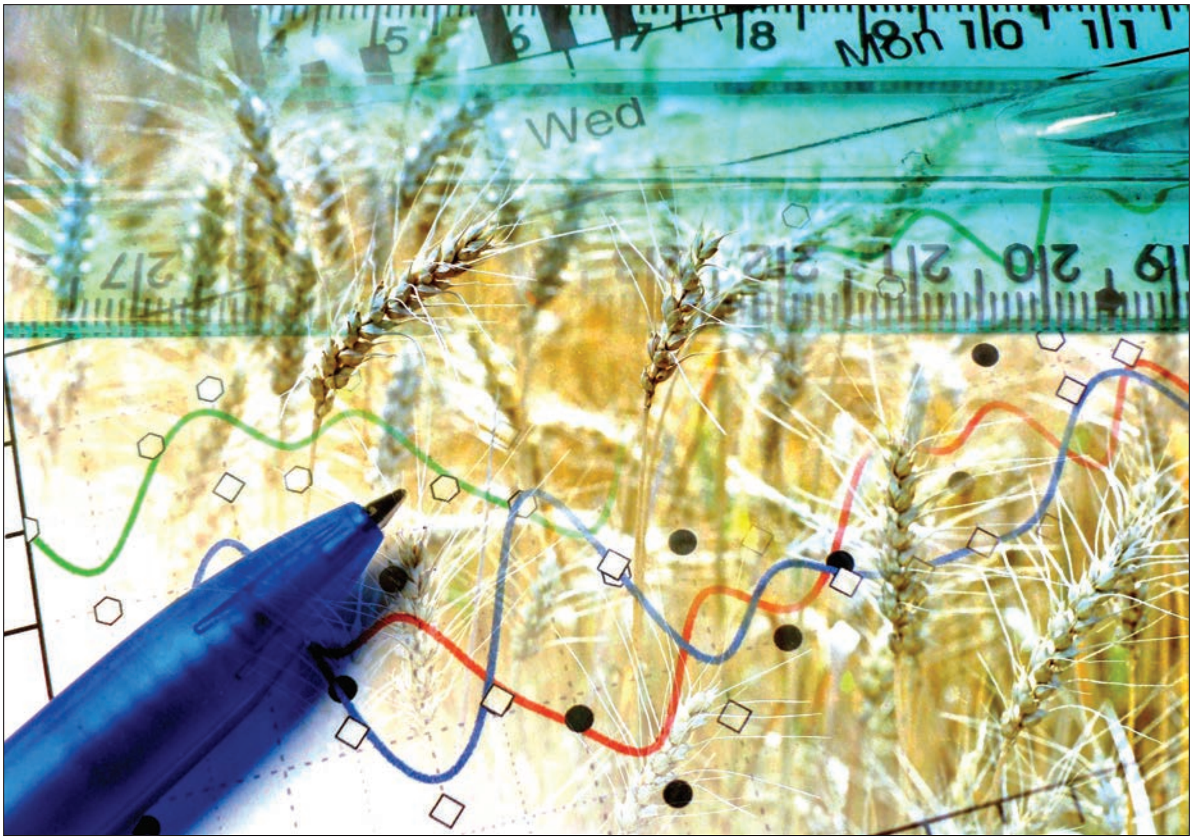

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Comparative Forecasting Models Accuracy of Short-term Natural Rubber Prices

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ABSTRACT

The study describes a number of short-term expost forecasts of econometric models and univariate model of autoregressive-integrated-moving average (ARIMA) model of Natural Rubber (NR) prices SMR20 (Standard Malaysia Rubber Grade 20) in the Malaysia market. The econometric models include single equation model using Vector Error Correction Method (VECM) and multivariate autoregressive-moving average (MARMA) model. The models were developed to determine the inter-relationships between NR production, consumption and prices, to forecast the price of NR (SMR20) and to determine which model is more efficient in their price forecasting accuracy. The models based on data from period January 1990-December 2008. Comparative forecasting models accuracy between single equation model, MARMA model and univariate model of ARIMA, were made in terms of their estimation accuracy based on RMSE, MAE, RMPE and (U-Theil) criteria. The results revealed that the values of the RMSE, MAE, RMPE and U of MARMA model were comparatively smaller than the values generated by single equation model and ARIMA model. These statistics suggested that MARMA model is more accurate and efficient measured in terms of its statistical criteria than single equation model and ARIMA model in forecasting the NR price of SMR20 in the next 6 months or so.

Key words: Expost forecasts, econometric models, single equation, MARMA, univariate model of ARIMA, natural rubber prices

INTRODUCTION

The leader in rubber production changed over time. Malaysia used to be number one before but in 2006, Thailand took over from Malaysia to become the largest producer with an annual production of 2.69 million MT (32% of world's NR production), followed by Indonesia at 2.45 million MT (27%) and Malaysia at 1.2 million MT (13%). However in 2008, Indonesia became the largest producer at 2.7 million MT, followed by Thailand at 2.6 million MT and Malaysia at 1.29 million MT. China was the largest consumer at 2.3 million MT, (26% of world's NR consumption), followed by USA at 1.89 million MT (11%) and Japan at 1.0 million MT (9.5%) in 2008. Table 1 also shows the world NR supply-demand surplus/deficit situation and from 2005-2008 shows a deficit situation in the world natural rubber supplies (IRSG, 2009).

