AGREX08

"Agriculture Sustainability Through Participative Global Extension"

15-19 June 2008
Venue: Equatorial Hotel Bangi-Putrajaya

Organized by:

UPM

Centre for Extension, Entrepreneurship and Professional Advancement (APEEC)
Universiti Putra Malaysia

In Collaboration with:

NATURAL RUBBER PRICE FORECASTING IN THE WORLD MARKET

By

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ABSTRACT

The paper presents various econometric models to forecast the short-run monthly prices of SMR20 in the world market. These models of the world natural rubber have specifications for production, consumption, prices. Among the objectives of this study are to determine the inter-relationships between NR production, consumption and prices, to derive and forecast the multivariate autoregressive-moving average (MARMA) model which integrates the normal autoregressive-integrated-moving average (ARIMA) and econometric model and to estimate and test individually in terms of their comparative price forecasting accuracy. The study develops some short term ex ante and ex post forecasts of natural rubber (NR) prices in the world market. The models are then used to generate ex ante forecasts for the period of January 2007 to December 2010. The results show that MARMA's ex post forecasts are more efficient in terms of its statistical criteria or even by visual proximity with the actual prices. The forecast figures reveals important implications for model specification and forecasting in relation to the current and expected fundamentals of the natural rubber producers and consumers as well as traders and planners for new investment decisions in the natural rubber world market.

Keyword: Price Forecasting, Natural Rubber, World Market.

Introduction

Natural rubber is a vital agricultural commodity used in the manufacture of a wide range of products. Its production from the rubber tree (*Hevea brasillensis*) plays a major role in the socio-economic fabric of many developing countries. Over 20 million families are dependent on rubber cultivation for their basic income in the world natural rubber market (http://www.irrdb.com/irrdb/NaturalRubber/). These millions of people, mainly small growers many with holdings of two hectares or less, are dependent upon *Hevea* for their livelihood. The low prices paid for natural rubber contribute to rural poverty in many countries, especially smallholders in South East Asia where currency turmoil has greatly dimished the purchasing power for essentials like medicines. Estates are now less significant in most countries. Products made from natural rubber, especially tyres; engineering components and latex products (used in the battle against AIDS and other disease) are essential to modern life.

The study provides some short term ex ante and ex post forecasts of natural rubber (NR) prices in the world market. Various econometric models were developed to forecast short-run monthly prices of SMR20 in the world market. These models of the world natural rubber have specifications for production, consumption, prices and among the objectives of this study are to determine the inter-relationships between NR production, consumption and prices, to derive and forecast the multivariate autoregressive-moving average (MARMA) model which integrates the normal autoregressive-integrated-moving average (ARIMA) and econometric model and to estimate and test individually in terms of their comparative price forecasting accuracy. The models are then used to generate ex ante forecasts for the period of January 2007 to December 2010 based on data from period January 1990 to December 2006. This study will examine two major grades of natural rubber, namely, the Standard Malaysia Rubber (SMR20) and traditional Ribbed Smoke Sheet (RSS1).The Standard Malaysia Rubber (SMR20) is the most commonly used specification in the industries and its forecasting will be the focus of this study.

Agricultural commodities futures trading was introduced to provide an efficient price discovery mechanism and to provide a hedging mechanism against the risk of price instability (Fatimah Mohd Arshad and Zainalabidin Mohamed, 1994). Like any other agricultural commodities, natural rubber was subjected to significant price fluctuations (Figure 1). The volatility of the natural rubber prices was a significant risk to producers, traders, consumers and others involved in the production and marketing in the natural rubber. In situations of considerable uncertainty and high risk, price forecasts were necessary to help in decision-making. Accurate price forecasts were particularly important to

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facilitate efficient decision making as there was considerable time lag between making output decisions and the actual output of the commodity in the market (Mad Nasir and Fatimah, 1991).
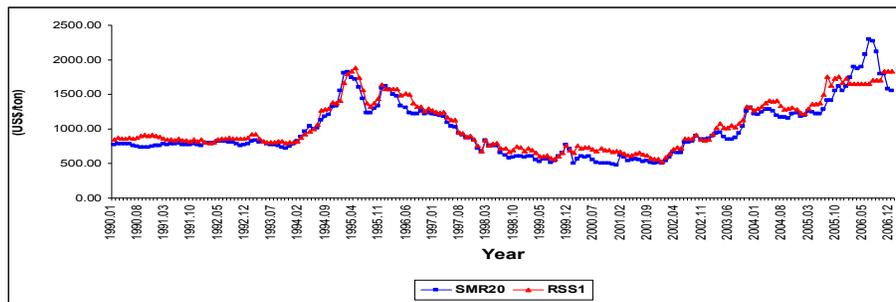

Figure: 1

Hence, price forecasting mechanism is necessary for the market participants to guide them in their production, consumption and financing decisions. Furthermore, hedging on futures is another effective risk management strategy available to reduce the associated risks that producers and traders are exposed to. Thailand was the largest producer with an annual production of 3.1 million tons (32% of world's NR production), followed by Indonesia at 2.6 million tons (27%) and Malaysia at 1.2 million tons (13%) in 2006. China was the largest consumer 2.4 million tons, at (26% of world's NR consumption), followed by U.S.A at 1.0 million tons (11%) and Japan at 0.9 million tons (9.5%) in 2006 (IRSG Rubber Bulletin Vol.61 No.8/Vol.61 No.9, May/June 2007) (http://www.weber-schaer.com/en.html).

