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The Rubber Pricing Model: Theory and Evidence

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Abstract

This research explores the appropriate rubber pricing model and the consistent empirical evidence. This model has been derived from the utility function and firm profit-maximization model of commodity goods. The finding shows that the period $t - 1$ affects expected commodity price and expected profit of commodity production. In fact, a change in the world price of rubber in the past period led to a change in the expected price of rubber in the short run which influenced the expected rubber profit. As a result, the past-period free on board price has an entirety effect on expected farm price of rubber given an exchange rate. In addition, the rubber pricing model indicates that the profit of local farmer on rubber plant depends solely on the world price of rubber in the short run in case of Thailand. In an empirical study, it was found that a change in the price of ribbed smoke sheet 3 in Singapore Commodity Exchange significantly and positively determined the fluctuation of rubber price at the farm gate in Thailand which was consistent with the behavior of the Thai farmers. Both prices are also cointegrated in the long run. That is, the result states that the VECM is an appropriated pricing model for forecasting the farm price in Thailand.

Keywords: Rubber Pricing Model, VECM, Commodity Goods, General Equilibrium

JEL Classification Code: D40 D51 G51

1. Introduction

In past the rubber price has experienced large fluctuations that have led Thai rubber farmers to be stuck in the debt problem. This phenomenon make policymaker reconsider the schemes every year especially in Thailand. It is because of this fact that the Thai government is not able to manage demand and supply of rubber in the appropriate quantity in order to control the fluctuations in the rubber price. Importantly, such policy is very much expected to reduce the historical volatility in rubber price, but the government has failed to stabilize such fluctuations. Future 1 will give one of many possible examples of the reason for volatile price of rubber. This graph (Figure 1) displays the wholesale price of rubber at the central market in Songkhla province which is located in the southern of Thailand. It is one of the five biggest local markets in Thailand. The graph shows no significant change in the monthly prices of rubber between January 2002 and December 2017, but there are several sharp peaks and troughs. The highest wholesale price of ribbed smoked sheet is notably 190.06 baht/kg[1] in February 2011. The lowest price of ribbed smoked sheet, however, is initially at 23.95 baht/kg in January 2002. It slowly rises to 45.66 baht/kg in January 2005 and then the price rapidly inflates to the level of 104 baht/kg in June 2006. Similarly, price of ribbed smoked sheet moves in the same pattern as the previous one. In fact, it declines to 60.38 baht/kg at the end of year 2006 and then dramatically increases to 107.51 in July 2008, and suddenly decrease at the end of that year. More surprisingly, it escalates to the new highest level that reaches the historical vertex within sixteen years. Such level is 190.06 baht/kg in 2011 which make all rubber farmers happiest with income beyond their expectations during this period. Conversely, they cannot exactly foresee the future price that sharply declines at a very fast rate. It is impossible to smoothen consumption from 2011 to 2015 because rubber price is at the bottom at 43.94 baht/kg in 2015 after reaching at a historical high level. The unbelievable gap between highest and lowest price is approximately 432 percent. The lower level still exists until December 2017, meanwhile a price of ribbed smoked sheet makes a big rise in February that year (See Figure 1).

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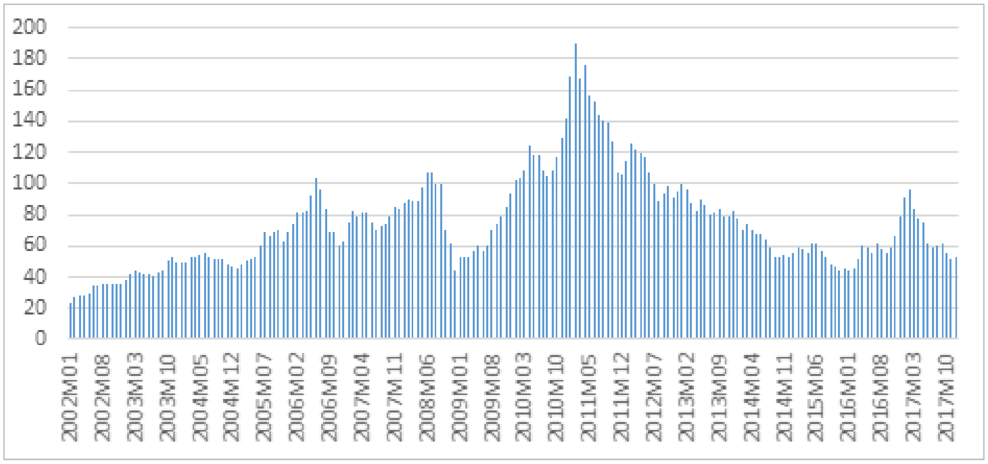