Changes to the world stock situation affect the price, supply and demand of world natural rubber. The stock of natural rubber was 2.3 million MT in 2004 and it declined to 2.0 million MT

Table 1: World supply-demand surplus/deficit situation

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]

[a]Rounded to nearest 10,000 MT, Source: IRSG (2009)

Table 2: Malaysia natural rubber production, consumption, export and import ('000 MT)

				Consumption				
Year	Estates	Smallholdings	Total NR production	NR	SR	NR exports	NR imports	Balance of trade
2004	71	1,098	1,169	403	84	1,109	426	683
2005	65	1,061	1,126	386	96	1,128	462	666
2006	68	1,215	1,283	383	112	1,134	512	622
2007	68	1,132	1,200	450	129	1,018	605	413
2008	59	1,013	1,072	469	139	917	523	394

Note: NR = Natural rubber, SR = Synthetic rubber, Source: MRB (2009)

in 2008 and it was the lowest level since 2004. Moreover, the stock of natural rubber shows a decrease situation in year-on-year terms during this period and a decrease situation of the world natural rubber stock was -0.038 million MT in 2008 as compared with 2007. An inverse relationship between NR price and stock levels is implied because prices tend to peak during low levels of stock and vice versa in 2004 to 2008. As was evident, the decline in stocks during this period led to a rise in rubber prices (Burger and Smit, 2000).

The Malaysian rubber industry had produced positive net trade flows; provided steady employment and consistent earnings for the government. Rubber was also planted in Sabah and to a limited extent in Sarawak. Production from the estate sector accounted for only 5.5% (59 thousand MT) of total NR production in 2008 while production from the smallholder sector accounted for 94.5% (1,013 thousand MT). During these periods, the increased in production had also been due to some extent by the government assistance programs for smallholders (principally the Rubber Smallholders Income Supplement Scheme and Assistance for Low Intensity Tapping Systems Adoption). This scheme had been implemented since in mid-2001 which had encouraged tapping and increased both tree and land productivity (MRB, 2009).

Meanwhile, consumption of natural rubber had shown significant increment indicating an expanding rubber downstream sector. Domestic consumption of Malaysian NR recorded an increase of 14% from 2004 (403 thousand MT) to 2008 (469 thousand MT; i.e. 6.6% of world NR consumption) (Table 2). The increase was particularly significant in the latex products manufacturing industries, which accounted for 95% of total domestic consumption of NR in 2008. Similarly, consumption of synthetic rubber had also increased from 84 thousand MT in 2004 to 139 thousand MT (i.e. 1.4% of world synthetic rubber consumption) in 2008 (Table 2). Moreover, the ratio of natural to synthetic rubber consumption as at end 2008 was 77.1:22.9, reflecting the demand for natural rubber especially by the latex products manufacturing industries. This scenario indicates that the current total supply of natural rubber is sufficient for domestic consumption with surplus for export (MRB, 2009).

Like any other agricultural commodities, natural rubber was subjected to significant price fluctuations (Fig. 1). The years 1997 to 1999 and as well as in the year 2000 were turbulent years

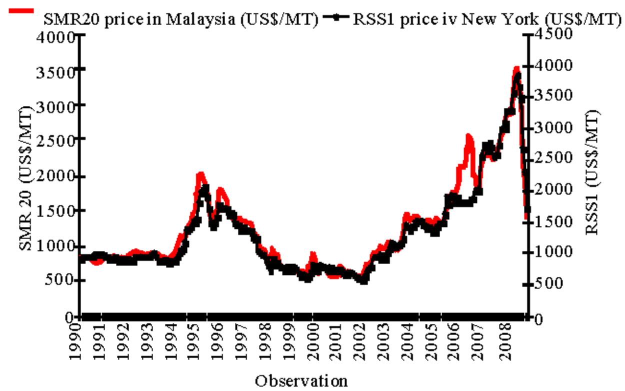

Fig. 1: SMR20 price (Standard Malaysia Rubber Grade 20) in Malaysia and RSS1 price (Ribbed Smoke Sheet Rubber Grade 1) in New York in January 1990 to December 2008 in the world NR market, Source: IRSG (2009)

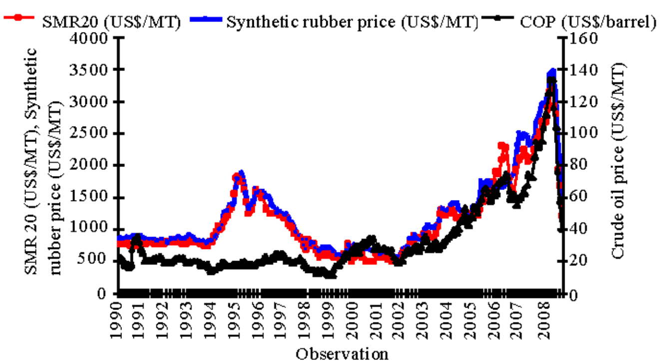

Fig. 2: Crude Petroleum Oil (COP), natural rubber (SMR 20) and synthetic rubber prices in January 1990 to December 2008. Source: IRSG (2009)

for the economies in South-East and East Asia (Fig. 2). In 2008, the extremely low prices due to the outbreak of the global recession. It experienced during these years contributed to price volatility and instability in many countries, especially rubber smallholders in South East Asia (ANRPC, 2009).

Variations in a series can arise from long term trends, short term fluctuations (instability) or both together. Uncertainty in a market generally originates from short-term fluctuations rather than long term trends. Therefore, a meaningful measure of instability is one representing short-term fluctuations alone. A limitation in measuring instability (i.e., market uncertainty) by using Coefficient of Variation (CV) (price variability) is that it gives the total variation arising from both long-term trends and short-term fluctuations. Economists prefer measuring instability by using the instability index (Ix) which gives a measure of variability arising from short term fluctuations after eliminating effect of long term fluctuations. Table 3 gives CVs and calculated instability indices (Ix) of major traded forms of NR prices in the world market. It reveals a much higher degree of market uncertainty in 2008 compared to 2007 and 2009. Moreover, if in terms of

Table 3: Price total variability and instability index of 2007 to 2009

	2007		2008		2009	
	Total Variability (CV)	Instability Index (Ix)	Total Variability (CV)	Instability Index (Ix)	Total Variability (CV)	Instability Index (Ix)
TSR						
Bangkok STR 20	6.5	4.5	22.6	8.5	14.7	4.0
Kuala Lumpur SMR 20	6.9	4.6	23.1	8.7	14.4	3.7
RSS						
New York RSS1	6.6	6.6	23.3	7.7	14.7	4.4
Bangkok RSS3	6.5	6.5	22.5	7.8	14.2	4.2
Kottayam (India) RSS4	7.4	5.5	23.9	10.6	16.7	6.2
Latex 60%						
Kuala Lumpur	9.5	9.5	23.6	8.2	10.2	6.5

Source: NR market review of ANRPC, 2010a,b. $I_x = CV\sqrt{(1-R^2)}$, where R^2 is the explanatory power of the best fitting trend curve. If long-term trend is insignificant for a series, R^2 would be zero and I_x would be equal to CV

price variability (CV) and price instability Index (I_x) examined, it had been much higher in 2008 as compared with 2007 and 2009 in all NR prices. Among various NR markets, the highest degree of uncertainty was for RSS4 in Kottayam (ANRPC, 2010a,b).