The fundamental factors influencing NR prices are demand and supply, while all other factors have indirect effects through changes in the fundamentals of demand and supply. For example, an improvement in the world economy leads to an increase in rubber demand, a decline in the price of natural rubber relative to synthetic rubber influences a falling share of synthetic rubber in total rubber consumption, and a weak currency exchange in the producing countries encourages an increase in exports and output from these producing countries and hence a rise in world natural rubber supply. Uncertain weather has also affected Malaysian production. Table 1 shows that world natural rubber supply-demand relationship and natural rubber supply was 8,634 thousand tons in 2004 & it reached to 9,340 thousand tons in 2008. Also, natural rubber demand was 8,343 thousand tons in 2004 & it reached to 9,880 thousand tons in 2008. It clearly shows the deficit of world natural rubber supply was -540 thousand tons in 2008.

Table 1. World Supply-Demand Surplus/Deficit

Year	2004	2005	2006	2007	2008
Supply[a]	8,634	8,703	8,890	9,040	9,340
Demand[a]	8,343	8,777	9,150	9,510	9,880
Surplus/Deficit	**291**	**- 74**	**- 260**	**- 470**	**- 540**

[a] Rounded to nearest 10,000 tonnes
Source: IRSG; Economist Intelligence Unit (October 2nd, 2006)

Changes to the world stock situation provide in Table 2 and show an indication of the relative tightness of the rubber market. Tightness in the rubber market provides upward pressure on prices and vice versa. Important factors in the long-term include technological innovation and economic development. In the medium-term, i.e. 2-3 years ahead, rubber prices depend mainly on the cyclical movement of the world economy. Then there are fluctuations influenced by various short-term factors such as weather, currency movements, futures market activities, market interventions and irregular demand.

Table 2. World Natural Rubber Stocks

	2004	2005	2006	2007	2008
1 Qtr [a]	2,277	2,389	2,425	1,770	1,250
2 Qtr [a]	2,192	2,231	2,110	1,480	1,000
3 Qtr [a]	2,379	2,275	2,080	1,480	1,090
4 Qtr [a]	2,413	2,258	1,860	1,280	930
% change	**16.6**	**-6.4**	**-17.6**	**-31.0**	**-27.3**

[a] Rounded to nearest 10,000 tonnes
Source: IRSG; Economist Intelligence Unit (October 2nd, 2006)

The forecasts of output discussed above by the IRSG assume that no extraordinary events occur in producing countries. Furthermore, the forecasts are based on production, consumption, price, stock, total production of natural rubber products and exchange rate about currency confusion in the world natural rubber market.

Literature Review

Multiple forecasts for autoregressive-integrated moving-average (ARIMA) models are useful in many areas such as economics and business forecasting. These methods were based on higher-order Bonferroni and product-type inequalities. Cheung, S. H., Wu, K. H. and Chan, W. S. (1998) found that the 'exact' method was computationally far more efficient. The 'exact' method is the evaluation of multivariate normal probabilities to the approximation method. Furthermore, the exact method can be applied to all ARIMA models while the approximation methods were limited to only a subset of ARIMA models.

Shamsudin, M. N & Fatimah (2000) provided some short term ex ante forecasts of Malaysian crude palm oil prices. The forecasts were derived from a multivariate autoregressive-moving average (MARMA) model which integrates the normal autoregressive integrated moving average (ARIMA) model for the residuals into an econometric equation estimated beforehand. The results showed that the MARMA model produces a relatively more efficient forecast than the econometric model. The forecast figures were discussed in relation to the current and expected fundamentals of the palm oil market.

Burger and Smit (2000) studied the long-term and short-term analysis of the natural rubber market. It included the economies of key players in the natural rubber market both on the demand side, on the supply side and price fluctuations. Prices would increase above their present level, when the additionally planted younger trees come into production, prices would fall, reaching the levels that were predicted for the standard case by the year 2000.

Jit Yang Lim (2002) estimated the short-term NR prices and evaluated the relative performance of 19 models based upon three different forecasting techniques, and four information sets. The generalized autoregressive conditional heteroscedasticity regression (or ARCH-type) models are generally better than the simple regression models and the results can potentially be beneficial to participants in the NR futures market.

Md Zakir Hossain (2006) developed and used for policy purposes as far as price forecasts of the commodities were concerned. It was to generate three types of forecasts, namely, historical, ex-post and ex-ante, using the world famous Box-Jenkins time series models for motor, mash and mung prices in Bangladesh. The models on the basis of which these forecasts have been computed were selected by six important information criteria such as Akaike's Information Criterion (AIC), Schwarz's Bayesian Information Criterion (BIC), Theil's R^2, Root Mean Squared Errors (RMSE), Mean Absolute Errors (MAE) and Mean Absolute Percent Errors (MAPEs). Three types of forecast errors were estimated, i.e. root mean squared percent errors (RMSPEs), mean percent forecast errors (MPFEs) and Theil's inequality coefficients (TICs). The estimates suggested that in most cases the forecasting performances of the models in question are quite satisfactory.

