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Determinants of Natural Rubber Price Instability for Four Major Producing Countries

Yi Chiun Fong*, Aye Aye Khin and Chee Seong Lim

Department of Economics, Faculty of Accountancy and Management (FAM), Universiti Tunku Abdul Rahman (UTAR), 43000 Kajang, Selangor Malaysia

ABSTRACT

Recently, price instability of natural rubber (NR) in the world market has affected the NR economy severely. It is believed that NR price can no longer be explained solely by the fundamental factors supply-demand, but it is largely driven by external factors. Therefore, this study aimed to explore the determinants of NR prices in 4 major NR producing countries namely Thailand, Indonesia, Malaysia and Vietnam. Annual data from 2008 to 2017 was collected and panel data analysis was performed. Results of Hausman Test suggested that Fixed Effect Model (FEM) was preferable than Random Effect Model (REM) in the study. Results indicated that NR production, consumption, Shanghai NR price, crude oil price and synthetic rubber (SR) price were statistically significant. This study could contribute to government policy implementation in NR producing countries to ensure the stability of NR production and price which will benefit the smallholders and countries' economic growth.

Keywords: Fixed effect model, Hausman test, natural rubber, panel data, panel cointegration, panel granger causality, panel unit root, price

INTRODUCTION

Being one of the most significant agricultural commodities in the world, natural rubber (NR) is acting as a crucial economic indicator

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E-mail addresses: ycyichiun@lutar.my (Yi Chiun Fong) ayekhin@utar.edu.my (Aye Aye Khin) cslim@utar.edu.my (Chee Seong Lim) * Corresponding author market has been acting as one of the major contributions to one country's economic growth, especially in South-East Asia (SEA) countries. It is produced from latex that is tapped from a certain species of plant namely the *Hevea Brasiliensis*. In SEA countries, there are optimal conditions and environments for the plantation and cultivation for *Hevea* trees as compared to its origin country, Brazil. Without any specific tapping seasons, plantation and production

especially in the NR producing countries. NR

ISSN: 0128-7702 e-ISSN 2231-8534 of NR in SEA countries are bound to have a better performance than other western and European NR producing countries. Although more than 90% of rubber supply is coming from SEA countries, still, there is NR plantation in Europe countries as in the seeds of the plantation was introduced from Brazil (Khin & Thambiah, 2015). However, European countries are mainly NR importer due to the unfavourable condition for the plantation of *Hevea* trees as compared to SEA countries.

According to Department of Statistics of Malaysia (DOSM, 2019), in Malaysia, agriculture sector had contributed around 7.3% which is approximately RM 99.5 billion to the Gross Domestic Product (GDP) in 2018. In the total contribution from the agriculture sector, NR itself contributed 2.8%. Although the contribution is far behind the percentage of palm oil (37.9%), but NR is still identified as one of the important agricultural crops in Malaysia. From 2010 onwards, NR, along with oil palm, had been recognised as a special focus sector under the National Key Economics Areas (NKEA). For instance, rubber gloves and latex goods had contributed significantly to the total exports of NR products in Malaysia (Matade, 2016). According to Khin et al. (2008), NR economy is indeed playing a vital role in terms of socio-economics aspect in most of the NR producing countries who at the same time are also developing countries such as Thailand, Indonesia, Malaysia and Vietnam. Most of the plantation areas of Hevea trees are managed by private individual

smallholders and farmers which indicates that the NR economy will ultimately affect their livelihood in rural areas.

In recent years, NR economy has been hit by the price instability as well as the imbalance of supply-demand situation in the world market where the NR world consumption has far exceeded its production. It is also believed that the factors behind the world NR price can no longer be explained solely by its fundamental factors (normal market supply-demand forces). However, it is actually largely affected by many non-fundamental or outside factors such as the real exchange rate, crude oil price, synthetic rubber (SR) price as well as the flow of speculative funds in the NR future exchange markets (Jacob, 2017; Khin & Thambiah, 2015). Besides, the volatility of NR price has also hit the production of NR. Much et al. (2011) mentioned that NR was a perennial agricultural crop which the plantation areas and average yield would decide on the future production of NR. When the world NR price is favourable to the cultivators and smallholders, they are encouraged to increase the NR production by either expanding existing plantation/ replantation areas or growing rubber yields. On the other hand, if the price becomes weaker, they tend to lower down the tapping and production or even switch to other agricultural crops that have better price such as palm oil, cocoa or wheat.

