (5) are used to estimate ex-post forecasts from April 1988 to March 1989 (Table 2). The value of the root mean square percent error which measure the deviation of the forecasted value from its actual value in percentage terms is small (7.210 percent). The Theil inequality coefficient is less than one. These figures indicate that the forecasting performance of

TABLE 2
Natural rubber price forecasts, RSS1 (Cents/kg.)

Period	Actual price	Forecasted price: Econometric	Box-Jenkins	Composite
April 1988	305.5	285.3	292.4	286.9
May	335.6	302.7	290.1	299.8
June	331.5	331.5	291.4	322.4
July	348.2	369.9	287.6	351.1
August	342.8	342.6	285.7	329.6
September	315.9	341.4	279.5	327.2
October	284.6	321.0	277.1	310.9
November	275.1	281.4	275.2	279.9
December	287.9	298.9	275.3	293.0
January 1989	303.0	289.9	274.9	286.6
February	307.0	307.2	278.8	300.7
March	299.7	313.0	276.2	304.8
RMSE		23.367	40.815	22.466
RMSPE		7.210	11.819	6.557
U		.369	0.682	.350
Turning Point Cyclical errors				
f_1		66.7	50.0	66.7
f_2		28.6	16.7	28.6
Statistical correct (%)		33.3	66.7	33.3

the estimated equation is satisfactory. The model however is not able to simulate accurately the turning points of the actual series. It only manages to predict correctly 33.3 percent of the turning points.

Box-Jenkins Model

After following the Box-Jenkins procedure of identification, estimation and diagnostic checking, the following model was chosen:

$$(1-B^2)\ (1-B^{10})\ (1-\phi_1 B)\ (1-\Phi_{10}B^{10})\ Z_t = (1-\theta_1 B - \theta_2 B^2)\ (1-\Theta_{10}B^{10})\ e_t \qquad (6)$$

This model involves a first order autoregressive element, a second order moving average element, a seasonal autoregressive element and a seasonal moving average element. The model is different from the one developed by Mohd. Napi and Mohd. Yusoff (1988). The application of the model adopted by the two authors to an updated data provides inferior forecast than the one identified in this study.

The chosen model is then fitted into the data from January 1978 to March 1988 which yield the following estimates (with estimated standard error in parenthesis):

$$\begin{aligned}
\phi_1 &= -.20707\ (.25672)\\
\Phi_{10} &= -.07969\ (.10271)\\
\theta_1 &= .43172\ (.22600)\\
\theta_2 &= .51455\ (.20986)\\
\Theta_{10} &= .82500\ (.05891)
\end{aligned}$$

The diagnostic checks shown in Table 3, do not detect any model inadequacies. There is no lag that is significant at either five percent or ten percent level.

TABLE 3
Diagnostic Chi-Square statistics for residual series of rubber prices

Lag	Chi-square	Degree of freedom	Probability
6	.37	1	.5412
12	5.59	7	.5887
18	15.81	13	.2596
24	24.45	19	.1796
30	28.59	25	.2814
36	35.21	31	.2756

The estimated model is then used to obtain ex-post forecasts for the twelve months beginning from April 1988. The forecasted values are shown in Table 2. The values of RMSE, RMSPE and U are larger than the corresponding values in the econometric method. Unlike most studies on comparison of forecasting methods, this study indicates that the econometric technique outperforms the Box-Jenkins model in predicting monthly rubber prices.

The relative efficient performance of the econometric method could be attributed to its ability to capture the dynamics of the structural changes in the market due to variation in the fundamentals which is pertinent in the natural rubber market. For instance, there was an "abnormal" upswing in natural rubber prices in the second and third quarters of 1988. The prices in fact exceeded INRO's "must sell" level. Prices hit an all-time high in June when RSS1 was traded at $3.76 per kg. This firmness in prices was partly due to increased buying by the centrally planned countries, particularly China, strong global demand for the tyre industry and uprecedented boom in the production of condoms and surgical gloves as result of worldwide concern about AIDS. The prevalence of wintering and adverse weather conditions in Indonesia further aggravated the prices. Since the Box-Jenkins model is essentially an extrapolation technique which is based on past values and not on economic theory, it could not capture this "abnormal" condition of supply and demand. The econometric model incorporated fundamental factors of supply and demand and inventory level in its specification, hence it has the ability to translate the upswing effects on its forecasts. The tracking performances of the Box-Jenkins model were relatively better. It correctly predicted 66.7 percent of the turning points of the actual series.