Methodology

MARMA Model

The multivariate autoregressive–moving-average (MARMA) model is well documented in Box and Jenkins (1994), Makridakis and Wheelwright (1998) and Pindyck and Rubinfeld (1998). A brief description of the model is discussed below. Suppose that one would like to forecast a variable Y_t using an econometric model. Presumably such a model would include explanatory variables which could provide an explanation for movements in Y_t but which are not themselves collinear. Let us suppose that the econometric model contains two explanatory variables, X_1 and X_2, as follows:

$$Y_t = a_0 + a_1 X_{1t} + a_2 X_{2t} + \varepsilon_t \qquad (1)$$

One effective application of time-series analysis is to construct an ARIMA model for the residual series u_t of this regression. Then, the ARIMA model for the implicit error term was substituted in the original regression equation. In using the equation to forecast y_t, it is able to make a forecast of the error term ε_t using the ARIMA moel. The ARIMA model provides some information about what futures of ε_t are likely to be the unexplained variance in the regression equation. The combined regression-time series model is:

$$Y_t = a_0 + a_1 X_{1t} + a_2 X_{2t} + \varphi^{-1}(B)\,\theta(B)\,\eta_t \qquad (2)$$

where η_t is a normally distributed error term which may have a different variance from residual error ε_t. The parameters a_0, a_1, and a_2 of the structural regression equation and the parameters $\varphi_1, \ldots, \varphi_p$ and $\theta_1, \ldots, \theta_q$ of the time-series model should be estimated *simultaneously*. This model Equation (2) is likely to provide better forecasts than the regression equation in Equation (1). It includes a structural (economic) explanation of that part of variance of Y_t that can be explained structurally. Equation (2) is referred to as a transfer function model or, alternatively, a multivariate autoregressive-moving-average (MARMA) model. This combined use of regression analysis with a time-series model of the error term is an approach to forecasting that in some cases can provide the best of both worlds.

ARIMA model

The autoregressive-integrated-moving average (ARIMA) model is discussed in detail in Box and Jenkins (1994) 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. There are two types of basic Box-Jenkins models: autoregressive (AR) models and moving-average (MA) models. The AR and MA models may also be combined to form ARMA models. These models are written as follows:

AR models: $\qquad\qquad X_t = A_1 X_{t-1} + \ldots\ldots\ldots\ldots A_p X_{t-p} + E_t$
where X_t is directly related to one or more past series values.

MA models: $\qquad\qquad X_t = - (B_1 E_{t-1} + \ldots\ldots\ldots\ldots B_q E_{t-q}) + E_t$
where X_t is related to one or more past random errors.

ARMA models: $\quad X_t = (A_1 X_{t-1} + \ldots\ldots\ldots\ldots A_p X_{t-p}) - (B_1 E_{t-1} + \ldots\ldots\ldots\ldots B_q E_{t-q}) + E_t$

where X_t is related to both past series values and past random errors.

The A_is are called autoregressive parameters and B_is are also called moving-average parameters. The subscripts on the A's and B's are called the orders of the parameters. In an AR model **p** is the order of the model, and in an MA model **q** is the order of the model. The order of an ARMA model is expressed in terms of both **p** and **q**. In terms of the original series such models are called integrated models and are denoted by Auto Regressive, Integrated, Moving-Average (ARIMA) models.

Box and Jenkins (1994) set four steps for this approach: model identification, parameter estimation, diagnostic checking and forecasting. The identification step involves the comparison of estimated 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 found. Finally, having arrived at an adequate model, "optimal" forecasts are generated by recursive calculation.

A series is stationary if it varies more or less uniformly over time, about a constant, fixed level. Otherwise, a series is nonstationary if it appears to have no fixed level. Fortunately, the Box-Jenkins method represents a computational process that is performed on the original series to convert the series into a stationary one. This is called regular differencing. If we have a series X1, X2, X3,……., then the differenced series would consist of the values X2 -X1, X3 - X2, X4 - X3, etc. The difference series may be written as follows:

$$Z_t = X_t - X_{t-1}, \qquad \text{for } t = 2,3,\ldots\ldots, N \qquad\qquad (3)$$

The general Box-Jenkins integrated (ARIMA) model for nonstationary series is written as follows:

$$Z_t = B_0 + \Phi_1 Z_{t-1} D + \ldots\ldots\ldots \Phi_p Z_{t-p} D - (\theta_1 E_{t-1} + \ldots\ldots\ldots\ldots \theta_q E_{t-q}) + e{<}SUB{>}t \qquad (4)$$

In Equation (4), e<SUB>t is a random disturbance assumed to be distributed as N $(0, \sigma^2)$. Equation (2) is an ARIMA (1,1,1) model of order (p,d,q). The numbers inside the parentheses refer to the order of the autoregressive process, the degree of differencing required to induce stationary, and the order of the moving average process, respectively. The stationary conditions for this model are:

$$/\Phi_1/ < 1 \qquad\qquad \text{and} \qquad\qquad /\theta_1/ < 1.$$

Econometric Model

The study will replace the supply, demand and price relationship in the earlier studies were based on the model developed by Meganathan (1983), Tan, C. Suan (1984), Mad Nasir et al. (1993), Fatimah & Zainalabdin Mohamad (1994), Barlow et al. (1994), Ferris (1998), Burger and Smit (1997 & 2000) and revised the model after incorporating latest available data into it.