Figure 1: Wholesale price of ribbed smoked sheet at central market in Songkhla province between January 2002 and December 2017 (Unit: Baht/Kilograms (bath/kg))
Source: Bank of Thailand

The rubber price variability has several reasons for its volatility, for instance; supply shortfall, low levels of stock, high levels of supply, low levels of demand, and high levels of demand. Similarly, the world economic situation which decelerated for many years has inevitably affected the world rubber demand. In fact, the lower demand of rubber has the same direction of impact on price of rubber in Thailand. Furthermore, the overstocks of Thai rubber in 2011 and 2012 were 361,557 and 516,675 tons. As a result, the excess supplies directly affected the wholesale price of ribbed smoked sheet. In addition, the domestic consumption of rubber does not change much more because there are only a few latex manufacturers who demanded the natural rubber in Thailand. These causes make price of ribbed smoked sheet reduce sharply over the last seven years. More importantly, such price changes in parallel with Thai farmer's income.

Even though the variation of storage and changes in supply and demand play an important role in determining rubber price, it is very much necessary that Thai government plays its role and intervenes in the natural rubber market. For this purpose, they established the Committee of Natural Rubber Policy and Rubber Authority of Thailand which actually manages and supports 1.8 million Thai rubber farmers and ensures price stability. The rubber solving scheme was set up to stabilize overall rubber price structure in 2014, for instance, government payed an unconditional cash 2,520 baht per rai[2] each (2,520 baht/ 0.395acre) for compensation. This long-term plan was limited to the quantity of rubber farm. In other words, this government transfer was supportive for those farmers who had no more than 25 rai of the farm land, and with the assumption that rubber tree has no more than 25 years of lifetime, and the farmers must have the document of title. Prior to that, Thai government launched the potential development project of farmer institution for rubber price stability. The relevant purpose of such scheme was to decelerate the supply of rubber via sell mechanism during price fall. Thai Government subsidize the financial fund to Rubber Estate Organization for purchasing rubber products such as field latex, unsmoked sheets, cup lump etc. in order to process it further. Such program continued for one year and three months, but it could not regularly maintain the rubber price as per the policy target.

As a result, several programs were designed to solve price fluctuation's problems. In addition, Agricultural Futures Exchange of Thailand (AFET) was established to observe the price movement of ribbed smoked rubber sheet no.3 in the future. It worked as a hedging tool so that it could diminish the volatile behavior of that price. In contrast, all policy schemes cannot drive the price mechanism to increase rubber price in the period of deceleration, or stabilize it during the price fluctuation.

The rest of this paper is organized as follows. Section 2 shows the closely related studies about the rubber pricing models and empirical findings. Section 3 presents rubber pricing model which derives from consumption-based of a general equilibrium framework. It comes up with factors which determine the rubber profit of farmer. It also demonstrates the research methodology and procedure for applying such model. Rubber price implication is displayed in section 4. Section 5 concludes with the key findings and discusses about such models with empirical results and policy implication.