According to Jacob (2017), among several important future exchange markets such as Singapore Commodity Exchange (SICOM), Tokyo Commodity Exchange (TOCOM) and Agricultural Future Exchange of Thailand (AFET), Shanghai Future Exchange Market (SHFE) is now becoming one of the most important future exchange in NR market. In major NR producing countries such as the International Tripartite Rubber Council (ITRC) which includes Thailand, Indonesia and Malaysia, the NR exports are mostly going to China. Therefore, being the top NR consumer in the world market, the rapid rising of the China Economy in recent years will definitely has an impact on the NR economy. On top of that, Global Rubber Market (GRM) supposes that even though it might be difficult to predict the NR economy in the near future, but it will absolutely be influenced by China's economic indicators.

IRSG indicates that the top 4 major NR producing countries as of 2017 are Thailand, Indonesia, Malaysia and Vietnam. Table 1 demonstrates the production and consumption of NR of the aforementioned producing countries in the world market from 2008 to 2017. Overall, in the recent

10 years, production of NR increases with slight fluctuation in most of the producing countries; while the consumption increases gradually over the years. NR production is not only dependent on its price but also highly dependent on the weather and seasonal conditions. For example, heavy rain season and flooding have severely affected NR production, especially in SEA countries in recent years. Unseasonal downpours have stopped the farmers from going to the plantation to tap for latex for the production of rubber. According to Association of Natural Rubber Producing Countries (ANRPC, 2018), unfavourable weather condition and the low NR price have caused the downfall of NR production in Malaysia, Vietnam, India and Sri Lanka in 2018. Besides, there was the outbreak of leaf diseases especially in Vietnam and India which further hit the NR production in the countries. Despite the raining and flooding, other NR producers saw an increase in production in 2018: Thailand's NR production increased by approximately

Table 1

NR production and consumption in major producing countries ('000 tonnes)

	Thailand		Indonesia		Mala	Malaysia		Vietnam	
	Pro	Con	Pro	Con	Pro	Con	Pro	Con	
2008	3089.90	397.60	2751.00	412.30	1072.40	469.00	660.00	100.00	
2009	3164.40	399.40	2440.00	352.00	857.00	469.80	711.30	120.00	
2010	3252.10	458.70	2736.00	421.30	939.00	457.80	751.70	140.00	
2011	3569.00	487.00	2990.00	460.20	996.20	402.20	789.30	145.00	
2012	4778.00	505.00	3012.00	464.50	922.80	441.40	877.10	150.00	
2013	4170.00	521.00	3237.00	508.90	826.50	434.10	949.10	154.00	
2014	4324.00	541.00	3153.20	539.60	668.10	447.30	953.70	159.60	
2015	4473.25	600.60	3145.40	509.40	721.55	474.70	1012.70	172.00	
2016	4519.00	649.90	3208.10	583.30	673.55	486.20	1032.10	194.00	
2017	4755.00	701.50	3409.00	610.50	738.80	488.60	1086.00	215.90	

10 percent and Indonesia's by around 6.3 percent. It was mainly due to the expansion of planted areas as well as the maturity of *Hevea* trees which increase the production.

Table 2 represents the average annual NR prices in the 4 major NR producing countries from 2008 to 2017. Note that the prices above are different grades of rubber in different countries based on data availability. For Thailand, Standard Thai Rubber 20 (STR20) price is collected; for Indonesia, Standard Indonesia Rubber 20 (SIR20) is collected; for Malaysia, Standard Malaysia Rubber 20 (SMR20) is collected; and lastly for Vietnam, Technically Specified Rubber 20 (TSR20) is collected. On average, NR prices fluctuate over the years. Ever since the subprime crisis occurred during 2008, not only the commodity market was hurt but the global economy had collapsed. Thus, the NR price dropped during 2008-09 as the spill-over effect of the global economic crisis. After that, it increased to the peak of the recent 10 years in 2011 and then continued to drop again until 2016. This could be explained by the low output from the main NR producers due to the unseasonal downpours. At the same time, the falling of crude oil price also hit the NR market. The low crude oil price has made SR more competitive than NR which further lower the NR price. Fortunately, during 2017-18, there was an increase in the world crude oil price which indirectly revive the NR price.