Composite Model

Following equations (3) and (4), the econometric and Box-Jenkins models could be optimally combined by assigning a weight of $K_1 = 0.7713$ to the former and $K_2 = 0.2287$ to the latter. The forecasted values generated from the composite model are presented in Table 2 which clearly indicates that it provides superior forecasts. The RMSE of the composite forecasts, 22.466, is about half as large as the value reported for the Box-Jenkins model, but it is only marginally less than that for the econometric model. The RMSPE and U of the composite forecasts is almost equivalent to the RMSE. The results obtained are consistent with the theoretical expectation in that if there are two (or more) forecasting techniques (which are based on different sets of information), the combination of the methods would improve the forecast quality.

CONCLUSION

This study seeks to develop a short term forecasting model for natural rubber prices (RSS1) using a composite approach. A minimum variance criterion was used to combine the forecasts generated by the econometric and ARIMA models. Despite the fact that the econometric model outperforms the Box-Jenkins model, it is possible to use the minimum variance criterion and combine the two approaches to produce even more efficient forecasts. The results show that forecast errors are indeed reduced by combining the individual predictions. This implies that forecasts taken from individual models are not likely to provide the user with the most accurate information. The user might be better off the combine the forecasts from alternative models to remove the likelihood of making gross mistakes based on forecasts of individual models.

REFERENCES

ABDUL HALIM HASSAN. 1978. Meramal Harga Getah Asli. Bahagian I – Satu Model Ekonometrik. *J. Rubb. Res. Inst. Malaysia* 2: 23-32.

ABDUL HALIM HASSAN. 1978. Meramal Harga Getah Asli. Bahagian II – Harga Gab 2, 3 dan Purata Bulanan. *J. Rubb. Res. Inst. Malaysia* **2**: 53-60.

BRANDT, J.A. and D.A. BESSLER. 1981. Composite Forecasting: An Application with U.S. Hog Prices, *Amer. J. Agr. Econ.* **63**: 135-140.

BATES, J.M. and C.W.J. GRANGER. 1969. The Combination of Forecasts. Operational Res. Quart. **20**: 451-68.

BOURKE, I.J. 1979. Comparing The Box-Jenkins and Econometric Techniques for Forecasting Beef Prices. *Rev. of Mktg. and Agr. Econs.* **47(2)**: 95-106.

BOX, G.E.O. and G.M. JENKINS. 1976. *Time Series Analysis,* Revised Edition, San Francisco: Holder-Day.

COOPER, R.L. 1972. The Predictive Performance of Quarterly Econometric Models of the U.S. Econometric Models of Cyclical Behaviour 1972. ed. Hickman. New York: Columbia Univ. Press.

GELLATLY, C. 1972. Forecasting N.S.W. Beef Production: An Evaluation of Alternative Technique. *Rev. Mktg. and Agr. Econ.* **47**.

GRANGER, C.W.J. and P. NEWBOLD. 1977. *Forecasting Economics Time Series.* New York: Academic Press.

HWA, E.C. 1979. Price Determination in Several International Primary Commodity Markets: A Structural Analysis, IMF Staff Papers. **26**: 157-188.

LEUTHOLD, R., A. MacCORMICK, A. SCHMITZ and D.

growing consumer preference for high quality cakes, bread, and rolls that require high protein wheat.

Information on production, consumption and import behavior of the various market agents of rice in Malaysia is important as the goverment continually evaluates rice programmes in Malaysia. The purpose of this paper is to identify empirically the factors affecting the supply and demand for rice in Malaysia. In addition, this paper attempts to explain the change over time in the level of protection using the price linkage equation or policy reaction function. Thus, the behaviour agents considered in the model includes consumers, farmers and the government who control prices with quota/tariffs.

