RESEARCH ARTICLE

# Investigating the Effect of Price of Rubber Fluctuations on Stock Prices and Exchange Rates in Malaysia

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This paper examines the relationship between the stock price and nominal exchange rate in Malaysia to ascertain the significance of using rubber price as a correction mechanism. The Johansen cointegration test was employed to investigate the effects of linear combination and the relationships among the components in a multiple time series. A two-regime, intercept-adjusted Markov switching vector error correction model was also used to examine the parameters concerned. Rubber price is used as a correction mechanism. Because rubber is one of Malaysia's main exports, using rubber price as a correction mechanism may affect the country's economy. The results of this study show that the said variables have cointegrating relations. Further, the nominal exchange rate has a negative relationship with the changes in stock price. Markov switching vector error correction model was found to be suitable for examining the data as the findings had a small variance.

***Keywords:*** cointegration, exchange rate, Markovswitching, rubber price, stock price

***JEL Classification:*** C32, G12, E32

For several decades now, Markov switching models are increasingly used to investigate financial time series data. The main reason for this is its capability to capture the volatility dynamics of a time series. Additionally, these models raise the plausibility of the interpretations of nonlinearities. Among these models, the Markov switching vector error correction (MS-VEC) model is even more popular because its features allow correlating nonlinearities with time-varying volatility. However, existing models are presented with the assumption that time series data is stationary or linear. However, this is rarely the case when it is applied in real life. Further, when the changes in the regime for the measurement of variance decomposition are excluded, it will lead to unreliable results.

The MS-VEC model was introduced by Krolzig (1997). It can allot all shocks to each variable. The transition probability is affected by the shocks during the phase shifting. The MS-VEC framework is also able to capture the temporary periods that diverge from the long-run relationship model. Consequently, this model is used to examine time-series data as it can detect the long-run properties of the system (Phoong etal., 2019). Several studies have applied the MS-VEC model in analyzing the economic and financial data. These include Gotz and Taubadel (2008), Altavilla and Grauwe (2010) and Hache and Lantz (2011), and Phoong etal. (2014).

Economic and financial datasets always exhibit irregular changes on the one hand and time series components and structural breaks or shocks on the other. Infinite shocks can lead to spurious regressions. It is possible to obtain a high R-square value even if the two non-stationary variables correlated with each other are unrelated (Brooks, 2002). Non-stationary variables might consist of time series components, such as trends, seasonal adjustment, or irregular patterns, which might lead to inflated R-square. Therefore, the standard regression technique is not suitable for making estimations if spurious regression exists in the data concerned, as a high likelihood ratio will result in a valueless result (Brooks, 2002; Anghelache et al., 2019).

Among the non-linear models, the Markov switching model, proposed by Hamilton (1989), is one of the popular models. It has been widely applied to model business cycles, interest rate dynamics, electricity pricing, and oil and natural gas pricing (Kleppe and Oglend, 2019). Markov switching is widely used due to its parsimonious yet flexible nature. In particular, its flexibility makes it better than the conventional linear time series model in estimating the distribution shape both within and outside the sample (Vazquez & Clempner, 2020). This model has been selected for this study because of its ability to deal with problems such as regime-switching, jumps or breaks, and missing values in time series data.

The parameters selected for this study are stock prices, exchange rates, and the price of rubber. The stock market is often a sentiment indicator for market movements. Investments in the stock market have exponentially grown in recent decades. Hence, analyzing the changes in stock prices is one of the aims of this paper. Besides, experts suggest that exchange rate issues are increasingly too prevalent to take a microstructural approach vis-a-vis the foreign exchange market (Lyon,2001). By understanding the exchange rates of countries, a blueprint can be derived for the market development in their economies.

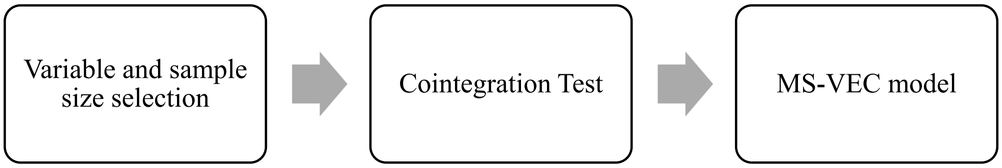
The price of rubber has been chosen because it plays an important role in effecting changes in stock prices and exchange rates. The top three rubber producing countries are Thailand, Indonesia, and Malaysia (http://faostat.fao.org/). Malaysia reported RM20.4 billion worth of rubber production in 2012. The export of Malaysia's rubber products has grown since 2001 and reached RM14.7 billion in 2013 (Malaysian Rubber Export Promotion Council, 2013). Therefore, the price of rubber might be a factor in influencing changes in Malaysia's exchange rate and stock prices.