Figures 1 to 4 illustrate the trends between NR SMR20 price with Synthetic Rubber (SR) price, Shanghai NR price, exchange rate and crude oil price from the year 2008 to 2017 respectively. Note that in this section, NR SMR20 price is taken to represent the world NR price for comparison and graph illustration. Overall, from Figure 1, 3 and 4, it shows that NR price is having positive relationship with SR price, Shanghai NR price as well as the crude oil price; while Figure 3 shows that NR price is negatively related to exchange rate. Firstly, SR is considered as the substitute product of NR in the market. Therefore, performance in the SR market will definitely have an impact, directly or

VR .	prices	in	major	producing	countries	(USD/ton)
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Countries	Thailand	Indonesia	Malaysia	Vietnam
2008	2627.91	2789.95	2484.47	2535.00
2009	1931.82	1870.60	1805.80	1407.90
2010	3646.69	3418.20	3286.49	3176.30
2011	4863.89	4363.80	4429.28	5332.00
2012	3422.32	3250.40	3071.23	3513.36
2013	2792.06	2521.20	2470.98	3042.46
2014	1967.36	1714.70	1695.72	2129.57
2015	1581.10	1379.10	1332.99	1427.14
2016	1645.00	1387.00	1368.53	1087.33
2017	2038.89	1661.60	1653.37	1090.00

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Figure 1. NR SMR20 and SR prices



Figure 2. NR SMR20 and Shanghai NR price



Figure 3. NR SMR20 price and exchange rate

indirectly to the NR market itself (Meutia & Putra, 2017). Since they are both substitute product to each other, they are having a positive relationship where both of the prices move together in the same direction as shown in figure 1. For instance, when SR becomes more expensive than before, the demand for NR will increase and NR is

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Figure 4. NR SMR20 and crude oil price

derived naturally from latex obtained from the plantation, while SR is a petroleumbased type of rubber. NR or latex are mostly used in the automobile industry such as the production of vehicle tires as well as medical products such as surgical gloves; SR is mostly used in the consumer and industrial application.

The price relationship between these 2 types of rubber can be more complex than it seems (Harder, 2018). Although they are both substitutable by each other to a certain degree, there are still many rubber products that actually require both types of rubbers. Technically, SR is not a perfect substitute for NR because various types or grades of SR often fail to meet certain essential properties of NR. For example, vehicle tires of passenger cars, buses as well as trucks tires which require both NR and SR to perform their specific function in the combination. Such technical consideration is the limiting factor for the substitution between the 2 types of rubber. However, a limited extent of substitution is still possible without sacrificing the quality and expected performance of manufactured end products.

Apart from that, since SR is petroleumbased, it will be also affected by the world crude oil trend. Crude oil is one of the main raw material in the production of SR. Any fluctuation in the oil price will definitely reflect on the SR market, and by extension, the NR market too (Khin et al., 2012). Therefore, in Figure 4, it indicates that the NR price is moving together with the crude oil price on average. When crude oil price increases, the production cost of SR will rise and so does its end product. Therefore, consumers could switch their preferences to NR provided that the rubber goods tolerate the substitution between these 2 types of rubber. Eventually, the increase in demand will stimulate the price to rise.

As mentioned above, SHFE is one of the most important future exchange market in the commodity markets including NR. As the biggest consumer of NR in the world market, Shanghai NR price would become the crucial factor of the world price (Jacob, 2017). Speculative fund investors will consider NR and SR to be substitutable by each other in the rubber futures market. Crude oil price will influence Shanghai rubber futures as the investors will bet on possible substitution between NR and SR based on the oil trend. They tend to invest in NR futures when crude oil price increases and they would switch over from NR futures when the crude oil price falls. Generally, the Shanghai future markets and the physical market of NR track the directional trends in the crude oil market. Therefore, as in Figure 2, SHFE and NR SMR20 are moving together in the same way with a positive relationship.

Figure 3 shows the trend between NR SMR20 price and exchange rate (RM/USD). It reveals that they are having a negative relationship with each other. Most of the agricultural commodities including NR are traded internationally in terms of USD. Therefore, any fluctuation in the currency exchange rate would have an impact on the market (Burger et al., 2002). In the case of Malaysia, as refer to Figure 3, when the exchange rate increases over the years, it indicates that the Malaysia Ringgit depreciates against USD. In the event of local currency devalues against USD, as an NR exporter, it means that there will be more export earning when converts back to Ringgit Malaysia. It prompts exporter to offer NR at a reduced price (quoted in USD) to attract buyers. When all exporters tend to adopt the same strategy to increase competitiveness, the NR price is expected to fall in terms of USD. Ultimately, a depreciating currency or in other word, an increase of exchange rate, it will depress NR price in terms of USD.