Supply
The supply of natural rubber (TPNR) as a function of the related factors is as follows:

$\text{TPNR}_t = f(\text{TPANR}_t, \text{NPANR}_t, \text{RPANR}_t, \text{PSMR20}_{t\text{-}i}, \text{D1}, \text{T}, e_{ti})$ $\qquad\qquad (5)$
where:
TPNR $\quad$ = Total production of natural rubber (Natural Rubber Supply) (000 tons)
TPANR = Total planting area of natural rubber (000 ha)
NPANR = New planting area of natural rubber (000 ha)
RPANR = Replanted area of natural rubber (000 ha)
PSMR20 = Average FOB monthly price of SMR20 (US$ /ton)
D1 $\quad$ = Dummy variable for Natural Rubber Production (1= Production increased month; 0= Production decreased month)
T $\qquad$ = Time trend, 1990 Jan: to 2006 Dec: $e_i \qquad$ = error terms

Demand

The short term demand model of natural rubber (TCNR) as a function of the related factors is as follows:

$$TCNR_t = f(TPPCT_t, TPCVCT_t, TPNRP_t, PSMR20_t, STONR_t, COP_t, WPOP_t, RSS1_t, D1, T, e_{ti})$$ (6)

where:

TCNR = Total consumption of natural rubber (000 tons)
TPPCT = Total production of passenger cars' tyres (000 units)
TPCVCT = Total production of commercial vehicle cars' tyres (000 units)
TPNRP = Total production of natural rubber products (000 tons)
PSMR20 = Average FOB monthly price of SMR20 (US$ /ton)
STONR = World total stock of natural rubber (000 tons)
COP = Crude oil monthly price (US$/barrel)
WPOP = World Population (000 million units)
RSS1 = Average FOB monthly price of RSS1 (US$ /ton)
D1 = Dummy variable for Natural Rubber Consumption (1= Consumption increased month; 0= Consumption decreased month)
T = Time trend, 1990 Jan: to 2006 Dec: ; e_i = error term

Price

The NR price (PSMR20) short term determination model was derived based on all related factors is as follows:

$$PSMR20_t = f(TPNR_t, TCNR_t, STONR_t, COP_t, EXM_t, TPPCT_t, TPCVCT_t, TPNRP_t, PSMR20_{t-i}, T, e_{ti})$$ (7)

where:

PSMR20 = Average FOB monthly price of SMR20 (US$ /ton)
TPNR = Total production of natural rubber (000 tons)
TCNR = Total consumption of natural rubber (000 tons)
STONR = World total stock of natural rubber (000 tons)
COP = Crude oil monthly price (US$/barrel)
EXM = Exchange rate for Malaysia RM to USD
TPPCT = Total production of passenger cars' tyres (000 units)
TPCVCT = Total production of commercial vehicle cars' tyres (000 units)
TPNRP = Total production of natural rubber products (000 tons)
T = Time trend, 1990 Jan: to 2006 Dec: ; e_i = error term

In summary, the explanatory variables also identified total production of natural rubber (000 tons), total consumption of NR (000 ton), world total stock (000 ton), crude oil price (US$/barrel), total production of passenger cars' and commercial vehicle cars' tyres (000 units), total production of NR product and exchange rate for RM to USD were the most important explanatory variables in the price (PSMR20) forecasting econometric model. Figure 2 was described by the econometric model of world natural rubber prices.

Forecasting

Data for all relevant variables are collected and the certain time series data was only available from 1990:01 to 2006:12. Forecasts are generated for 2006:01 to 2010:12. The model is solved dynamically for ex ante forecasts and the model is subsequently employed for ex post forecasts (Figure 2).
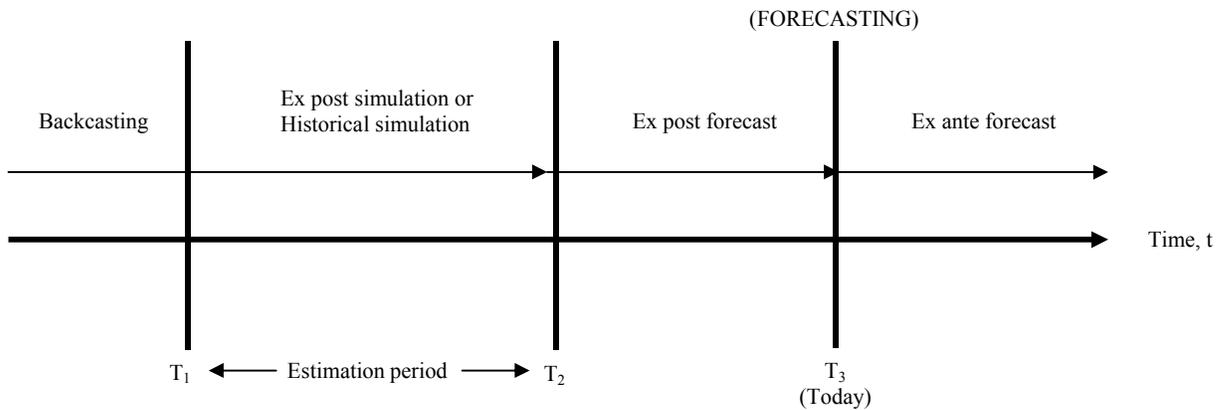

Figure 2: Simulation time horizons (Robert S. Pindyck and Daniel L. Rubinfeld , 1998).