This paper had two research questions. The first research question is:What is the cointegration relationship between the exchange rate, rubber price, and stock price? After conducting a comprehensive literature review, the Johansen cointegration test is used in this study to evaluate whether the variables correlated between several time series in the long term. In light of the first research question, it is hypothesized that a cointegrating relationship exists in the estimated model. The second research question is:What are the correlations between exchange rate, rubber price, and stock price in Malaysia? Considering the past literature, the constructed hypothesis is that there is a relationship between the exchange rate, rubber price, and stock price in Malaysia. The MS-VEC model is used in this study to investigate the irregular changes of the time series and asymmetric distribution of the datasets.

This paper contributed to identifying the existence of the cointegration relationship between the exchange rate, rubber price, and stock price. Cointegrating relations is particularly important for investors as the concept of cointegration is widely applied in measuring the possible correlation between time series processes in the long term. The second contribution of this paper is the analysis of the financial time series using sophisticated econometric estimation. Financial time series always exhibits nonlinearity or structural changes, which may lead to biased result if we investigate the data using the standard regression method such as the ordinary least square method (Brooks, 2002). Therefore, this paper proposed the Markov switching model to investigate the relationship of the time series variables.

## Theoretical and Analytical Framework

The research framework of this paper is as follows, and the theories of statistical techniques are explained in this section.




The first step in the research design is to select the variables and sample size. The samples used for this study included the nominal exchange rate, the stock price (Kuala Lumpur Composite Index, KLCI), and rubber price with the currency in Malaysian ringgit (RM). The datasets were not seasonally adjusted, and the proxy is natural logarithm data to reduce variation of the datasets.

The next step is to check for cointegrating relationships among the variables by using the Johansen cointegration. A cointegration test is used in examining multivariate time series data. The concept of cointegration was introduced by Engle and Granger in 1987. Cointegration always relates to non-stationary, unit root, and common trends. A cointegration test is used to find a possible correlation between variables series. The long-run relationship between variables can be identified through a cointegration test. This test examines the effects of linear combination and correlations among the components in multiple time series. The cointegration framework deals with the common multiple time series to generate stationarity after a certain linear transformation. Engle and Granger (1991), Lütkepohl and Kraetzig (2004, 2005) formulated the idea of cointegration and presented the statistical procedures to analyze the properties of cointegration in time series data. When non-stationary arises or a stationary process is aggregated,

$$X_t \sum_{i=1}^{t} S_i \tag{1}$$

where $S_i$ is the uncorrelated sequence of random variables with the white noise sequence $S_i \sim N(0, \sigma^2)$. Integrated order one $I$ (1) process is applied to the cumulative sum of $S_i$ since it leads to the non-stationarity of the series. $\sum_{i=1}^{t} S_{i1}$ is also known as the common stochastic trend of the process $X_t$. Either differencing or taking a linear combination can express the stationarity of the series.

Let $X_t$ be an $I(1)$ process, $\beta \neq 0$ then $\beta' X_t$ is stationary. $X_t$ is cointegrated, and $\beta$ is known as the cointegrating vector. Under the hypothesis testing of $H_0: \varphi = \alpha\beta'$ with the rank ($\varphi$) = $k$, the maximum likelihood for $\beta$ is $\hat{\beta} = (\hat{\rho}_1, \ldots, \hat{\rho}_k)$ where $\hat{\rho}_k$ is a $m$ x 1 vector that is obtained by estimating the eigenvalues and eigenvectors using maximum likelihood estimation.

If the variables have a cointegrating relationship, then the MS-VECM model is used because the cointegration relationships are often interpreted as the long-run equilibrium in econometrics. The MS-VEC model can examine the correlations of variables if the variables have the same stochastic trend. Moreover, this model can correct the errors of multivariate variables in a disequilibrium regime and can capture the long-run behavior of the variables in the system (Krolzig, 1997). Phoong et al. (2014) added that for the variables that are undergoing phase shifting, the MS-VEC model could detect every change in the variables in the model.