2. Literature Review

Such rubber price variability still exists as a part of the world commodity prices. That is why many previous works try to model all commodity series for solving the price volatility that leads to very low income of rubber farmers. Deaton and Laroque (1992) account for behavior of commodity price with a simple theory based on competitive storage. This paper develops a simplified model with random harvests that do not reflect the current and future price. A price is set for each season which has only one market. This model serves to focus attention on the role that storage plays in transferring commodities from relatively plentiful times to relatively scarce times, and its effects on the price behaviour. It illustrates the prediction power with autoregressive, conditional variances, and conditional expectations. In fact, behavior of commodity prices from year to year conforms to the predictions of the theory. However, such model does not yield a fully satisfactory explanation for high autocorrelation. They also develop model of commodity price for long-run equilibrium as in Deaton and Laroque (2003). This paper proposes a statistical model of commodity prices based on Sir Arthur Lewis. This work assumes that labor supplies are unlimited. The results show that demand is associated with the level of world income and with the price of the commodity. The prices are stationary for a long-run trend, and production is cointegrated with world income. Moreover, the growth rate of supply responds to deviations of price from its long-run equilibrium. The model is fitted to long-run historical data for six commodities; cocoa, coffee, copper, rice, sugar, and tin, over (some subset) during the years 1900–1987.

The difference between the implication of economic theory and the implication of empirical evidence regarding commodity prices, however, is still challenged. Chen, Jacksony, Kimz and Resiandinix (2010) demonstrate the factors that play dominant roles in determining the dynamics of highly tradable commodity prices. The first common factor that has a predictable effect on the exchange rate will have a corresponding predictable effect on commodity prices. The second common factor and the idiosyncratic components of each series are found to be stationary, and the short-lived deviations quickly revert back to equilibrium. These two results give a viable rationale for the theory and evidence dichotomy of international commodity prices. Instead, the later works focus on the rational expectations of competitive storage model especially storage as described by Williams and Wright (1991). Arsenneau and Leduc (2013) show that the interaction between storage and interest rate under general equilibrium improve the effects of competitive storage on commodity prices. This work presents that storage in general equilibrium leads to more persistence in commodity prices and to a lower frequency of stock outs. A key mechanism driving this result is a link between the ability of a household for smooth consumption over a period of time and the level of storage in the stochastic equilibrium. As regards policy implication, the finding displays that ethanol subsidies do little to significantly alter commodity price dynamics and have only a minor impact on the broader macro economy.

The previous empirical studies also normally conform to many theoretical papers regularly developed related to commodity prices. In particular, the paper of Miao, Wu, and Funke (2011) describes the predominant role of the output/demand ratio as the most significant finding, which must be combined with the intertemporal storage. It displays the long-run commodity price movements and the high autocorrelations observed in actual prices. Short-run price movements are mostly not due to shocks with a large variance but rather because of the realization of small-probability events, such as a yield stock larger than two standard deviations. Monetary policy plays a limited role in normal times but could have nonlinear and significant impact when the real rate becomes deeply negative.

On the contrary**,** Arunwarakorn, Suthiwartnarueput and Pornchaiwiseskul (2019) developed demand and supply models to forecast equilibrium in amount and price on the world natural rubber market using monthly data from 2004 to 2015 with a three-stage least square technique and simultaneous equations. The first finding shows that there is a positive relationship of the explanatory variables of world natural rubber production quantity, synthetic rubber price, percentage year of year of gross domestic product (GDP), and the exchange rate in the demand model, while a negative relationship variable is natural rubber price. In the supply model, the positive relationship variables are natural rubber price, mature area, rainfall, and crude oil price, while the negative relationship variables are world natural rubber stock and urea price. Another result indicates that the predicted variables; production, percentage year of year of GDP, exchange rate, amount of stock, and the mature area tend to gradually expand, while the synthetic rubber price, urea price, rainfall, and crude oil price tend to slowly decline from 2017 to 2026. In particularly, Oktora and Firdani (2019) show that natural rubber price, exchange rate, and China's economic slowdown significantly affected natural export to China. In contrast, Southeast Asian natural rubber production has no significant effect. China plays an important role in growing natural rubber export in Southeast Asia.