Model Evaluation

Performance of the model is measured by the validity of its estimate on the basis of its forecasting power. The forecasting ability is tested based on the Root Mean Squared Simulation Error (RMSE), the Root Mean Squared Percent Error (RMSPE) and Theil's inequality coefficients (U) criteria. In the historical simulation, the **RMSE** of all the endogenous variables are **less than one** percent. The values of **U** are all **nearly zero** suggesting the superiority of the model over the native no-change model.

The values of **RMPSE** are all **small** and the values of **U<SUP>m** are all **very closed to zero**, indicating the non-existence of a systematic bias. Thus a revision of the model is not necessary. The values of **U<SUP>s** are also **very small** which indicate that the model is able to replicate the degree of variability in the variable of interest. In the ex post simulation, the value of the RMPSE which measures the deviation of the forecasted value from its actual value in percentage terms is 0.1.The Theil's inequality coefficient is less than one which is that the forecasting performance of the estimated model is satisfactory.

The RMSE for the variable A, given by

$$RMSE = [\ 1/T\ \Sigma^T_{t=1}\ (P_t - A_t)^2\ ]^{\frac{1}{2}}$$

where T is number of periods in the simulation, P is the predicted value and A is the actual value. It measures the deviation of the predicted value from its actual time path. The RMPSE is defined as:

$$RMPSE = [\ 1/T\ \Sigma^T_{t=1}\ (P_t - A_t\ /\ A_t)^2\ ]^{\frac{1}{2}}$$

The Theil's inequality coefficient (U-statistic) is defined as follows:

$$U = \frac{1/T\ \Sigma^T_{t=1}\ (P_t - A_t)^2}{1/T\ \Sigma^T_{t=1}\ (P_t)^2\ +\ 1/T\ \Sigma^T_{t=1}\ (A_t)^2}$$

Results

Econometric Model

Estimated Structural Equation of Supply Model

$\ln TPNR_t = 6.96 + 0.37\ \ln TPANR_{t-1} - 0.07\ \ln NPANR_{t-1} - 0.113\ \ln RPANR_{t-1} + 0.077\ \ln PSMR20_{t-1}$
                    (1.42)   (-3.05)   (-3.28)   (3.83)

            $- 0.024\ D1_{t-1} + 0.49\ \ln TPNR_{t-1} + 2.46\ \varepsilon_t$
            (-1.91)   (7.23)   (2.83)

                        $R^2 = 0.88$ Adjusted $R^2 = 0.87$

(Note: Numbers in parentheses are t-values).

The slope coefficient of price of PSMR20 measures the proportional change in total production of natural rubber (TPNR) for a given proportional change in price of PSMR20. Therefore, a 1% increases in price of PSMR20, average and other things unchanged, increases in total production of natural rubber (TPNR) by 0.08%. Burger and Smit (2000) found that at the each short-term supply model, a 1% increases in price of RSS1 in Singapore, average and other things unchanged, increases in total production of natural rubber (TPNR) by 0.1%, 0.06%, 0.18% and 0.07% in Malaysia, Indonesia, Thailand and Philippines, respectively. The coefficient of dummy variable for natural rubber total production is leading to a reduced production by 2 per cent of the total production. The equation as a whole explained about 88% of the variation in supply.

Estimated Structural Equation of Demand Model

$\ln TCNR_t = 1.20 + 0.012\ \ln TPPCT_{t-1} + 0.016\ \ln TPCVCT_{t-1} + 0.005\ \ln TPNRP_{t-1} - 0.078\ln STONR_{t-1}$
                    (0.74)   (1.36)   (0.26)   (-3.63)

$- 0.02\ \ln PSMR20_{t-1} - 0.03\ \ln RSS1_{t-1} + 0.19\ln WPOP_{t-1} - 0.002\ln COP_{t-1}\ - 0.014\ D1_{t-1} + 0.74\ \ln TCNR_{t-1} + 0.27\ \varepsilon_t$
(-0.32)   (-1.80)   (3.40)   (-0.22)   (-2.99)   (13.90)   (4.99)

                        $R^2 = 0.97$ Adjusted $R^2 = 0.96$

(Note: Numbers in parentheses are t-values).

The slope coefficient of average FOB price (PSMR20) measures the proportional change in total consumption of natural rubber (TCNR) for a given proportional change in price of PSMR20. Therefore, a 1% increases in price of PSMR20, average and other things unchanged, decreases in total consumption of natural rubber (TCNR) by 0.02%. Besides, it states that a 1% rises in price of RSS1, average and other things unchanged, total consumption of

natural rubber (TCNR) falls by 0.03%. Burger and Smit (2000) found that at the short-term demand model for world as a whole, a 1% increases in price of RSS1 in Singapore, average and other things unchanged, decreases in total consumption of natural rubber (TCNR) by 0.026%. The coefficient of dummy variable for natural rubber consumption is leading to a reduced consumption by 1 per cent of the total consumption. The equation as a whole explained about 97% of the variation in demand.