Policy Environment

After independence, three major policy goals in Malaysia were formulated. These were to (1) reduce dependency on world markets (2) save foreign exchange, and (3) improve the welfare of rice producers. These objectives are to be attained through the adoption of modern agriculture inputs, large investments in infrastructure and a producer- oriented rice policy. The imports of rice are restricted and rice prices are maintained above world prices (Goldman, 1975).

In the 1959's Peninsular Malaysia produced about 50-60% of the domestic rice requirements and by the middle of the 70's this percentage had increased to 90%. The increased paddy production was the result of improving water control, the opening of new rice land and a high producer price support programme. Despite the rapid adoption of double-cropping and widespread planting of new paddy varieties, Malaysia's yield performance has been disappointing. Goldman reported that from 1962, prior to the introduction of new seed varieties, to 1974, dry-season yields in irrigated areas increased at an average compound rate of only 1.86%.

Malaysia nearly achieved self-sufficiency in rice in the 70's but was unable to maintain this policy objective in the 80's because of the changing economic environment. The cost of pursuing self-sufficiency is too high and with the large budget deficit, the administration thought that it would be advantageous to aim to a lower degree of self-sufficiency, relying more on imports to make up for the shortfall. This change in policy is facilitated by the declining international rice price. Further, the country's import requirement is not large relative to the world market. Malaysia, in its 1984 Malaysian National Agriculture Policy, lowered the self-sufficient target to 80-85% and subsequently this was lowered to 60-65%.

The decision to give up the objective of self-sufficiency in rice and rely on imports for a significant share of consumption was implemented without drastic change in trade policies. Malaysia still maintains a restrictive trade policy in rice although trade liberalisation is under consideration currently by the administration. Imports are taxed to provide revenue to the government and provide protection to domestic producers. Malaysia still maintains a certain level of stock as food security reserve. The government seeks a gradual adjustment of production through the measure of freezing price support rather than cutting it suddenly.

The extent of gevernment intervention in the rice sector is significant. Both the producers and consumer prices for rice are considerably above world level, sometimes as much as 1.5 to 2.0 times the prevailing world market. However, Malaysia is not the only country that provides incentives to the rice producers. For example, Japanese rice prices were about 200% above the international prices in early 1980. Countries like Korea and Taiwan maintained domestic prices 150% above the international price in the same time period.

Relevant Literature

Wong (1978) developed a simple dynamic simultaneous equation model which allows for interaction between rice production, consumption and export sectors to evaluate the effect of taxation on rice exports in Thailand. The model consist of four equations – a domestic supply equation, a domestic consumption equation, export price equation and price transmission equation. The results obtained were consistent with theoretical expectation.

Nik Fuad (1985) evaluated the Malaysian rice policy using an ecornometric model. He found that the estimated elasticity of area planted with rice with respect to the guaranteed minimun price ranges from 0.17 to 1.13 for the various regions in Malaysia. Overall results suggested a positively sloped supply curve althought the respond to support price was small. Nik Fuad reported an estimated price elasticity of demand -0.5 and found that this was comparable to other studies. The income elasticity was small but negetive (-0.13). The small negative income elasticity reflects a changing consumption pattern away from stable food, as is usually expected as the country reaches a higher average income.

Agricultural economists typically treat policy variables exogenously in econometric models. There are at least four reasons for this. These are (1) the analyst believes that policy variables are essentially random variables unrelated to the system being modeled; (2) the analyst believes that policy variables are influenced by the economic environment but the relationship is weak; (3) the purpose of the analysis is to calculate policy multipliers, so the policy variable must be exogenous; and/ or (4) the major variables are difficult if not impossible to measure.

Meilke and Griffith (1983), however, argued that the above reasons are invalid and showed that policy reaction function can be successfully estimated and included in a structural econometric model. They used a trade model of the international market for soybeans, rapeseed and other related products to illustrate the idea. By simulation experiments, they showed that the model with endogenous policy variables performs well in comparison with a model which treats policy exogenously. Examples of other research that have attempted to account for government intervention include Reed and Ladd (1980) and Sarris and Freebairn (1983).