The general MS-VEC framework is

$$\Delta y_t = \varphi_{0,s_t} + \varphi_{1,s_t}\Delta y_{t-1} + \varphi_{2,s_t}\Delta y_{t-2} + \cdots + \varphi_{k-1,s_t}\Delta y_{t-k+1} + \alpha_{s_t}\beta'_{s_t} y_{t-k} + \epsilon_t \tag{2}$$
$$\epsilon_t \sim N(0, \textstyle\sum s_t)$$

where $s_t$ is the unobservable state variable, $\varphi_{0,s_t}$ is the intercept, $\propto_{s_t}$ is the equilibrium adjustment factor, $\beta$

is fixed, and $\sum s_t$ is the covariance matrix that allows switching across the states.

A statistical non-linear inference of unobserved $s_t$ can be estimated using Hamilton's (1989) filtering algorithm and Kim's (1994) smoothing algorithm. The parameter estimation $\hat{\lambda}_{ML}$ can be determined using the expectation-maximization (EM) algorithm to maximize the incomplete data likelihood function for the model.

The EM algorithm is used for obtaining maximum likelihood estimates of the missing data. Furthermore, the EM algorithm can also be used for obtaining the maximum likelihood estimates in estimating the missing data, random effects model, log-linear model, and latent variables. The EM algorithm is first introduced by Dempster,Laird and Rubin in 1977. This algorithm is further extended and applied in several areas. Engel and Hamilton (1990) further discussed and applied the EM algorithm to Markov switching models on estimating the financial time series.

The MS-VEC model exhibits both equilibrium and error correction mechanisms in each disequilibrium regime and adjusts the error. Choosing exogenous factors such as the impacts of facts on major economic shocks or those that affect changes in the data series because an error correction mechanism is reasonable from an economic viewpoint in estimating the changes of exchange rate and stock price. According to Ihle and Taubadel (2008), the threshold in the series affects the adjustment pattern of the transition variable. The unobserved regime state follows the exogenous stochastic process during the transition period. Therefore, the MS-VEC model is sensitive to the shock or the sudden change of the series passing the time compared to the conventional threshold model.

## Results and Discussion

The optimal lag length was calculated before conducting the cointegration test. The lag order selection is important as it may affect the reliability of the results. The lag length selection tests, including the Akaikeinformation criterion (AIC), the Schwarz information criterion (SIC), the likelihood ratio (LR), the final prediction error (FPE), and the Hannan-Quinn information criterion (HQ), were used in this study to determine the best lag length. The results are summarized in Table 1.

**Table 1.** *Lag Order Selection*

| Optimal lag selection tests | Number of lag suggested | Number of lag adopted |
|---|---|---|
| AIC | 1 | |
| SIC | 1 | |
| LR | 7 | 1 |
| FPE | 1 | |
| HQ | 1 | |

Based on the findings presented in Table 1, lag order 1 was selected for the cointegration test. The outputs of the Johansen cointegration test are summarized in Table 2.

Johansen test was used to determine the cointegrating rank of the parameters. At the most, two cointegrating equations may have existed in the model because three parameters were tested in the estimated model. The cointegrating rank is crucial to normalize the cointegrating coefficients to require a suitable order of the variables and to avoid distortions in the findings. Based on the results presented in Table 2, one cointegrating relation was found to exist in the estimated model.

**Table 2.** *Findings of the Johansen CointegrationTest*

| No. of Cointegrating Equation(s) | Eigenvalue | Trace Statistic | Maximum -Eigen Statistic |
|---|---|---|---|
| 0* | 0.4453 | 101.0040 | 49.5009 |
| 1 | 0.3320 | 51.5032 | 33.8901 |
| 2 | 0.1892 | 17.6131 | 17.6131 |

** indicates that the t-value is significant at the 0.05 significance level*

The MS-VEC model was used to investigate the connection between the parameters as the datasets comprised long-run properties.

Table 3 depicts a negative relationship between exchange rate and stock price where rubber price acts as an exogenous variable. According to Krolzig(1997), the exogenous variable acts as an error correction mechanism and is used to adjust the disequilibrium condition. Malaysia is the top 3 rubber-producing countries in the world and also plays a significant role as a member of the Association of Natural Rubber Producing Countries (ANRPC). ANRPC's membership comprises 11 countries, and together they account for approximately 92% of the global production of natural rubber. Moreover, Malaysia, China, and India are the three main rubber-consuming countries within the ANRPC and account for approximately 48% of the global demand. Therefore, rubber price affects exchange rate changes and stock prices because the exchange rate and the stock price are the key macroeconomic variables that explain the economic condition of a country.