Estimated Structural Equation of Price Model

$$\ln PSMR20_t = -1.69 + 0.04 \ln TPNR_{t-1} - 0.06 \ln TCNR_{t-1} - 0.02 \ln STONR_{t-1} + 0.12 \ln TPPCT_{t-1}$$
$$\qquad\qquad (0.65) \qquad\qquad (-2.69) \qquad\quad (-0.38) \qquad\qquad (2.55)$$

$$+ 0.04 \ln TPCVCT_{t-1} + 0.07 \ln TPNRP_{t-1} + 0.02 \ln COP_{t-1} - 0.01 \ln EXM_{t-1} + 0.98 \ln PSMR20_{t-1} + 0.83\, \varepsilon_t$$
$$\quad (1.35) \qquad\qquad (1.32) \qquad\qquad (0.65) \qquad\quad (-0.21) \qquad\qquad (39.26) \qquad\qquad (2.04)$$

$$R^2 = 0.96 \qquad\qquad \text{Adjusted } R^2 = 0.96$$

(Note: Numbers in parentheses are t-values).

The results of all the estimated coefficients in the price equation show the expected signs. In the price equation, the explanatory variables explained about 96% of the variation in the monthly natural rubber price. The results indicated that the price of natural rubber (PSMR20) is highly dependent on demand, total production of passenger cars' and commercial vehicle cars' tyres, total production of natural rubber product and the price in the pervious period where they are significant at the 1% level. Burger, Smit and Vogelvang (2002) found that the short-run error-correction model included (E^I) the average exchange rates of seven important natural rubber importing countries to represent the demand side and (E^Q) the real exchange rates of the three major natural rubber producing countries to capture the important changes on the supply side. It mentioned that in the price linear model, the elasticity of price of PSMR20 with respect to (E^Q) is 0.219 and (E^I) is -0.32.

In the structural price log-linear model, the slope coefficient of exchange rate measures the proportional change in price of PSMR20 for a given proportional change in exchange rate. Therefore, a 1% increases in Exchange Rate for RM to US$, on average and other things unchanged, decreases in price of PSMR20 (US$/ton) by 0.01%. Also, a 1% rises in crude oil price (US$/barrel), on average and other things unchanged, increases in price of PSMR20 by 0.02%. Shane, M. (2007) mentioned that the outlook for sustained high prices of crude oil and petroleum price has changed the basic environment for global agriculture in a fundamental way. It is clear that bio-fuels energy sources are likely to be a significant part of the production of agricultural commodities. Energy prices were likely to stay high in 2001 and, prices tripled by 2006. Therefore, the bio-diesel production in Indonesian and Malaysian has been tempered by high palm oil prices and subsidized petroleum prices.

ARIMA Model

After following the Box-Jeckins procedure, the model of ARIMA (1,1,1) was chosen. It meant that to find out what the autocorrelation and partial autocorrelation pattern was for the series $PSMR20_t$, we needed to determine the relationship between $PSMR20_t$ and $PSMR20_{t-1}$ for all t. Thus, $PSMR20_t$ was autocorrelated for lag 1; i.e., the autocorrelation for lag 1 was nonzero. Otherwise, the autocorrelation for any lag greater than 1 was zero. The model was then fitted into the residual series from March 1990 to December 2006 which parameters the following estimates (with t-values in parantheses) and showed details in Table 4 & 5 (Appendix 1).

$$\ln PSMR20_t = 0.615\, PSMR20_{t-1} - 0.405\, E_{t-1} + 0.076\, E_t$$
$$\qquad\qquad (14.343) \qquad\qquad (9.316) \quad\; (2.481)$$
$$\qquad\qquad R^2 = 0.54 \qquad\qquad \text{Adjusted } R^2 = 0.54$$

$$\Phi_1 = 0.615^{***}\ (14.343) \qquad\qquad \theta_1 = 0.405^{***}\ (9.316)$$

where $PSMR20_t$ was the stationary series. The $\Phi_1 PSMR20_{t-1}$ represented the fit to the series value $PSMR20_t$, and Φ_1 was called an AR parameter of order 1. The term $\theta_1 E_{t-1}$ and E_t represented the assumed random error in the data at period t-1 and period t and θ_1 was called a MA parameter of order 1. Table 4 (Appendix 1) showed the parameter diagnostics that any given value in price of $PSMR20_t$ was directly proportional to the previous value $PSMR20_{t-1}$ plus some random error E_t and E_{t-1}. That was, what happens this period was only dependent on what happened last period, plus some current random error. The term ($-\theta_1 E_{t-1}$) was the use of the minus sign in front of θ_1 was conventional only and had no other significance. In Box-Jenkins models, the random error component played a dominant role in determining the structure of the model. Table 5 (Appendix 1) showed the residual diagnostics that residuals were not correlated to each other and significant that the model have included the correct parameters. Residual diagnostics and parameter diagnostics comprised the tools available for determining whether a selected model was valid. In the ARIMA model price equation, the AR and MA parameters explained about 54% of the variation in the monthly natural rubber price.