Model Specification and Estimation

This paper employs a similar model to that formulated by Wong to identify the economic factors affecting the rice industry in Malaysia. The model used in this study, however, incorporates the guaranteed minimum price equation which was suggested by Meilke and Griffith. The model, formulated in aggregate terms for this paper, consists of 3 equations. It includes a domestic supply equation (Q_t), a domestic consumption equation (C_t), a price formulation (GMP_t), and an identity (the market clearing identity). The specification of the model is a follow:

1. The Domestic Supply Equation

The quantity available for consumption from domestic production (Q_t) in a particular year is primarily the result of production decisions. The supply equation is the familiar Nerlovian type where the quantity of rice produced is regarded as a function of the expected prices of rice and of competitive crops. Quantities are adjusted each period by a fraction of the discrepancy between the last period's observed value and the desired value. This hypothesis is consistent with an economy where there are rigidities which prevent complete adjustment in each period.[1] In Malaysia, paddy farmers are guaranteed a minimum price (GMP_t) and the GMP is usually maintained above the world price.

Paddy farmers depend on other source (s) of income to supplement their income from paddy. The variable PR_{t-1}, the price of rubber, is the expected opportunity cost of resources. Based on the optimization behaviour of the producers, it is hypothesized that both Q_{t-1} and GMP_t will be positively related to Q_t and the variable PR_{t-1} will have a negative sign.

2. The Domestic Consumption Equation

Economic theory states that the quantity demanded is a funtion of the price of the commodity itself, the price of related

[1]The partial adjustment (PA) and adaptive expectation model has long been used to investigate the dynamics of the supply of agriculture products. Recently, these models have been nested in the more general PAAE model by Doran (1988) to diagnose for the appropriate specification using the likelihood principles. To simplify the analysis, it is assumed here that the PA Model is sufficient to capture the underlying dynamics.

commodity and income level. During each marketing year, the National Paddy and Rice Authority (LPN) announce the wholesale and retail prices for each grade of rice. The domestic consumption equation is simply specified with the retail price of rice (RPR_t), world price of wheat (WPW_t), income (Y_t) and population (POP_t) serving as the determinants.

Bases on the utility optimization behaviour of the individual, it is hypothesized that the retail price will be negatively correlated to consumption. Income as measured by gross national products and price of wheat, a subtitute for rice are both expected to have positive signs. Population growth has been identified by policy analysts to be the most important factor affecting the domestic as well as the international demand for food. The domestic demand for food products will probably increase in accordance with population growth. Thus, population (in thousand persons) is included to capture this positive effect on aggregate domestic consumption.

3. The Guaranteed Minimum Price Equation

Malaysian rice policy emphasizes protection of the domestic industry and domestic price stability. Malaysia's trade policy in rice is subjected to import quotas, and a minimum price maintained above the world market price. The objective of the pricing policy is to provide a "fair" farm income to rice producers. The price support programme is often rationalized on distributional grounds by the decision makers and the guaranteed price is sometimes viewed as the relevant domestic supply inducing factor.

To estimate the behavioral equations for the minimum price variable, a simple specification employed by Meilke and Griffith (1983) is used in this study. Three variables are expected to capture the major factors influencing guaranteed price and they are the world market price (WPR_t), the volume of imported rice (M_t) and the lagged dependent variable (GMP_{t-1}). The lagged dependent variable is included to allow for partial adjustments which reflects a government's strong tendency to be cautious in adjusting minimum price. In Malaysia, the minimum guaranteed producer price is generally set above the world prices. As the world market price is increased, the subsidy or protection provided to the producers declines. Hence, this should result in increased pressure from producers to increase price supports. Thus, the world price for rice (PW_t) is expected to be positively related to GMP_t. The volume of imports (M_t) is a policy variable and is hypothesized to be negatively correlated to GMP_t.