The fundamentals influencing NR prices are demand and supply factors, 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 fall in the price of natural rubber relates to synthetic rubber. Moreover, the crude petroleum oil price is an important component of synthetic rubber. A fall in the crude petroleum oil price also relates to synthetic rubber. It influences a declining share of synthetic rubber in total rubber consumption.

Currency exchange rate also affects in the NR producing countries because most commodities are traded in US dollar. It encourages an increase in exports and concomitant output from these producing countries and hence a rise in world natural rubber supply. If the price is expected to have negative relationship with the exchange rate for Malaysia RM per USD (RM/USD), indicating that more Malaysia RM would be paid for 1 USD, then the NR price would be decreased as experienced during the forecasting period. Natural rubber price rose from USD 2314.51 per MT in June 2007 rising to USD 3457.58/MT in June 2008 whilst RM per USD decreased from 3.38 to 3.22 over the same period. Therefore, world NR supply and demand situation, world NR stocks, trend of crude petroleum oil price and currency exchange rate values in NR exporting countries are the various factors generally should be considered as influencing NR price movements in current Malaysia NR industry and for the modeling process to develop the monthly short-term price forecasting model of natural rubber in this study. Uncertain weather, including haze, has also affected production. Moreover, the objectives of the study are to determine the inter-relationships between NR production, consumption and prices, to forecast the price of NR (SMR20) and to determine which model is more efficient in their price forecasting accuracy.

MATERIALS AND METHODS

The study presents short-term ex post forecasts of econometric models and univariate model of autoregressive-integrated-moving average (ARIMA) model of Natural Rubber (NR) prices SMR20

(Standard Malaysia Rubber Grade 20) in the Malaysia market. The econometric models include single equation model using Vector Error Correction Method, (VECM) (Gilbert, 1986; Hendry and Ericsson, 2001) and multivariate autoregressive-moving average (MARMA) model. They were developed to determine the inter-relationships between NR production, consumption and prices, to forecast the price of NR (SMR20) and also to determine which model is more efficient in terms of their comparative price forecasting accuracy. The study was conducted in 2009 using secondary data from Jan. 1990 to Dec. 2008.

The earlier studies examined and reviewed the supply, demand and price relationship based on models developed by Shepherd (1963), Meyanathan (1983), Tan (1984), Arshad and Zainalabidin (1994), Barlow *et al.* (1994), Goodwin (1994), Shamsudin and Arshad (1998), Ferris (1998), Burger and Smit (1997, 2000) and Enders (2004).

Model specification

Single-equation econometric models of nr supply, demand and price

NR supply forecasting model: A monthly short-term model of the Malaysia natural rubber market is formulated comprising of three behavioral single-equations and identified the supply of natural rubber (TPNR) as a function of related factors (in logs) as follow:

$$TPNR_t = f\,(PSMR\ 20_{t-i}, TPNR_{t-i}, T, e_{ti}) \quad (1)$$

Where:

TPNR = Total production of natural rubber (Total Supply) (000 metric tonnes) (MT)
PSMR20 = Real monthly price of SMR20 in Malaysia (USD/MT) deflated by the CPI
T = Time trend, Jan. 1990 to Dec. 2008
t and e_i = Time period and error terms, respectively

NR demand forecasting model: The demand of natural rubber (TCNR) as a function of related factors (in logs) can be specified as follow:

$$TCNR_t = f\,(PSMR\ 20_t, RSS1_t, TCNR_{t-i}, T, e_{ti}) \quad (2)$$

Where:

TCNR = Total consumption of natural rubber and synthetic rubber (Total Demand) (000 MT)
PSMR20 = Real monthly price of SMR20 in Malaysia (USD /MT) deflated by the CPI
RSS1 = Real monthly price of RSS1 in New York (USD /MT) deflated by the CPI
T = Time trend, Jan. 1990 to Dec. 2008
t and e_i = Time period and error terms, respectively

NR price forecasting model: The NR price (PSMR20) equation, which was derived based on related factors (in logs) can be stated as follows:

$$PSMR20_t = f\,(TPNR_t, TCNR_t, STONR_t, COP_t, EXM_t, PSMR20_{t-i}, T, e_{ti}) \quad (3)$$

Where:

PSMR20 = Real monthly price of SMR20 in Malaysia (USD/MT) deflated by the CPI

TPNR = Total production of natural rubber (Total Supply) (000MT)
TCNR = Total consumption of natural rubber and synthetic rubber (Total Demand) (000 MT)
STONR = Total stock of natural rubber (000 MT)
COP = Crude petroleum oil monthly price (USD/barrel)
EXM = Real monthly average exchange rate (Malaysia Ringgit (RM) per USD) (RM/USD)
T = Time trend, Jan. 1990 to Dec. 2008
t and e_i = Time period and error terms

Model estimation

Vector Error Correction Method (VECM): A vector error correction method (VECM model) is a restricted vector autoregression (VAR) designed for use with non-stationary series that are known to be cointegrated (Gilbert, 1986; Hendry and Ericsson, 2001). The VECM model has cointegration equation built into the specification so that it restricts the long-term behavior of the endogenous variables to converge to their cointegrating relationship while allowing for short-term adjustment dynamics. The cointegration equation is known as the error correction method (ECM model) since the deviation from long-term equilibrium is corrected gradually through a series of partial short-term adjustments (Engle and Granger, 1991).