LITERATURE REVIEW

Previous researches had been done to investigate the factors affecting the NR price. (Khin et al., 2011) employed Vector Error Correction Model (VECM) and Multivariate Autoregressive Moving Average (MARMA) model to determine the inter-relationship between the production, consumption and price of the NR. Standard Malaysia Rubber Grade 20 (SMR20) NR price was included in the models. In the single equation NR price model, results showed that the NR price has a strong positive relationship with its production and a strong negative relationship with its consumption. Besides, the result of the cointegration equation of the SMR20 model also proved the existence of a long-run cointegrated relationship between NR price and its production and consumption. The results can be supported by the study by Arunwarakorn et al. (2019) and Kannan (2013).

Kannan (2013) investigated the NR market in India and found out that NR price had a direct positive impact on NR production which was statistical significance at 0.05 level. While Arunwarakorn et al. (2019) also revealed that the increase or decline of NR production could be due to the volatility of NR price. It also proved that there was a negative relationship between NR price and consumption. Besides, Khin and Thambiah (2015) also found out that NR price was having a negative relationship with its consumption at 0.05 level. It was also proven that they were having a long run cointegrated relationship between these 2 variables.

In (2012) conducted a study to forecast the short run SMR20 price by using univariate and multivariate econometric models. Results indicated that the NR price and crude oil price were having a positive relationship. When there was a 1% increase in crude oil price, it would positively impact the NR price by increasing 2.67% at 0.01 level. This result was supported by Khin et al. (2017) and Vijayakumar (2019) who also suggested the same results. When crude oil price increases, it will incur a higher cost in the production of SR which will eventually drive up the SR price. Therefore, consumers will switch their preference to NR since it becomes cheaper compared to SR.

As mentioned, NR is international trading in terms of USD. Therefore, the NR market is bound to be sensitive to currencies of exporting countries (Burger & Smit, 2002). Another finding by In (2012) was that there was a negative relationship between exchange rate and NR price. Mdludin et al. (2016), Soares et al. (2013), and Vijayakumar (2019) obtained similar results as In (2012). In (2012) mentioned that if the currencies of the rubber-producing countries appreciated against the USD, the rubber would be undervalued. According to Khin et al. (2011),

in the case of Malaysia, when the Malaysian Ringgit (RM) depreciates against USD, which means that consumers need to pay more amount of RM for 1 USD, thus the NR price would be decreased. Therefore, the real exchange rate is one of the crucial factors that affect the NR price in the market.

In short, many of the previous researches tended to focus only on one country while investigating the NR market. For instance, they studied the NR market in Thailand, Malaysia or India which only within the country itself. Besides, many of them were using only time-series data for data analysis and result interpretation for the study. Methodologies such as VECM, univariate and multivariate analysis, forecasting were used. As such, it becomes the motivation of the study to employ panel data analysis which there is less literature using this methodology to investigate the NR market in several countries in a certain period.

METHODS

Conceptual Framework and Model Specification

Figure 5 illustrates the conceptual framework of the NR price factors in 4 Major NR producing countries namely Thailand,



Figure 5. Conceptual framework of the determinants of NR price in 4 major NR producing countries

Indonesia, Malaysia and Vietnam. Variables such as NR production, NR consumption and real exchange rate act as explanatory variables in the model while crude oil price, Shanghai NR price and SR price act as control variables. In Figure 5, NR price, production, consumption and real exchange rate indicate the domestic data and the remaining control variables are similar for all countries.

$$price_{it} = \beta_0 + \beta_1 pro_{it} + \beta_2 con_{it} + \beta_3 exr_{it} + \beta_4 cop_{it} + \beta_5 shg_{it} + \beta_6 srp_{it} + \beta_7 e_{it}$$

Where,

 $price_{it} = NR$ Prices (USD/ton) in Thailand, Indonesia, Malaysia and Vietnam $pro_{it} = NR$ Production ('000 tonnes) in Thailand, Indonesia, Malaysia and Vietnam $con_{it} = NR$ Consumption ('000 tonnes) in Thailand, Indonesia, Malaysia and Vietnam exr_{it} = Real Exchange Rate (local currencies/USD) cop_{it} = World Crude Oil Price (USD/ barrel) shg_{it} = Shanghai NR Price (USD/ton) $srp_{it} = SR$ Price (USD/ton) $e_{it} = \text{Error term}$ $\beta_0 = \text{Intercept}$ $\beta_1 \dots \beta_7 = \text{Coefficients}$

Annual data from 2008 to 2017 were collected from the International Rubber Study Group (IRSG) for the econometric analysis. In the model, there are 4 countries involved in the data analysis and the data was from 2008 to 2017 means that there was a short-balanced panel with N=4 and T=10.