The complete model for the rice sector in Malaysia is as follows:

The domestic supply equation is

$$1.\ Q_t = \beta_{10} + \beta_{11}Q_{t-1} + \beta_{12}GMP_t + \beta_{13}PR_{t-1} + U_{1t}$$

The domestic consumption equation is

$$2.\ C_t = \beta_{20} + \beta_{21}RPR_t + \beta_{22}Y_t + \beta_{23}WPW_t + \beta_{24}POP_t + U_{2t}$$

The guaranteed minimum price equation is

$$3.\ GMP_t = \beta_{30} + \beta_{31}GMP_{t-1} + \beta_{32}WPW_t + \beta_{33}M + U_{3t}$$

and the market clearing identity is

$$4.\ S_t - S_{t-1} = Q_t - C_t + M_t$$

The model, formulated in aggregated terms, consists of 3 equations (3 endogenous variables) and a market clearing identity. The endogenous variables are Q_t=domestic production of rice; C_t=domestic consumption of rice, GMP_t=guaranteed minimum price and S_t=stocks.[2] There are ten exogenous variables. The exogenous variables are PR_{t-1}=price of natural rubber; Y_t=gross national product, GMP_{t-1}=guaranteed minimum price lagged one period; RPR_t=retail price of rice in Malaysia; WPR_t=world price of rice; Q_{t-1}=domestic production lagged one period; WPW_t=world price of wheat; POP_t=population; M_t=volume of rice imported into Malaysia and S_{t-1}=stocks lagged one period. The U_{it} (where i=1,2,3) are the random disturbances. The small letter t appearing as subcript denotes the time period

[2]Stocks may be an important policy variable in the present context. However, given that data on stocks are subjected to large errors and the specification of the stock equation usually involves a complex dynamic relationship, stock are treated as an identity.

– crop year for agriculture production statistics and calender year for all other statistics. Prices and income have been deflated by the consumer price index with 1980 as the base year. The order and rank conditions of identification are both satisfied and equation (1) to (3) are overidentified. The 2SLS method will privide consistent estimates of the structural coeffiecient in equations (1) to (3). The 2SLS is a limited-information estimation technique. The results of this estimation technique are compared with the full-information method and for this purpose, the 3SLS is used.

Data

The annual data used in fitting the model are obtained mainly from the Malaysian Ministry of Agriculture and Rural Development (Paddy Statistics), the Statistical Year Book for Asia and the Pacific, the International Financial Statistic Yearbook dan World Rice Statistics 1985. The period of analysis is from 1960 to 1985, thus providing twenty-six observations in each equation.

The Regression Results

The estimates of the structural coefficients are presented in Table 1. The figures in parenthesis are the standard errors. Most of the signs on all the estimated coefficients are consistent with theoretical expectations. The supply equation fits the data fairly well but the estimated coefficients were found to be statistically insignificant. The coefficient of adjustment is 0.1738, implying that about 17 percent of the discrepancy between the desired and actual production level is eliminated in a year. The results of the regression support the hypothesis the producers respond positively to the price they received and with some lagged response. the coefficients for Q_{t-1} is statistically significant at the one percent level.

The explanatory variables appering in the consumption equation have the expected signs. In general, the results from fitting the consumption equation are better than the supply equation. In should be noted that the consumption figures used in this study include private stock. It is not possible to separate them in the analysia given that data on private stocks are poorly document for the period under investigation.

The explanatory power of the estimated guaranteed price equation is high, suggesting that the lagged GMP, world market price (WPR) and imports are important policy variables. Positive feedback from world market prices was found in the Malaysian market for rice. This suggests that Malaysia is not willing to alter its domestic agricultural policies, at least in the short-run, in respond to fluctuating world market conditions. This is consistent with the nation expressed by development economists that stable domestic price is an important policy target which cannot be allowed to fluctuate which external conditions. Further, it can be concluded that the strength of the world market price feedback is weak compared to the lagged dependent variable. This implies that the domestic price policy has a strong partial adjustment component in the Malaysian rice market.