According to Krolzig (1997), error correction terms, including the constant coefficient and exogenous variable, can be used to adjust the disequilibrium condition of the estimate model. Chauduri and Kumar (2015) have further applied Krolzig's model to evaluate the correlations between trading volume and Indian stock price. The stochastic model is then corrected by Krolzig in 2001 by considering the gap and the labor share on investigating the post-war effect in the U.K. labor market. Several past studies examined the correlations of the financial time series variables by using the parametric models, including univariate time series models with asymmetric cointegration models or dummy variables to accommodate the disequilibrium in the relationship of the macroeconomic variables. An earlier study by Henriques and Sardorsky (2008) used generalized least square (GLS) that corrects the autocorrelation and heteroskedasticity in panel data. Altaville and Grauwe (2010) adjusted the exchange rate and its fundamentals towards the long-run equilibrium by using inflation as the error correction mechanism. Volatility is a statistical measurement of the dispersion of returns for a market's index. Volatility can be measured either by using the standard deviation or by using variance between the returns from the respective security or market index. When the variance is small, the prices are tightly bunched together. As described by the modern portfolio theory, volatility creates a risk associated with the degree of dispersion of return around the average. In other words, the higher the chance of a lower-than-expected return, the riskier the investment is. Many studies have investigated the volatility using different versions of GARCH models, including GARCH (1,1; Falzon& Castillo, 2013), MGARCH-DCC (Mollick& Assefa, 2013), BEKK-GARCH (Lv et al., 2020) as well as MRS-GARCH (Ready, 2018). Different methodologies were also used in several studies, including the Taylor series

**Table 3.** *Results of the Intercept Adjusted MS-VEC Model*

| | **Exchange rate** | **Stock Price** |
|---|---|---|
| Constant in regime 1 ($T_{s_1}$) | 0.0017 | -0.0656 |
| Constant in regime 2 ($T_{s_2}$) | -0.0015 | 0.0216 |
| Exchange rate | -0.0922 | 0.5575 |
| Stock Price | -0.1367 | -0.0064 |
| Error correction mechanism (rubber price) in regime 1 | -0.0345 | 0.1340 |
| Error correction mechanism (rubber price) in regime 2 | 0.0038 | -0.0212 |
| $\sigma^2_{s_1}$ | 0.000022 | 0.00056 |
| $\sigma^2_{s_2}$ | 0.000002 | 0.000031 |

*Note: $T_{st}$ is coefficient of state t, $\sigma^2_{s_2}$ is a variance of state t where t = 1, 2* on computing the annual growth rate using CAGR, moving average, beta approaches, and so forth.

Rubber price was used in this study as the correction mechanism in estimating the relationship between the exchange rate and stock price. Based on the results presented in Table 3, it can be seen that the exogenous variable can adjust the disequilibrium error because the coefficient for the error correction mechanism (rubber price) is negative. This proves that the error correction mechanism has a significant effect on correcting the disequilibrium in the estimated model. Furthermore, the small variance reported for both regimes in Table 3 indicates that the prices are closer to the expected returns.

**Table 4.** *Contemporaneous Correlation*

| | Exchange rate | Stock Price |
|---|---|---|
| Exchange rate | 1.0000 | -0.5814 |
| Stock Price | -0.5814 | 1.0000 |

Table 4 reports the contemporaneous correlation between the nominal exchange rate and the stock price. A negative relationship was found to exist between these two variables.

**Table 5.** *Sampling Period Classification*

| Regime 1 | Regime 2 |
|---|---|
| 2008:1 - 2008:3 | 2005:9 - 2007:12 |
| 2008:6 - 2008:10 | 2008:4 - 2008:5 |
| 2011:8 - 2011:9 | 2008:11 - 2011:7 |
| | 2011:10 - 2012:9 |

Table 5 outlines the classification of the sampling period on regime 1 (recession state) and regime 2 (growth state). It records that there are three depression periods in the sampling period. The slump period that occurs in 2008 relates to the Global Economic Crisis 2007/08. In addition, the down turn from August 2011 to September 2011 relates to the contagion of the European sovereign debt crisis.

The result shows that about 87% of the samples were categorized in regime 2; therefore, asymmetric properties exist in the estimated business cycle. The theory of asymmetric behavior in the business cycle is large and negative in recession, but small and close to zero in expansions (Acemoglu& Scott, 1997; Morley & Piger, 2009). The concept of asymmetry is particularly important, especially when measuring the turning points and the degree of heterogeneity. In macroeconomics, there are three main categories of fluctuations in economic activity: the business cycle, seasonal patterns, and long-run growth (Morley & Piger, 2009). The business cycle analysis is crucial in predicting whether the economic activity deems to be a recession or not. The asymmetric business cycle potentially reconciles the twolong-standingbut competing theoriesabout the main source of macroeconomic fluctuations.