Hypothesis Development

- H₀₁: There is no significant relationship between NR production and NR price.
- H_{A1} : There is a significant relationship between NR production and NR price.
- H₀₂: There is no significant relationship between NR consumption and NR price.
- H_{A2} : There is a significant relationship between NR consumption and NR price.
- H₀₃: There is no significant relationship between real exchange rate and NR price.
- H_{A3} : There is a significant relationship between real exchange rate and NR price.
- H₀₄: There is no significant relationship between world crude oil price and NR price.
- H_{A4} : There is a significant relationship between world crude oil price and NR price.
- H₀₅: There is no significant relationship between Shanghai NR price and NR price.
- H_{A5}: There is a significant relationship between Shanghai NR price and NR price.
- H₀₆: There is no significant relationship between world SR price and NR price.
- H_{A6} : There is a significant relationship between world SR price and NR price.

Methods

Panel Data Analysis. Panel data combines both cross-sectional (N) and time (T) dimensions and it is also known as longitudinal data. Panel data becomes popular in econometric research due to several advantages that it provides as compared to either cross-sectional or timeseries data. Firstly, by combining both N and T dimensions, panel data, therefore, provides more informative data with more variability. There is also less collinearity among the variables in the model and more degree of freedoms, thus, it provides more accurate inference of model parameters by improving the efficiency of econometric estimates (Hsiao, 2007). Moreover, panel data analysis tolerates the heterogeneity issue in the model since a panel data model normally relates to individuals or firms, or in this case, it relates to countries over time which bound to suffer from heterogeneity problem (Gujarati & Porter, 2009). Besides, panel data can control the impact of omitted variables in a model because it contains the information on both intertemporal dynamics and the individuality of the entities which can control the impact of unobserved variables.

Panel Unit Root Tests. The unit root is known as a stochastic trend or a random walk with drift in a series which will provide an unpredictable systematic pattern. Unit root test is meant to test on the stationarity of the variables. A non-stationary series may cause serious issue such as providing a spurious regression where the R-squared value is too high even if the data is not correlated. If unitroots exist in a series, a series of successive differences can transform the series to become stationary. It can be denoted by I(d)where d indicates the order of integration. If the data are stationary at level data, it is denoted as I(0); when the data only become stationary after first differencing, it can be denoted by I(1). In this study, the typical panel unit root test was being employed namely the Levin et al. (2002) test. The hypothesis testing of the panel unit root tests is as below:

 H_0 : each time series contains a unit roots ($\rho = 0$) H_A : each time series is stationary (ρ

< 0)

Table 3 represents the panel unit root tests results for all the variables in the model. The Levin et al. (2002) panel unit root test was carried out. Results showed that at level data, all variables are stationary except for NR production and consumption; at ln data, only NR consumption is not stationary. After the first differencing, the null hypothesis was rejected. Therefore, all variables become stationary and the series can be denoted as I(1).

Panel Cointegration Test. Panel cointegration tests are meant to test on the cointegration between variables in the model. Kao (1999) and Pedroni (2004) extended the Engle-Granger framework to tests involving panel data. Kao (1999) tested for cointegration in a homogeneous panel and the test statistic were calculated by

Variablas		Levin Lin & Chu	
variables	Level	Ln	1 st diff
Price	-1.6364**	-1.2946*	-4.5232***
Pro	-0.7294	-1.5640*	-5.9041***
Con	2.2654	1.0307	-4.8575***
Exr	-2.7418***	-3.7107***	-2.8518***
Сор	-2.3426***	-2.1599**	-5.2771***
Shg	-1.9913**	-2.0726**	-5.5824***
Srp	-6.5470***	-6.6735***	-5.3522***

Table 3Panel unit root tests of NR price model

Note: * indicates statistically significant at $\alpha = 0.10$ level

** indicates statistically significant at $\alpha = 0.05$ level

***indicates statistically significant at $\alpha = 0.01$ level

pooling all the residuals of all cross-sections in the panel. It was assumed that all the cointegrating vectors in every cross-section were identical. Pedroni (2004) proposed several tests for cointegration which allowed considerable heterogeneity. Seven different cointegration statistics were proposed which could be classified into 2 categories to capture within and between effects.