MARMA Model

$$\ln PSMR20_t = -5.65 + 0.41 \ln TPNR_{t-1} - 0.14 \ln TCNR_{t-1} - 0.13 \ln STONR_{t-1} - 0.03 \ln TPPCT_{t-1}$$
$$\quad\quad (2.72) \quad\quad\quad (-2.33) \quad\quad\quad (-0.94) \quad\quad\quad (-0.29)$$

$$+ 0.24 \ln TPCVCT_{t-1} + 0.79 \ln TPNRP_{t-1} + 0.42 \ln COP_{t-1} - 1.09 \ln EXM_{t-1} + 0.013\, PSMR20_{t-1} - 0.003\, E_{t-1} + 1.61\, E_t$$
$$\quad (2.65) \quad\quad\quad (4.97) \quad\quad\quad (5.36) \quad\quad\quad (-7.55) \quad\quad\quad (3.64) \quad\quad\quad (4.33) \quad\quad (3.50)$$

$$R^2 = 0.63 \quad\quad\quad \text{Adjusted } R^2 = 0.62$$

(Note: Numbers in parentheses are t-values).

The ARIMA model was substituted for the implicit error in the original econometric model equation. The combined regression-time-series model was referred to a MARMA model in Table 6 (Appendix 1). MARMA model equation related a dependent variable PSMR20 to lagged values of itself, current and lagged value of one or more independent variables, and an error term which was partially "explained" by a time-series model and it was estimated simultaneously. Table 7 (Appendix 1) showed the residual diagnostics that residuals were also not correlated to each other and significant that the model have included the correct parameters. In the MARMA model price equation, the explanatory variables and AR and MA parameters explained about 63% of the variation in the monthly natural rubber price.

Table3. Ex Post Natural Rubber (SMR20) Price Forecast (US$ per tonne) and Model Evaluations

Year	Actual Price	Econometric	ARIMA	MARMA
1990	757.5854	729.6986	757.2725	757.6224
1991	776.3920	758.3533	766.8331	775.7936
1992	795.1579	738.7839	740.0387	725.7421
19923	778.0796	789.3375	870.8128	774.6836
1994	1119.8500	818.9926	1213.1938	1038.3045
1995	1533.9718	1122.4041	1634.9364	1563.5094
1996	1313.9032	957.4687	1397.8274	1381.1625
1997	989.2150	946.5539	945.7956	982.3282
1998	666.0006	694.2222	674.8099	675.4455
1999	598.5746	580.6009	692.7961	595.5451
2000	533.0044	505.3284	536.2250	570.6206
2001	541.2719	532.5814	528.0674	586.4852
2002	749.4079	749.1173	790.5548	752.0606
2003	999.9298	993.7415	1132.3458	993.5872
2004	1215.3114	953.2568	1353.6466	1243.6898
2005	1380.5035	1071.2433	1538.9377	1389.1230
2006	1907.3101	1195.9170	1724.4981	1934.5316
RMSE		0.0852	0.0831	0.0814
RMPSE		3.0049	2.9484	2.8344
U		0.0198	0.0192	0.0189
U<SUP>m		0.0000	0.0000	0.0000
U<SUP>s		0.0167	0.0159	0.0153
U<SUP>c		0.9833	0.9841	0.9846

Source: Own calculation

Note: U<SUP>m = Fraction of error due to bias;
     U<SUP>s = Fraction of error due to variation
     U<SUP>c = Fraction of error due to covariation

The estimated model was then used to obtain the residual forecasts from 1990 to 2006 in Table 3 and obtained fitted values as close as possible to the original series values; i.e., minimize the sum of the squared residuals. The results of the Ex Post Natural Rubber (SMR20) Price Forecast (US$ per tonne) were presented by using Econometric, ARIMA and MARMA model in Table 3. The forecasting ability was tested based on the RMSE, RMPSE and Theil's inequality coefficients (U) criteria. The values of the RMSE, RMSPE and U of MARMA model were comparatively smaller than the values generated by the econometric and ARIMA model. These statistics suggested that the forecasting performance of the MARMA model was more efficient than the econometric and ARIMA model.

The price forecasts from 2007 to 2010 generated from the econometric, ARIMA and MARMA were presented in Figure 3. The prices of natural rubber (SMR20) are expected to remain firm and will increase around US$ 2000 per tons in 2010. Burger and Smit (2000) also showed that the assumption in the base scenario was the natural rubber prices would increase by 3% per annum to around US$ 1500 per tonne in 2020. If the natural rubber prices increased is assumed (6%) under this scenario with natural rubber prices increasing to around US$ 2000 per tonne. These higher natural rubber prices will lead to higher production and a steeper decline in prices after 2015.

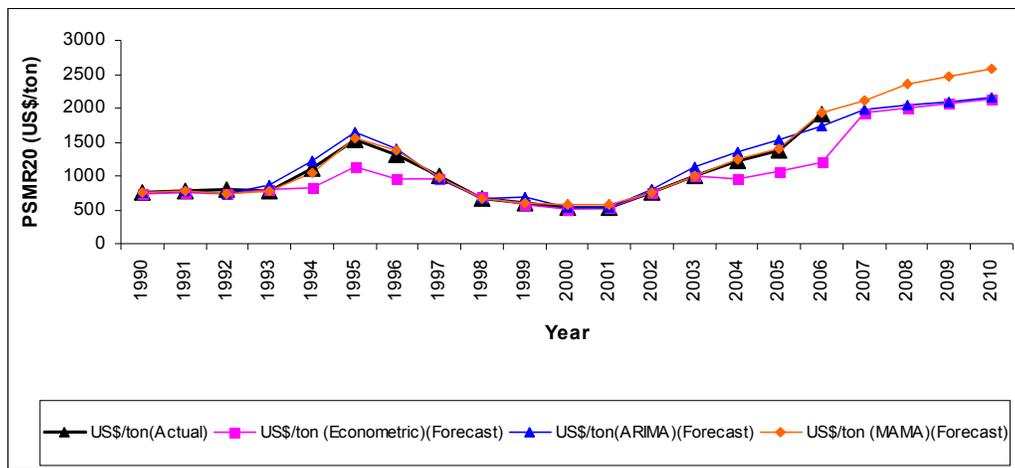*Ex ante Natural Rubber (SMR20) Price Forecast (US$ per tonne)*