The corresponding VECM model is:

$$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta\, y_{1,t-1}) + \varepsilon_{1,t} \tag{4}$$

$$\Delta y_{2,t} = \alpha_2 (y_{2,t-1} - \beta\, y_{1,t-1}) + \varepsilon_{2,t} \tag{5}$$

where, α_i is a vector of intercept terms, β_i is the coefficient matrices and ε_i is the disturbance terms. Therefore, the VECM model is included a vector of intercept terms (α_i) and the disturbance terms (ε_i).

In the error correction method (ECM model) (cointegration equation), the only right-hand side variable is the error correction term. In long-term equilibrium, this term is zero. Therefore, ECM models have without a vector of intercept terms (α_i) and the disturbance terms (ε_i). However, if and deviate from the long-term equilibrium, the error correction model will be nonzero and each variable adjusted to partially restore the equihbrium relation. The coefficient α_i measures the speed of adjustment of the i-th endogenous variable towards the equilibrium.

For this study, the VECM model for NR supply is:

$$\Delta TPNR_t = \alpha_1 + \beta_1\, PSMR\ 20_{t-1} + \beta_2\, TPNR_{t-1} + \varepsilon_t \tag{6}$$

The VECM model for NR demand is:

$$\Delta TCNR_t = \alpha + \beta_1 (PSMR\ 20_{t-1}) + \beta_2 (RSS1_{t-1}) + \beta_4\, TCNR_{t-1} + \varepsilon_t \tag{7}$$

The VECM model for NR price is:

$$\Delta PSMR\ 20_t = \alpha + \beta_1 (TPNR_{t-1}) + \beta_2 (TCNR_{t-1}) + \beta_3 (STONR_{t-1}) + \beta_4 (COP_{t-1}) + \beta_5 (EXM_{t-1}) + \beta_6 PSMR\ 20_{t-1} + \varepsilon_t \tag{8}$$

The VECM models for NR supply, demand and price have described in detail and, however, the VECM model for NR price will be only carried out for in this study.

MARMA model: The multivariate autoregressive-moving-average (MARMA) model is well documented in (Makridakis *et al.*, 1998; Pindyck and Rubinfeld, 1998). A brief description of the model is discussed below. The multivariate autoregressive-moving average (MARMA) model was developed to forecast short-run monthly prices of SMR20 in the Malaysia market. The model will also be used to generate ex post forecasts for the period of January 2007 to December 2008 based on data from period January 1990 to December 2008.

Model specification: Suppose that one would like to forecast a variable $PSMR20_t$ using an econometric model. Presumably such a model would include explanatory variables which could provide an explanation for movements in $PSMR20_t$ but which are not collinear. One effective application of time-series analysis is to construct an ARIMA model for the residual series ε_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 $PSMR20_t$, it is able to make a forecast of the error term ε_t using the ARIMA model. 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:

$$PSMR20_t = a_0 + a_1 TPNR_{t-1} + a_2 TCNR_{t-1} + a_3 STONR_{t-1} + a_4 COP_{t-1} + a_5 EXM_{t-1} + \underbrace{AR(1)(\phi_1) + MA(1)(\theta_1)}_{\varphi^{-1}(B)\,\theta(B)\eta_t} \quad (9)$$

where, Δ_t is a normally distributed error term which may have a different variance from residual error ε_t. The parameters α_0, α_1, α_2 and ..... 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. Then,

PSMR20	= Real monthly price of SMR20 in Malaysia (USD/MT) deflated by the CPI.
TPNR	= Total production of natural rubber (Total Supply) (000 metric tonnes) (MT)
TCNR	= Total consumption of natural rubber and synthetic rubber (Total Demand) (000 MT)
STONR	= Total stock of natural rubber (000 MT)
COP	= Crude oil monthly price (USD/barrel)
EXM	= Real monthly average exchange rate (Malaysia Ringgit (RM) per USD) (RM/USD)
$AR(1)(\phi_1)$	= AR parameter of order 1 (The ϕ_1 $PSMR20_{t-1}$ represented the fit to the series value $PSMR20_t$,)
$MA(1)(\theta_1)$	= MA parameter of order 1 (The term θ_1 ε_{t-1} and ε_t represented the assumed random error in the data at period t-1 and period t)
T	= Time trend, 1990 Jan: to 2008 Dec:
t and e_i	= Time period and error terms respectively

Equation 9 is referred to as a transfer function model or, alternatively, a multivariate autoregressive-moving-average (MARMA) model. The MARMA model with the residual correction methods such as ARCH (LM) (Autoregressive Conditional Heteroskedasticity) test will be developed to forecast short-term monthly natural rubber prices in the Malaysia market. 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 *et al.* (1994), Hoff (1983), O'Donovan (1983) and Cheung *et al.* (1998). 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. In terms of the original series such models are called integrated models and the AR and MA models may also be combined to form by Auto Regressive, Integrated, Moving-Average (ARIMA) models.

Model specification: The short-term price forecasting models based on the Box-Jeckins procedure, univariate time-series model of the autoregressive-integrated moving average ARIMA (p,d,q) can be specified follows:

$$PSMR20_t = C + \underbrace{(\phi_1 PSMR20_{t-1} + ...\phi_p PSMR20_{t-p})}_{(AR(1)(\phi_1)} - \underbrace{(\theta_1 \varepsilon_{t-1} + ...\theta_q \varepsilon_{t-q})}_{(MA(1)(\theta_1)} + \varepsilon_t \quad (10)$$

where, $PSMR20_t$ = Real monthly price of SMR20 in Malaysia (USD/MT) deflated by the CPI and C = intercept terms and ε_t = the disturbance terms.