Table 4 demonstrates the panel cointegration tests results of Pedroni (2004) and Kao (1999). Pedroni test results indicate that, out of the seven statistics, there are four statistics that are statistically significant at α

= 0.01 level namely the panel PP-statistics, panel ADF-statistics, group PP-statistics and group ADF-statistics. Kao test result also suggests that the null hypothesis can be rejected at $\alpha = 0.01$ level. Therefore, there is sufficient evidence of the presence of cointegration relationship between variables in the model.

Panel Models Selection. Generally, there are 3 types of panel models namely Pooled Ordinary Least Square (POLS), Fixed Effect Model (FEM) and Random Effect Model (REM). Basically, a POLS pool all the

Pedroni	Test	Kao Te	est
Panel v-Statistic	-1.4419	ADF	-6.7188 ***
Panel rho-Statistic	1.8048		
Panel PP-Statistic	-10.4818***		
Panel ADF-Statistic	-6.7157***		
Group rho-Statistic	2.8237		
Group PP-Statistic	-13.4902***		
Group ADF-Statistic	-6.4928***		

Table 4Panel cointegration tests of NR price model

Note: ***indicates statistically significant at $\alpha = 0.01$ level

observations and provide a simple general regression. OLS would provide efficient and consistent results if it is assumed that individual effect does not exist. On the other hand, for the presence of individual effects, it can be either FEM or REM. In a FEM, although the intercepts may differ across the subject, each entity's intercept does not vary over time which is also known as time-invariant. Since an individual effect is time-invariant and considered a part of the intercept, the individual effect is allowed to be correlated with other regressors. Moreover, a REM explores the differences in error variance components across individual or time periods. REM assumes individual effects (heterogeneity) are not correlated with any regressors and estimate error variance specific to groups. The intercepts and slopes of regressors are the same across individuals in REM. the difference among individual lies in their individual specific error instead of their intercepts (Gujarati & Porter, 2009).

To determine whether which model was best for the analysis, there were several tests to be carried out to select one of the models. Firstly, to determine whether to use a POLS or FEM, a Redundant Fixed Effect Test was used. In a regression of FEM, the null hypothesis was that all dummy parameters, except for the one that had been dropped, were all zero. The alternative hypothesis was that at least one dummy parameter was not zero and this hypothesis was tested with an F test based on loss of goodnessof-fit. If the null hypothesis is rejected, it can be concluded that there is a significant fixed effect or a significant increase in

goodness-of-fit in the FEM. Therefore, FEM is preferable than POLS. Next, the Breusch-Pagan Lagrange Multiplier (BPLM) test provides a test of the REM against the POLS. Null hypothesis indicates that the individual effects do not exist and OLS is applicable. If it is to be rejected, it means that REM is preferable than a POLS. Finally, the Hausman Test was used to select whether to use a FEM or REM. It compares directly the random effect estimator and fixed effect estimator. In the presence of correlation between the individual effects and the regressors, the OLS fixed effects results are consistent. However, if there is no correlation between fixed effects and the regressors, both estimators are consistent, but the OLS fixed effects estimator is inefficient. In short, the null hypothesis is that REM is preferable and the alternative is that FEM is preferable.

Table 5 shows the tests for panel model selection. First and foremost, redundant fixed effect test was used to select between POLS and FEM. P-value was equal to 0.000 which is smaller than 0.05, which meant that the null hypothesis could be rejected, thus, FEM is preferable than POLS. Next, BPLM test was to determine whether a POLS or REM was suitable for analysis. P-value obtained from the test was equal to 0.0000 which was also smaller than 0.05, thus, the null hypothesis could also be rejected and REM was preferable than POLS. Lastly, the Hausman test result shows that p-value was smaller than 0.05 level. The null hypothesis was rejected and the final decision was that a FEM was preferable in this case.