The smooth transition probabilities are also captured and reported as follows:

$$p_{ij} = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} = \begin{bmatrix} 0.6916 & 0.3084 \\ 0.0454 & 0.9546 \end{bmatrix}$$

The smoothed response over time is the consequence persistence in aggregate shocks fluctuates across heterogeneous states. The purpose of analyzing the smooth transition and the asymmetric behavior in this study is that the symmetric "return-to-normality" model does not tackle the sharpness of downturns,whereas the discrete regime-switching model does not sufficiently allow for smooth transitions between different states of the business cycle. The regime probabilities are further explained in Figures 1 and 2.

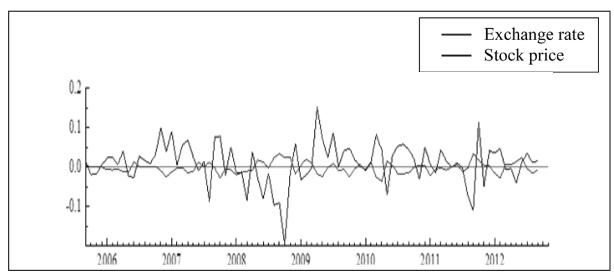



***Figure 1.*** Probabilities Sketch

Figure 1 depicts the regime probabilities of the time series data after modeling the data using a two regime MS-VEC model. The nominal exchange rate has a negative relationship with the changes in the stock price when the rubber price acts as the exogenous variable.

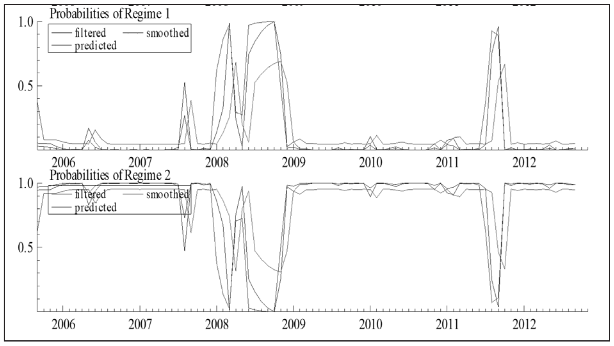



***Figure 2.*** Sketch of Filtered and Smoothed Probability

Figure 2 depicts the sketch of filtered and smoothed probability for regimes 1 and 2. Several structural changes can be seen in Figure 2, and these changes can be related to economic events, such as the Global Financial Crisis in 2008/2009, the Euro crisis in 2011, and oil price shock in 2011,which contributed to the appreciation and depression of the series. These international events had a great impact on the Malaysian economy and have been captured in regime 1, whereas regime 2 represents the growth state.

## Conclusions

In order to analyze the time series data with classical methods such as regression analysis or ordinary least squares, the assumption of mean and variance of the series are independent of time and are hard to achieve, especially for financial data. Most financial data are non-stationary time series. Consequently, their mean and variance vary over time. Therefore, this study employed an in-depth analysis to investigate the cointegration relationship between the variables, and subsequently adopted an intercept adjusted MS-VEC model to estimate the associations in the multivariate time series data.

The information criterion test suggests that lag order 1 is suitable to use in the Johansen cointegration test. The findings of the Johansen test reported that there is a cointegrating relation between the time series. Furthermore, the MS-VEC model is also employed in this study to estimate the best possible moment to undertake macroprudential measures. The issue of coherence of national contractions and expansions in the multinational model of the global and international business cycles can be examined by using the MS-VEC model. The results of this study have shown that the nominal exchange rate has a negative relationship with the stock price and that about 87% of the sampling data were categorized in the second regime. Hence, it can be concluded that the estimated model is an asymmetric business cycle since the second regime is the recession. Acemoglu and Scott (1997) have revealed that a large and negative recession is the property of asymmetric business cycles.

Besides that, the results show that rubber price is one of the error correction mechanisms in the disequilibrium relations of the exchange rate and stock price. Malaysia is ranked as the top 3 rubber-producing countries in the world after Thailand and Indonesia. The changes in the price will thereafter affect Malaysia's economy as it exported RM41 billion rubber products in 2020. Malaysia is serving as the leading supplier of medical gloves and latex threads of the global demand. Furthermore, the results of filtered and smoothed probability in regimes 1 and 2 are captured by using the MS-VEC model. Dramatic changes of the time series and the sharpness downturn of the series express that the international events such as Global Financial Crisis in 2008/2009, the Euro crisis in 2011, and oil price shock in 2011 had a great impact on the Malaysian economy.

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