$PSMR20_t$ is related to both past series values and past random errors and it was the stationary series. The ARIMA model of order ARIMA (1,1,1) was found to be the most appropriate model and generate the best forecast with minimum error. The numbers inside the parentheses of ARIMA (1,1,1) model of order (p,d,q) 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. It meant that to find out what the autocorrelation and partial autocorrelation pattern was for the series the monthly prices of $PSMR20_t$, 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.

In Eq. 8, ε_t is a random disturbance assumed to be distributed as N (0, σ^2). The ϕ_i s are called autoregressive (AR) parameters and θ_i s are also called moving-average (MA) parameters. The subscripts on the ϕ's and θ'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.

The stationary conditions for this model are:

$$|\phi_1| < 1 \quad \text{and} \quad |\theta_1| < 1$$

The $\phi_1 PSMR20_{t-1}$ represented the fit to the series value $PSMR20_t$ and ϕ_1 was also called an AR parameter of order 1. The term θ_1 ε_{t-1} and ε_t represented the assumed random error in the data at period t-1 and period t and θ_1 was also called a MA parameter of order 1. The parameter diagnostics showed that any given value in price of $PSMR20_t$ was directly proportional to the previous value $PSMR20_{t-1}$ plus some random error ε_t and ε_{t-1}. That was, what happens this period was only dependent on what happened last period, plus some current random error. The term ($-\theta_1$ ε_{t-1}) was the use of the minus sign in front of θ_1 was conventional only and had no other significance.

The ARIMA model with the residual correction methods such as ARCH (LM) (Autoregressive Conditional Heteroskedasticity) test will also be developed to forecast short-term monthly natural rubber prices in the Malaysia market. The model will also be used to generate ex post forecasts for the period of January 2007 to December 2008 based on data from period January 1990 to December 2008.

Model simulation: The comparison of the forecast accuracy of the selected natural rubber price forecasting models of the single equation model, MARMA model and ARIMA model were evaluated and generated. Firstly, the data used from January 1990 to December 2006 for estimation, with observations from January 2007 to June 2007 simulated for ex post forecast. It means that the data was in beyond the time period used to estimate the price SMR20 in the next 6 months or so. Similarly, the data was simulated forward in time beyond the estimation period from January 1990 to June 2007 and reserved for ex post forecast with observations from July 2007 to December 2007. The data was subsequently employed for ex post forecast from January 2008 to June 2008 and ex post forecast from July 2008 to December 2008. Only data up from January 1990 to December 2008 was generated for simulation of ex post forecasts.

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 Error (RMSE), the Mean Absolute Error (MAE), the Root Mean Percent Error (RMPE) and Theil's inequality coefficients (U) criteria. In the historical or ex post simulation, the RMSE of all the endogenous variables are less than one percent and the values of MAE are all small. The values of the Theil's inequality coefficient U are all nearly zero which is that the forecasting performance of the estimated model is satisfactory. The MAE and the RMSE can be used together to diagnose the variation in the errors in a set of forecasts. The RMSE will always be larger or equal to the MAE; the greater the difference between them, the greater the variance in the individual errors in the sample. If the RMSE = MAE, then all the errors are of the same magnitude. Both the MAE and RMSE can range from 0 to ∞. They are negatively-oriented scores and lower values are better.

RESULTS

Single equation NR price econometric model: Table 4 shows that single equation of short-term monthly natural rubber price econometric model with the forecast error reduced methods using Vector Error Correction Method (VECM) with cointegration characteristics and the explanatory variables which accounted for about only 39% of the variation in the monthly natural rubber price. In the cointegration equation of price (PSMR20) forecasting econometric model, the results indicated that the price of natural rubber (PSMR20) is highly and positively dependent on Total Production of Natural Rubber (TPNR).

The results also indicated that the price of natural rubber (PSMR20) is highly and negatively dependent on Total Consumption of Natural Rubber (TCNR). The cointegration approach was used directly to test long-term variables and indirectly to know imbalance in short-term by using parameter estimate from long-term relationship variables. Estimations reveal that the explanatory variables, namely Total Production of Natural Rubber (TPNR) and the total consumption of natural rubber and synthetic rubber (TCNR), were the most important explanatory variables in the cointegration equation of price (PSMR20) forecasting econometric model with significance at 0.01 level.

Table 4: Results of single equation of NR price econometric model to determine structural equation