Tests	Hypothesis	P-value	Conclusion
Redundant Fixed	H_0 = POLS is preferred	$0.0000 < \alpha = 0.05$	Reject H ₀ , FEM is preferred.
Effect Test	H_A = FEM is preferred		
Breusch-Pagan	H_0 = POLS is preferred	$0.0000 < \alpha = 0.05$	Reject H ₀ , REM is preferred.
LM Test	$H_A = REM$ is preferred		
Hausman Test	H ₀ = REM is preferred	0.0000 < $\alpha = 0.05$	Reject H ₀ , FEM is preferred.
	H_A = FEM is preferred		

Table 5Panel model selection

RESULTS AND DISCUSSION

FEM of NR Price Model

Equation 1 shows the FEM of the NR price model. R² is equal to 0.9092 which means that almost 91 percent of the variation is well-explained by the independent variables in the model. The equation also indicates that the most important variables in the model are NR production, NR consumption, COP, Shanghai NR price and SR price.

 $Ln \text{ price}_{it} = -7.9442 + 0.0645 Ln \text{ pro}_{it}$ t-stat: [2.9106***] - 0.0839 Ln con_{it} - 0.0081 Ln exr_{it} [-2.4596**] [-1.6618] + 0.3181 Ln cop_{it} + 0.4368 Ln shg_{it} [10.0206***] [8.6201***] + 1.3895 Ln srp_{it} + 0.0590 e_{it} [1] [16.0901***] R² = 0.9092 adj R² = 0.8926

Every one-unit increase in NR production, on average, it will have a positive effect on increasing 0.0645 unit of NR price at = 0.01 level; every one unit increase in NR consumption, on average, it will have a negative effect on decreasing 0.0839 unit of NR price at $\alpha = 0.05$ level; every one unit increase in COP, on average, it will have a positive effect on increasing 0.3181 unit of NR price at = 0.01 level; every one unit increase in Shanghai NR price, on average, it will have a positive effect on increasing 0.4368 unit of NR price at $\alpha = 0.01$ level; every one unit increase in SR price, on average, it will have a positive effect on increasing 1.3895 unit of NR price at $\alpha = 0.01$ level. In short, NR production, COP, Shanghai NR price and SR price are positively related to NR price while NR consumption is negatively related to NR price in 4 of the major NR producing countries.

Panel Granger Causality Test

Granger causality test is a test proposed by Granger (1969) used to detect the directional causal relationship among variables in a model. If the variables are cointegrated, it would be expected that causal relationships running between variables in at least one direction. Instead of investigating a cause and effect relationship, a causality test is more on examining if a particular variable comes before another in a time series (Gujarati & Porter, 2009; Studenmund, 2014). Granger Causality test hypothesis is as below:

H₀: X does not Granger Cause Y H_A: X Granger Causes Y

Table 6 shows the Granger Causality test results of the model. Results indicate that there was two bi-directional causal relationships running between (1) NR price and Shanghai NR price as well as (2) SR price and NR Price. On the other hand, there were three unidirectional causal relationships running from (1) NR price to COP; (2) NR production to NR consumption and (3) NR production to the real exchange rate.

Model Evaluation

Figure 6 illustrates the model evaluation of the NR price model. The estimation of price model evaluation criteria are Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Theil's U statistic. Therefore, in Figure 6, it indicates a lower value of the statistics which suggests that the model is better fit and accurate as well as having a satisfactory and valid forecasting performance.

Hypothesis Testing

Table 7 presents the hypothesis testing for the NR price model. It shows that all alternative hypothesis are supported except H_{A3} . For

Table 6				
Granger causality	tests	of NR	price	model

Alternative Hypothesis (H _A)	Obs	F-Statistic	Prob.	Conclusion
Pro Granger Cause Price	22	0.13728	0.8723	Rejected
Price Granger Cause Pro	32	0.09887	0.9062	Rejected
Con Granger Cause Price	22	0.47107	0.6294	Rejected
Price Granger Cause Con	32	1.16258	0.3278	Rejected
Exr Granger Cause Price	22	0.20403	0.8167	Rejected
Price Granger Cause Exr	32	0.34475	0.7115	Rejected
Cop Granger Cause Price	22	0.81006	0.4553	Rejected
Price Granger Cause Cop	32	5.52958	0.0097***	Supported
Shg Granger Cause Price	22	5.27545	0.0116*	Supported
Price Granger Cause Shg	32	6.17435	0.0062***	Supported
Srp Granger Cause Price	22	13.4789	9.E-05***	Supported
Price Granger Cause Srp	32	12.9370	0.0001***	Supported
Con Granger Cause Pro	22	1.10261	0.3465	Rejected
Pro Granger Cause Con	32	7.40815	0.0027***	Supported
Exr Granger Cause Pro	22	1.65409	0.2101	Rejected
Pro Granger Cause Exr	52	3.00021	0.0666*	Supported