The elasticities at the mean correspond to the 2SLS results are presented in Table 1. They show that production adjusts rather slowly to price changes. This is consistent with the findings by Wong (1978) for Thailand and by Nik Fuad (1984) for Malaysia. The estimated short-run price elasticity of demand is -0.14. Nik Fuad, however, reported -0.5 for his study and concluded that the estimate was probably biased upward because of the inclusion of private stock change in the demand equation. The negative income elasticity implies that rice is an inferior good. Nik Fuad also found negative income elasticities for Malaysia. The relatively low elasticity of price transmission supports the theory that domestic pricing policies are effective in insulating domestic market from a change in world price at least in the short run.

The same model was estimated by 3SLS method and the results are also reported in Table 1 so that a comparison can be made between the procedure of the two estimations. The values of the coefficeints between the two estimating procedures do not appear to be different. The similarities are revealing when the elasticities are compared. For examples, the 2SLS estimates imply a short-run price elasticity

TABLE 1
The results of the regression analysis

No.	Estimated equations
A.	**Two-Stage Least Square:**
1.	$Q_t = 241.07 + 0.8262\, Q_{t-1} + 0.9299\, GMP_t - 3.3560\, PR_{t-1}$ $\quad R^2=.84 \quad h=-1.15$ (137.32) (0.1249)** (1.0798) (0.5460)
2.	$C_t = -772.0 - 2.5663\, RPR_t - 0.0213\, Y_t + 4.7231\, WPW_t + 0.2311\, POP_t$ $\quad R^2=.93 \quad DW=1.37$ (336.13)* (2.7586) (0.0063)** (2.3656) (0.0361)**
3.	$GMP_t = 0.7793 + 0.9685\, GMP_{t-1} + 0.1158\, WPW_t - 0.0183\, M_t$ $\quad R_2=.99 \quad h=-0.63$ (7.8707) (0.0359)** (0.0239)** (0.0147)
B.	**Three Stage Least Squre:**
1.	$Q_t = 178.53 + 0.8886\, Q_{t-1} + 0.2267\, GMP_t - 0.1933\, PR_{t-1}$ $\quad R^2 = .84 \quad h=-2.51$ (134.95) (0.1210)** (1.0315) (0.5181)
2.	$C_t = -709.5 - 1.9661\, RPR_t - 0.225\, Y_t + 4.2794\, WPW_t + 0.2244\, POP_t$ $\quad R_2=.93 \quad DW=1.35$ (298.5)* (1.9707) (0.0055)** (1.8329)* (0.0321)**
3.	$GMP_t = -7.812 + 0.9730\, GMP_{t-1} + 0.1156\, WPW_t - 0.0003\, M_t$ $\quad R_2= .99 \quad h=2.39$ (7.7260) (0.0354)** (0.0229)** (0.0143)

Estimates of Elasticities at Means:

		Short-run	**Long-run**
1.	Price elasticity of supply	0.0830	0.4856
2.	Cross price elasticity	−0.0569	−0.3273
3.	Price elasticity of demand	−0.1387	–
4.	Cross price elasticity of demand	0.2161	–
5.	Income elasticity	−0.1223	–
6.	Elasticity of price transmission	0.1093	4.4790

Note: The estimated parameters of 2SLS and 3SLS were obtained using the SHAZAM package. The usual test of significance may not be applicable here and the single equations statistics reported here must be interpreted with care. The estimated of the elasticities were calculated using the results from the 2SLS method. Figures in the parentheses are the standard errors.
** significant at one percent level.
* significant at five percent level

to demand of -0.14 while the 3SLS results in an elasticity of -0.11. Similarly, the computed elasticities for all others do not differ between the two estimation techniques.

The 3SLS method is a system method and it utilizes more information than the 2SLS that is, it takes into account the entire structure of the model. Both estimators are biased but they are consistent. The 3SLS, however, is an asymptotically efficient estimator. The reason for the lack of asymptotic efficiency in 2SLS is because it disregards the correlation of the disturbances across equations and over identified restrictions in other equations. However, the 3SLS requires a complete knowledge of the entire model. A single specification error in one of the equations is transmitted during estimation to all the equations in the model. The 2SLS is preferred over the 3SLS since the accuracy of the specification of some of the equations is uncertain. The 2SLS, however may be less sensitive to specification error in the sense that those parts of the system that are correctly specified will not be affected appreciably by errors in specification in other parts (See Klein, 1974). Finally, the Breusch-Pagan LM test for diagonal covariance matrix indicated that the covariance matrix was diagonal implying that the 3SLS estimator would reduce to 2SLS estimator.