Figure: 3

Conclusion

Based on the results of the above analysis, MARMA's ex post forecasts were more efficient measured either in terms of its statistical criteria or even by visual proximity with the actual prices. All the estimated coefficients in the price equation showed the expected signs. In the price equation, the price of natural rubber (PSMR20) was significantly related to five variables considered, i.e.., demand, total production of passenger cars' and commercial vehicle cars' tyres, total production of natural rubber product and the lagged price. In particular, prices were highly sensitive to changes in demand level at the estimated structural equation of price model.

A forecast which was found to be way off target when actual data become available provided information which may lead to revision of the model that provided the forecast. The study can be safely concluded that futures market is able to establish forward prices efficiently particularly as the expiry date approaches. This means that a forecast of a high price that is based on the assumption of a large budget increase may lead policy makers to alter their budget plans to invest for new decisions in the natural rubber market.

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Table 4. Estimation ARIMA (1,1,1) Model for PSMR20

Dependent Variable: PSMR20
Method: Least Squares
Date: 12/31/07   Time: 15:44
Sample (adjusted): 4 204
Included observations: 201 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR (1)	0.615324	0.042900	14.34309	0.0000
MA (1)	0.404746	0.043446	9.316026	0.0000
R-squared	0.540457	Mean dependent var		0.031943
Adjusted R-squared	0.538148	S.D. dependent var		0.661303
S.E. of regression	0.449419	Akaike info criterion		1.248179
Sum squared resid	40.19355	Schwarz criterion		1.281048
Log likelihood	-123.4420	Durbin-Watson stat		0.552992

Table 5. Evaluation ARIMA (1,1,1,) Model for PSMR20

ARCH Test (Residual Test)

F-statistic	36.39035	Probability		0.000000
Obs*R-squared	53.88541	Probability		0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 12/31/07   Time: 15:47
Sample (adjusted): 6 204
Included observations: 199 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.075621	0.030483	2.480807	0.0140
RESID^2(-1)	0.264412	0.072277	3.658292	0.0000
RESID^2(-2)	0.403404	0.088937	4.535823	0.0000
R-squared	0.270781	Mean dependent var		0.201974
Adjusted R-squared	0.263340	S.D. dependent var		0.437791
S.E. of regression	0.375752	Akaike info criterion		0.895184
Sum squared resid	27.67310	Schwarz criterion		0.944832
Log likelihood	-86.07079	F-statistic		36.39035
Durbin-Watson stat	1.853778	Prob(F-statistic)		0.000000

Table 6. Estimation MARMA Model for PSMR20

Dependent Variable: PSMR20
Method: Two-Stage Least Squares
Date: 01/14/08   Time: 02:32
Sample (adjusted): 4 204
Included observations: 201 after adjustments
Instrument list: PSMR20 TPNR TCNR STONR TPPCT TPCVCT TPNRP COP EXM AR(1) MA (1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.648023	1.613381	-3.500738	0.0006
TPNR	0.405764	0.149205	2.719505	0.0071
TCNR	-0.143753	0.061645	-2.331960	0.0208
STONR	-0.132119	0.140330	-0.941486	0.3477
TPPCT	-0.031733	0.111257	-0.285217	0.7758
TPCVCT	0.236802	0.089415	2.648348	0.0088
TPNRP	0.786608	0.158211	4.971905	0.0000
COP	0.420253	0.078406	5.359987	0.0000
EXM	-1.093117	0.144748	-7.551878	0.0000
AR(1)	0.012980	0.020177	3.643324	0.0000
MA (1)	0.002610	0.020341	4.328309	0.0000

R-squared	0.634910	Mean dependent var		2.129912
Adjusted R-squared	0.615695	S.D. dependent var		0.338353
S.E. of regression	0.209753	Sum squared resid		8.359304
F-statistic	33.04199	Durbin-Watson stat		0.538963
Prob(F-statistic)	0.000000			

Table 7. Evaluation MARMA model for PSMR20

ARCH Test: (Residual Test)

F-statistic	76.80536	Probability	0.000000
Obs*R-squared	55.89800	Probability	0.000000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 01/14/08   Time: 02:32
Sample (adjusted): 5 204
Included observations: 200 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.019407	0.004026	4.820410	0.0000
RESID^2(-1)	0.529439	0.060412	8.763866	0.0000
R-squared	0.279490	Mean dependent var		0.041534
Adjusted R-squared	0.275851	S.D. dependent var		0.052116
S.E. of regression	0.044349	Akaike info criterion		3.383508
Sum squared resid	0.389431	Schwarz criterion		3.350525
Log likelihood	340.3508	F-statistic		76.80536
Durbin-Watson stat	2.071336	Prob(F-statistic)		0.000000