Error correction:	$\Delta(PSMR20_t)$	$\Delta(TPNR_t)$	$\Delta(TCNR_t)$	$\Delta(STONR_t)$	$\Delta(COP_t)$	$\Delta(EXM_t)$
CointEq1	-0.020	-0.161***	0.711***	0.590	-0.142	0.383
	(0.002)	(0.003)	(0.001)	(0.001)	(0.003)	(0.001)
	[-0.869]	[-5.472]	[6.127]	[3.976]	[-0.541]	[0.558)
$\beta_1(TPNR_{t-1})$	0.077	0.044	-0.149***	0.042	0.012	-0.013
	(0.049)	(0.062)	(0.002)	(0.031)	(0.055)	(0.015)
	[0.156]	[0.701]	[-6.108]	[1.343]	[0.213]	[-0.914]
$\beta_2(TCNR_{t-1})$	-0.103	-0.904***	0.131	-0.137	0.048	-0.032
	(0.125)	(0.003)	(0.062)	(0.079)	(0.141)	(0.037)
	[-0.819]	[-5.719]	[2.110]	[-1.721]	[0.345]	[-0.874]
$\beta_3(STONR_{t-1})$	-0.062	0.189	-0.123	0.081	0.137	-0.015
	(0.125)	(0.158)	(0.062)	(0.079)	(0.139)	(0.037)
	[-0.496]	[1.199]	[-1.980]	[1.009]	[0.982]	[-0.414]
$\beta_4(COP_{t-1})$	0.054	0.021	0.128	0.026	0.341	0.008
	(0.061)	(0.077)	(0.030)	(0.039)	(0.068)	(0.018)
	[0.887]	[0.267)	[4.222)	[0.681)	[4.983)	[0.461)
$\beta_5(EXM_{t-1})$	-0.459	-0.117	-0.048	-0.072	0.102	0.182
	(0.226)	(0.285)	(0.112)	(0.144)	(0.253)	(0.066)
	[-2.029]	[-0.409]	[-0.429]	[-0.503]	[0.401]	[2.752]
$\beta_6(PSMR20_{t-1})$	0.281***	0.098	-0.044	-0.031	0.115	-0.0649
	(0.004)	(0.088)	(0.035)	(0.044)	(0.078)	(0.021)
	[4.019]	[1.116]	[-1.257]	[-0.679]	[1.468]	[-3.171]
α	0.001	-0.004	-0.001	0.003	0.001	0.001
	(0.005)	(0.006)	(0.002)	(0.003)	(0.006)	(0.001)
	[0.025]	[-0.630]	[-0.233]	[0.807]	[0.220]	[0.677]
Statistical analysis						
R-squared	0.395	0.284	0.309	0.160	0.145	0.096
Adj.R-squared	0.366	0.261	0.287	0.133	0.118	0.067
Sumsq.resids	0.181	0.279	0.290	0.476	0.378	0.101
S.E.equation	0.074	0.093	0.036	0.047	0.082	0.022
F-statistic	3.269	12.368	13.968	5.948	5.299	3.302
Loglikelihood	273.033	220.542	431.608	375.799	247.674	550.569
AkaikeAIC	-2.245	-1.881	-3.749	-3.255	-2.121	-4.802
SchwarzSC	-2.024	-1.759	-3.628	-3.134	-1.999	-4.681
Meandependent	0.002	0.002	0.001	0.002	0.003	0.001
S.D.dependent	0.076	0.108	0.043	0.051	0.088	0.022

Source: Own Data calculations, Standard errors in ( ) and t-statistics in [ ]. Note: ***Statistically significant at the 0.01 level, **at the 0.05 level and *at the 0.10 level

Therefore, a 1% increase in price of SMR20 in Malaysia (USD/MT), other things unchanged, increases Total Production of Natural Rubber (TPNR) by 0.16% with statistically significance at the 0.01 level. Moreover, a 1% increase in price of SMR20 in Malaysia (USD/MT), on average, has the adverse effect of decreasing the total consumption of natural rubber and synthetic rubber (TCNR) by 0.71% with statistically significance at the 0.01 level. Therefore, they are cointegrated between the Total Production of Natural Rubber (TPNR), total consumption of natural rubber and synthetic rubber (TCNR) and price of SMR20 in the single equation of price econometric forecasting model.

Significantly, in the results of the single equation of price forecasting model with the forecast error reduced methods using Vector Error Correction Method (VECM) with cointegration characteristics, estimations revealed that the explanatory variables, namely, the price of SMR20 in the price (PSMR20) equation, total consumption of natural rubber and synthetic rubber (TCNR) in the supply (TPNR) equation and Total Production of Natural Rubber (TPNR) in the demand (TCNR) equation, were the most important explanatory variables with statistically significance at the 0.01 level, respectively.

MARMA model: In the MARMA model price equation, the explanatory variables and AR and MA parameters also explains about 76% of the variation in the monthly natural rubber price model in Table 5. It also shows the results of the ex post forecast of MARMA model of the short-term monthly prices of PSMR20. The term AR (1) (ϕ_1) ($\phi_1 PSMR20_{t-1}$) (ϕ_1 is an AR parameter of order 1) represents the fit to the series value $PSMR20_t$ and the coefficient value is 0.607. The term MA(1) (θ_1) ($\theta_1\ \varepsilon_{t-1}$) ($\theta_1$ is a MA parameter of order 1) and ε_{t-1} represents the assumed random error in the data at period t-1 and ε_t represented at period t and the coefficient value is 0.318 and 0.042. The parameter diagnostics of MARMA model shows that any given value in price of $PSMR20_t$ was directly proportional to the previous value $PSMR20_{t-1}$ plus some random error ε_t and ε_{t-1} significant that the model have included the correct parameters. The residual diagnostics shows that residuals are significance at the 0.01 level that the model has included the correct parameters.

Furthermore, a 1% increase in price of SMR20 in Malaysia (USD/MT), other things unchanged, increases total production of natural rubber (TPNR) by 0.49% with statistically significance at the 0.01 level. Moreover, a 1% increase in price of SMR20 in Malaysia (USD/MT), on average, has the adverse effect of decreasing the total consumption of NR and SR (TCNR) by 0.79% with statistically significance at the 0.01 level. Besides, a 1% increase in price of SMR20 in Malaysia (USD/MT), on average, has the adverse effect of decreasing the world total stock of natural rubber (STONR) by 0.45% with statistically significance at the 0.01 level.

The result of the model indicated that there is an inverse relationship between the price of natural rubber (SMR20) and world total stock of NR (STONR). It was indicating that prices may tend to peak while the stock was low level during the forecasting period. The slope coefficient of exchange rate measures the proportional change in price of PSMR20 for a given proportional change in exchange rate. Results indicated that the price of natural rubber (PSMR20) is highly and negatively dependent on the exchange rate for Malaysia RM per USD (RM/USD). It indicates that more Malaysia RM would be paid for 1 USD when the NR price would be low again as experienced during the forecasting period.

Besides, the results indicated that the price of natural rubber (PSMR20) is highly and positively dependent on Crude Oil Price (COP). Therefore, a 1% increase in crude oil price (USD/barrel), on average and other things unchanged, increases the price of PSMR20 by 0.43%. Shane (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. The price of crude oil had been on an upward move again, rising from its lowest level in over five years of USD 40 per barrel in December 2008 and also compared with the lowest level of natural rubber price (SMR20) of USD 1376.57 per MT in December 2008 (IRSG, 2009).