Model Diagnostic Test

One of the most important components of economic model-building is tests for specification errors. The pupose of this section is to test the assumptions on the disturbance term. The disturbance term in the classical regression analysis assumed that the disturbance are homoskedastic, serial independent and normally distributed. The following section discusses the tests.

1. Serial Correlation:

Serial correlation of the error term can lead to inefficient estimators and predictions, and to inconsistent estimates of β if a lagged dependent variable is in the set of regressors. Perhaps the most useful test for serial independence against AR(p) and MA(q) has been developed by Breusch (1978) and Godfrey (1978). If U_t follows an AR(p) process, then $U_t = p_1 U_{t-1} + p_2 U_{t-2} + \ldots + p_p U_{t-p} + \epsilon_t$, where ϵ_t is white noise. The LM test of the null hypothesis H_0: $p_1 = p_2 = \ldots = p_p = 0$ is obtained by replacing U_{t-j} with $\hat{U}_{t-j}$ (j=1, 2, . . ., p), the lagged values of the OLS residuals. The LM test statistic under the null hypothesis is calculated as TR^2 and $TR^2 \sim x(p)$ under H_0, where T is the samples size and R is the coefficient of multiple determination from the auxiliary regression. The test is conducted for the three system of equations using the residuals from the 2SLS. The computed $x^2(3)$ are 1.07, 4.0, and 3.7 for equations 1, 2 and 3 respectively and the critical $x^2(3)$ equal 37.65. Thus, the null hypothesis H_0: $p_1 = p_2 = p_3 = 0$ cannot be rejected at 0.05 level of significance.

2. Heteroskedasticity

To test for heteroskedasticity, a simple test proposed by Breucsh and Pagan (1979) is available. Here we assume that

$$\sigma^2_i = V(U_i) = h(Z_i\ \alpha) \qquad (i=1, 2, \ldots, T)$$

where $Z_i\ \alpha' = h(\alpha_0 + \alpha_1 Z_{i1} + \alpha_2 Z_{i2} + \ldots + \alpha_p Z_{ip})$ and h(.) possesses first and second derivatives with respect to α. Our H_0: $\alpha_2 = \ldots = \alpha_p = 0$, so that under H_0: $V(U_i) = h(\alpha_1)$=constant. The LM test statistic for H_0 is 1/2 SSR from the regression of ϵ^2_i/σ^2_i on Z_i where, ϵ_i are OLS residuals and $\sigma^2 = \epsilon'\epsilon/n$. Koenker (1981) showed that this test is not robust under non-normality and suggested a slight modification of the test statistic. Asymptotically under the null hypothesis of homoskedasticity,

$$LM = TR^2 \sim x_{(p-1)} \text{ under } H_0$$

where R is the coefficient of determination in regressing ϵ_i on Z_i.

$$\sigma^2_i = V(U_i) = h(Z_i\ \alpha)$$

The test is constructed for the system of equation and the results show no evidence of heteroskedasticity.

3. Normality Test

Numerous tests have been proposed to test for normality. The test proposed by Bera and Jarque (1981) is used in this paper. The test statistic under the null hypothesis is given by:

$$LM = n[b_1/6 + (b_2-3)^2/24] \sim x^2(2)$$

where $b_1 = \hat{U}_3/\hat{U}_2^3$, $b_2 = \hat{U}_4/\hat{U}_2$, $\hat{U}_r = 1/n \sum e_i^r$ (r=2, 3, 4) and b_i (i=1, 2) are estimates of β´s. The normality test is carried out for the 3 equations using the residual form the 2SLS. The computed x^2 for equations 1, 2 and 3 are 9.31, 9.33 and 7.77, respectively. Thus, the hypothesis, that the errors are normally distributed, cannot be rejected.