Note: * indicates statistically significant at $\alpha = 0.10$ level

***indicates statistically significant at $\alpha = 0.01$ level



Figure 6. Model evaluation of the NR price model

Table 7Hypothesis testing for NR price model

Alternative hypotheses	Conclusion
H_{A1} : There is a significant positive relationship between NR production and NR price.	Supported
H_{A2} : There is a significant negative relationship between NR consumption and NR price.	Supported
H _{A3} : There is a significant negative relationship between real exchange rate and NR price.	Rejected
H_{A4} : There is a significant positive relationship between world crude oil price and NR price.	Supported
H _{A5} : There is a significant positive relationship between Shanghai NR price and NR price.	Supported
H_{A6} : There is a significant positive relationship between world SR price and NR price.	Supported

 H_{A1} and H_{A2} , there is a significant positive relationship between NR production and price and a significant negative relationship between NR consumption and price. The result could be supported by most of the studies in the related field such as Arunwarakorn et al. (2019), Karunakaran (2017), Khin and Thambiah (2015), and Vijayakumar (2019). In fact, production and consumption are the fundamental factors of NR price, thus, it should be significant in the model. Moreover, H_{A4} indicates the significance of a positive relationship between crude oil and NR price. This can be supported by In (2012) and Khin et al. (2012, 2017).

In the NR market, NR price usually follows the trend of crude oil price. As mentioned above, the crude oil price is the crucial material of SR production. When SR is considered as the substitute product of SR, fluctuation in SR price will impact on NR price too. In the case of falling crude oil price, the production cost of SR will

drop and so as its final pricing. To ensure competitiveness, NR price eventually will fall according to the market. By this, it could also explain the significance of H_{A6} which indicates a significant positive relationship between NR and SR price. It can be supported by the studies of Yusof (1988), Khin et al. (2012), and Pindyck and Rubinfeld (1998) who mentioned that price of substitute goods were positively related. H_{A5} suggests that there is a significant relationship between Shanghai NR price and NR price. This can be considered as a new variable in the related studies, thus, there is limited literature to support the finding. However, as the China economy is rising rapidly in the recent years, it is bound to impact on the commodity market as China is the top consumer of NR who consumes almost one-third of the NR in the world. Besides, referring to the statistics (Figure 2), Shanghai NR price and world NR price are actually moving in the same direction which already explain the positive relationship between them. Therefore, the finding in this study can also contribute to the literature on this variable.

Lastly, H_{A3} has failed to be supported in this study. It means that the relationship between real exchange rate and NR price is insignificant. This could be explained by the sampling period of this study, which is captured from the year 2008 to 2017. During this period, the global financial crises ever since the year 2008 has had a spill-over effect on the commodity market including NR. The exchange rate was extremely unstable and volatile during the period and commodity price would be vulnerable to the exchange rate as it is traded in USD worldwide. For example, the previous study by Khin et al. (2011) had proven that the real exchange rate and NR price were negatively related and significant. The sampling period of the study was captured from the year 1990 to 2008 (monthly data). Thus, a longer sampling period and a difference in the types of data provide different findings. Although the variable of the real exchange rate is insignificant in this study, the sampling period can better represent and explain the recent 10 years of the current situation in the NR market. High volatility of exchange rate has affected the typical relationship between itself and the NR price and become more complicated. Perhaps when the global economy becomes more stable than before, the variable will eventually become significant, as previous studies.

CONCLUSION

Overall, this study provides findings on the development of the NR price model in 4 major NR producing countries in the world. In short, NR price is not only determined by the normal market force such as supply and demand, but it is largely driven by external factors i.e. world crude oil price, real exchange rate, SR price and Shanghai Future Exchange Market. Moreover, this study also provides an insight of the NR market from the year 2008 to 2017 to better represent the recent 10 years instead of studying too much historical data which can no longer capture the current situation. On the other hand, there is a recommendation

for future studies where future researchers could extend sampling period (based on data availability) to increase the N and T dimensions in the panel model, thus, a dynamic panel model instead of the static model could be studied. By using longer N and T dimensions, future researchers could employ other methodologies such as panel time series and panel Generalized Method of Moment (GMM). The results of the study could contribute to the policymakers and policy implementation especially in NR producing countries. As NR is an important agricultural commodity to them, the government should ensure the stability and sustainability of NR production which will ultimately benefit the farmers and smallholder. Eventually, it will contribute to economic growth as well.

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