Table 5: Results of MARMA model to determine structural equation

Independent variable	Dependent variable ($PSMR\ 20_t$)	ARCH LM test
a_0	0.027	0.117
	(0.042)	(0.065)
	[0.633]	[1.798]
$a_1\ TPNR_{t-1}$	0.494***	
	(0.114)	
	[4.344]	
$a_2\ TCNR_{t-1}$	-0.790***	
	(0.289)	
	[-6.188]	
$a_3\ STONR_{t-1}$	-0.453***	
	(0.119)	
	[-3.781]	
$a_4\ COP_{t-1}$	0.427***	
	(0.052)	
	[8.301]	
$a_5\ EXM_{t-1}$	-0.514***	
	(0.158)	
	[-9.587]	
AR (1) (ϕ_1)	0.607***	
	(0.041)	
	[14.724]	
MA(1) (θ_1)	0.318***	
	(0.041)	
	[7.755]	
F-statistic		67.447***
Obs R-squared		52.197***
MA(1) (θ_1)		0.808***
		(0.098)
		[8.213]

Statistical analysis	Values	Statistical analysis	Values
R-squared	0.759	Mean dependent var	2.341
Adjusted R-squared	0.752	S.D. dependent var	0.429
S.E. of regression	0.076	Akaike info criterion	-2.286
Sum squared resids	0.231	Schwarz criterion	-2.149
Log likelihood	265.013	F-statistic	868.470
Durbin-Watson stat	0.239	Prob(F-statistic)	0.000

Source: Own Data Calculations, Standard errors in ( ) and t-statistics in [ ]. Note: *** Statistically significant at the 0.01 level, ** at the 0.05 level and * at the 0.10 level

ARIMA model: Table 6 shows that the results of the ARIMA model of the ex post forecast of short-term monthly prices of SMR20. Briefly, the model was a univariate approach which was built on the premise that knowledge of past values of a time series was sufficient to make forecasts of the variable in the equation. The term $\phi_1 PSMR20_{t-1}$ (ϕ_1 is an AR parameter of order 1) represents the fit to the series value $PSMR20_t$ and the coefficient value is 0.591. The term $\theta_1\ \varepsilon_{t-1}$ (θ_1 is a MA parameter of order 1) and ε_{t-1} represented the assumed random error in the data at period t-1 and ε_t represented at period t and the coefficient value is 0.431 and 0.036.

The parameter diagnostics shows that any given value in price of $PSMR20_t$ was directly proportional to the previous value $PSMR20_{t-1}$ plus some random error ε_t and ε_{t-1}. Meaning that,

Table 6: Results of AIRMA model to determine structural equation

Independent variable	Dependent variable (PSMR 20_t)		ARCH LM test
C	0.094		0.136
	(0.036)		(0.041)
	[2.601]		[3.339]
ϕ_1 PSMR20_{t-1} (AR (1) ϕ_1	0.591***		
	(0.039)		
	[15.028]		
θ_1 ε_{t-1} (MA(1)(θ_1)	0.431***		
	(0.039)		
	[10.924]		
F-statistic			26.341***
Obs R-squared			42.976***
MA(1) (θ_1)			0.266***
			(0.066)
			[4.066]
Statistical analysis	Values	Statistical analysis	Values
R-squared	0.569	Mean dependent var	0.087
Adjusted R-squared	0.566	S.D. dependent var	0.816
S.E. of regression	0.538	Akaike info criterion	-2.261
Sum squared resides	0.219	Schwarz criterion	-2.120
Log likelihood	175.719	F-statistic	145.125
Durbin-Watson stat	0.201	Prob(F-statistic)	0.000

Source: Own Data Calculations, Standard errors in ( ) and t-statistics in [ ]. Note: *** Statistically significant at the 0.01 level, ** at the 0.05 level and * at the 0.10 level

what happens this period was only dependent on what happened last period, plus some current random error. The term ($-\theta_1 \varepsilon_{t-1}$) with the minus sign in front of θ_1 was conventional only and had no other significance. In Box-Jenkins models, the random error component plays a dominant role in determining the structure of the model. The residual diagnostics (ARCH LM test) shows that residuals are significance at the 0.01 level that the model has 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 explains about 57% of the variation in the monthly natural rubber price.

DISCUSSION

The results showed that of the explanatory variables identified, total production of natural rubber (total supply) (000 MT) ($TPNR_t$),total consumption of natural rubber and synthetic rubber (total demand) (000 MT) ($TCNR_t$), world total stock of natural rubber (000 MT) ($STONR_t$), crude oil monthly price (USD/barrel) (COP_t), real monthly average exchange rate (Malaysia Ringgit (RM) per USD) (RM/USD) (EXM_t), (ϕ_1) (is an AR parameter of order 1) represents the fit to the series value PSMR20_t (real monthly price of SMR20 in Malaysia (USD/MT) deflated by the CPI) and (θ_1) (is a MA parameter of order 1), were the most important explanatory variables in the NR price forecasting models. The results of the comparison of the forecast accuracy of the ex post forecast of natural rubber (SMR20) monthly price (US$ per MT) using single equation model, MARMA model and ARIMA model are presented in Table 7. The forecasting power was compared based on the RMSE, MAE, RMPE and Theil's inequality coefficients (U) criteria. The values of the RMSE, MAE, RMPE and U of MARMA model were comparatively smaller than the values generated by single

Table 7: Model Evaluation of Ex post forecast of monthly natural rubber price SMR20 (USD per MT) of single equation, MARMA and ARIMA models from July 2008 to December 2008

Period	Actual price	Single equation (VECM)	MARMA	ARIMA
2008.01	2765.492	2548.798	2552.814	2855.117
2008.02	2909.098	2857.426	2841.517	3002.664
2008.03	2866.651	2833.594	2832.380	2920.172
2008.04	2874.150	2996.063	2977.444	3009.728
2008.05	3104.299	3018.294	3045.237	3253.994
2008.06	3457.580	3367.698	3420.441	3484.395
2008.07	3530.961	3724.157	3720.819	3420.677
2008.08	3266.276	3135.168	3087.639	3168.465
2008.09	3144.362	2892.827	2859.372	3144.362
2008.10	2150.917	2023.563	2013.099	2165.125
2008.11	1891.631	1647.343	1793.887	2016.145
2008.12	1376.566	1128.134	1269.448	1202.452
RMSE		0.334	0.208	0.209
MAE		0.276	0.162	0.164
RMPE		7.887	7.349	7.414
U-STAT		0.058	0.044	0.045

Source: Own Data Calculations

equation and ARIMA models. These statistics suggested that the forecasting performance of the MARMA model was more efficient than single equation and ARIMA models.