CONCLUSION

In general, the results of the model satisfactorily explained the behaviour of the Malaysian rice sector and the residuals are well-behaved despite the weakness of data used in the analysis. After analyzing the empirical results, one can conclude that rice producers are relatively unresponsive to guaranteed minimum price in the short-run and are also fairly unresponsive in the long-run. The low price elasticities suggest that there is little scope for price manipulation in achieving the rice policy of self-sufficiency. Thus, if policy makers are unwilling to accept the income consequences of large price changes, they may need non-price policies to boost domestic production in future. Such measures should primarily aim at raising productivity through the introduction of high-yielding seeds and improvement in production technology and practices.

The important factors that have been identified as affecting consumption are population, prices and income. Both the income and price elasticities are found to be inelastic. Wheat is a substitute and has acquired an important position in the Malaysian diet. The hypothesis that rice is an inferior good is consistent with recent findings.

The empirical estimates of the guaranteed price equation suggest that the minimum price is determineed by the world market price, import volume and the lagged guaranteed minimum price. The Malaysian price support programme is sensitive to changes in world market situations. Some form of feedback rule rather than an ad-hoc price support policy is used to induce producers to make necessary adjustments.

Finally, the model recognized the importance of including domestic pricing policy in the rice sector in Malaysia but of course it is not without limitations. The model does not consider stock changes to avoid the complex dynamic problem. The model, being a partial equilibrium one, also ignores interaction with other commodities.

REFERENCES

BERA A.R. and C.M. JARQUE. 1981. An Efficient Large-Sample Test for Normality of Observations and Regression Residuals. Australian National University, Canberra.

BREUCH, T.S. 1978. Testing for Autocorrelation in Dynamic Linear Models. *Australian Economics Paper* **17**:334-335.

BREUCH, T.S. and A.R. PAGAN. 1979. A Simple Test for Heteroskedasticity and Random Coefficient Variation. *Econometrica* **47**:1287-1294.

BREUCH T.S. and A.R. PAGAN. 1980. The Langrange Multiplier Test and its Application to Model Specification in Econometrics. *Review of Economic Studies* **47**:239-253.

DORAN E.D. 1988. Specification Test for the Partial Adjustment and Adaptive Expectations Models. *Amer. J. Agr. Econ.* **70**:713-723.

GOLDMAN, R.H. 1975. Staple Food Self-Sufficiency and Distributive Impact of Malaysian Rice Policy. *Food Research Institute Studies* **14**:251-293.

GODFREY, L.G. 1978. Testing for Higher Order Serial Correlation in Regression Equations When Regressors Included Lagged Dependent Variable. *Econometrica* **46**:1303-1310.

KLEIN, L.R. 1974. *A Textbook of Econometrics.* 2nd edn., New Jersey: Prentice-Hall Inc., Englewood Cliffs.

KOENKER, R. 1981. A Note on Studentizing a Test for Heteroskedasticity. *Jurnal of Econometrics* **17**:107-112.

NIK FUAD KAMIL. 1984. An Economic Analysis of the Malaysian Rice Sector: Prospects and Policy Alternatives. Ph. D. Thesis, Washington State University.

MEIKLE, K.D., and G.K. GRIFFITH. 1983. Incorporating Policy Variables in a Model of the World Soybean/Rapeseed Market. *Amer. J. Agr. Econ.* **65**:65-73.

REED, M.R. and G.W. LADD. 1980. Feed Grain Imports and Feed Grain Prices in Importing Countries. Research Bulletin 588, Iowa Agriculture and Home Economics Experimental Station,, Ames, Iowa.

SARRIS, A.H. and J. FREEBAIRN. 1983. Endogenous Price Policies and International Wheat Prices. *Amer. J. Agr. Econ.* **65**:214-224.

WONG, CHUNG MING. 1978. A Model for Evaluating the Effects of Thai Government Taxation on Rice Exports on Trade and Welfare *Amer. J. Agr. Econ* **65**:65-73.

(Received 27 June, 1989)