World NR prices were used to forecast by using econometric model of the world natural and synthetic rubbers market (Tan, 1984). The study was concerned with the specification, estimation and validation of an econometric model of the world natural and synthetic rubber market. The study was also concerned the application of the model to forecast natural rubber price and to analyse the implications of natural rubber price stabilisation along the lines of the International Natural Rubber Agreement. The results showed that of the explanatory variables identified, stock of NR in consuming countries ('000 tons) (SCC_t), consumption (demand) of NR ('000 tons) (CON_t) and price of NR (PNR_t) (for the study, SMR20 spot price in sen/kg) in the previous two periods, were the most important explanatory variables in the NR price forecasting model.

Barlow *et al.* (1994) presented a broad economic framework and the overall rubber industry where the supply of rubber was determined by the expected price in the market place, together with its production capacity, input costs and underlying technological progress. It then interacted in a dynamic and recursive manner with demand. Demand was set by the expected rubber price as well as by the income level in the overall economy, prices of rubber substitutes and prices of final goods, technology, consumer preferences, stocks and manufacturing capacity utilisation. They also explained that the organisational structure of production, marketing and consumption and government measures towards rubber were also important but they entered the rubber framework through the mentioned supply and demand factors.

Multiple forecasts for autoregressive-integrated moving-average (ARIMA) models are useful in many areas such as economics and business forecasting. Shamsudin and Arshad (1998) 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. They also found that the MARMA model produced 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.

Armstrong and Collopy (1998) argued for offers the characteristics of forecasting methods and their relationships. Forecasting involved methods that were derived from judgmental sources and from statistical sources. There was an increasing amount of integration between judgmental and statistical data and procedures. This integration, which had been studied by researchers in the last decade, can improve forecast accuracy.

Burger and Smit (2000) also studied the long-term and short-term analysis of the natural rubber market. The essential elements of NR long-term supply model are: planted area, new planting, replanting and uprooting, the age of the area and the yield profiles, technical progress, other factors influencing normal production and prices. The variables used for demand model are the NR share in total world rubber consumption, the ratio of the Singapore RSS1 price of NR (in US$) and the US export unit value of SBR (Styrene-Butadiene Rubber) (in US$) and also the short-term price model included world natural rubber average production, world total rubber consumption, exchange rate, private world stocks, RSS1 price in Singapore (US$/tonne) and a dummy (taking in time trend). It included the economies of key players in the natural rubber market both on the demand side, on the supply side and price fluctuations.

The Asian crisis provided strong evidence on how exchange rates affected natural rubber price of SMR20 (USD) in the world market (Burger *et al.,* 2002). From this paper, it provided a theoretical basis for establishing a link between the exchange rates and the NR price for short-term natural rubber price forecasting in the paper.

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 modified autoregressive moving average models were generally better than the simple regression models and the results can potentially be beneficial to participants in the NR futures market.

Hossain *et al.* (2006) developed and used ARIMA model of order (3,1,3)×(2,0,2)12 was selected as the best model for both motor and mash prices and the model (3,1,2)×(3,0,2)12 was selected as the best model for mung prices in Bangladesh for policy purposes as far as price forecasts of the commodities were concerned. He also generated forecasts, namely, historical, ex post and ex-ante, using the familiar Box-Jenkins univariate time series models. The models on the basis of which these forecasts have been computed were selected by important information criteria such as Root Mean Squared Percent Errors (RMSPE), Mean Percent Forecast Errors (MPFE) and Theil's inequality coefficients (U). The smaller these values, the better are the forecasting performance of the model.

The generated price forecasts from January 2008 to December 2008 generated from single equation, MARMA and ARIMA models are presented in Table 7. The results of the ex post Natural Rubber (SMR20) monthly price forecast (US$ per MT) using MARMA model is estimated to decrease to around US$ 1269.45 per MT in December 2008, a decrease of 65% from July 2008 at US$ 3530.96 per MT.

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. For many years now, MRB (Malaysia Rubber Board) and IRSG (International Rubber Study Group) have forecasted the price of natural rubber which will be beneficial for the industry in their future economic planning.

A forecast of a high price may lead policy makers to alter their budgetary plans to invest for new decisions in the natural rubber market. The result of the study indicates that NR ex post forecast price of SMR20 shows a decreasing trend. This could be due to global financial crisis during the forecasting periods. The global financial crisis and its concomitant shrinking in demand of virtually on all commodities have resulted in perhaps a widespread global recession. It would be interesting to investigate factors and new parameters that influence the reduction in demand for rubber. The factors could be due in part to the global vehicle sales contraction because of lower purchasing power and delayed buying decisions, the appropriate supply responses by the tripartite NR producing countries. and to determine what the new price forecast of NR would be in the interim world market.

Significantly, short-term ex post forecast of NR price forecasting models developed in this paper, could provide a useful test of the validity of the model and also beneficial to producers and consumers as well as traders and planners for policy analysis in the world NR market. Furthermore, this conceptual economic framework was a good starting point for discussion and perceptive of short-term ex post forecast of NR price forecasting models developed, with the opportunity of using some of these factors later in the other study for forecasting of rubber prices. Forecasts using other alternative models such as simultaneous supply-demand and price model, ARCH (Autoregressive Conditional Heteroscedasticity), GARCH (Generalized ARCH) and EGARCH (Log Generalized ARCH), not attempted for this study, could also be potentially beneficial for future work.

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