Moreover, Wang and Lu (2013), propose an adapted autoregressive model and a stochastic volatility model with dummy variables. Such work finds that price limits are efficient in controlling future copper prices in Shanghai Futures Exchange (SHFE), but future rubber prices are distorted significantly. Furthermore, unlike the previous one, Romprasert (2009) shows that the preceding monthly futures prices of rubber and oil prices significantly affect the rubber futures prices in the same direction. The net import of natural rubber by Japan is the leading indicator for trends in futures prices in Thailand. However, Boonkomrat and Chancharoenchai (2011) display that the Agriculture Futures Exchange of Thailand can be very much categorized as a semi-strong efficient form of market. The results also indicate that the market and macroeconomic information has a statistically significant impact on future basis which is consistent with Yimlamai, Phromchana and Kao-ian (2011). Nevertheless, Go and Lau (2014) find that the noise traders' hypothesis as the time span for variance of past trading volume to cause variance of current return is found Kuala Lumpur Options and Financial Futures Exchange (KLOFFE). This means that the current prices can be influenced by speculators, momentum traders, insiders as well as institutions. Moreover, concerning the econometric tools, Ortiz, Xia and Wang (2015) predict GDP, domestic demand, investment, and net exports more precisely by using a vector autoregressive (VAR) model and the Granger causality test. In addition, Cherdchoongam and Rungreunganun (2016) developed useful forecasting model for natural rubber pricing in Thailand. The finding shows that the ARIMAX(0,1,1) is the most appropriate model for prediction of variable explanation of Thailand's natural rubber price of 99.89% and absolute mean percentage error of 1.11. Nevertheless, all papers as mentioned above do not firmly assert the rubber pricing model as the unique determinant of current price. As a result, there is still no clear evidence to show what factors regularly influence the farm price of rubber that actually results in the entrepreneur profit especially of the Thai farmer.

3. Research Methods and Materials

The modeled economy in this study follows Arseneau and Leduc (2013) which put the canonical rational expectations storage model into a general equilibrium macroeconomic model. Consistent with such models, this research considers the household side which is made of homogenous agents that supply labor to firms and save over time by holding one-period pure discount bond. It is assumed that agents hold inventories of primary commodity. In fact, inventory speculation actually helps the agents to smoothen viability in the primary commodity which is modeled as a stochastic endowment process.

3.1. Model Specification

3.1.1. Household

Such economy has infinitely homogeneous households that will exist forever. Hence, the entire agents can be modeled as a single representative household. In each period, he or she spends time endowment working hour, n_t, and taking leisure, l_t. For simplicity, such endowment is normalized to one, such that $l_t + n_t = 1$. The household's utility function is defined over consumption of a final good, c_t, consumption of a primary good, $q_{H,t}$, and hours worked. Assume that a representative household earns income from labor wage at time t, $w_t n_t$, bonds holding at time t, b_t, commodity storage at time $t-1$, $p_t s_{t-1}$, and profits of the commodity producer, π_t^C, to allocate for consumption, c_t, purchasing a one-period real discount bond, $p_{b,t+1} b_{t+1}$, purchasing the primary commodity, $p_t q_{H,t}$, purchasing the commodity storage for holding until the next period, $p_t s_t$, and cost of storage valued in unit of aggregate consumption good, κs_t. That is, the household chooses sequences of $c_t, n_t, q_{H,t}, s_t, b_{t+1}$ to maximize objective function given by equation (1) subject to the budget constraint in equation (2) and a nonnegativity constraint given by equation (3) which can be written as

$$\text{Max } U_t = \sum_{t=0}^{\infty} \beta^t \left(\log c_t + \log\left(1 - n_t\right) + \log q_{H,t} \right); \quad 0 < \beta < 1 \tag{1}$$

Subject to

$$c_t + p_{b,t+1} b_{t+1} + p_t q_{H,t} + p_t s_t + \kappa s_t = w_t n_t + b_t + p_t s_{t-1} + \pi_t^C \tag{2}$$

$$s_t \geq 0 \tag{3}$$

where β is the subjective discount factor. $p_{b,\ t+1}$ represents the price of real discount bond. κ stands for the cost of storage valued in unit of the aggregate consumption good. w_t is the real wage. p_t is the relative price of commodity. π_t^C represents the profit of commodity producer.

3.1.2. Firm

Contrary to Arseneau and Leduc (2013), this study not only explores the production side, but also simplifies commodity goods as the supply side of the economy modeled in small country. As a result, there are not two sectors in production function, unlike previous model. In fact, this economy is also populated by infinitely homogenous firms which produces commodity goods. Therefore, the firm's profit function of commodity goods which can be written as

$$\pi_t^C = A(TR_t - TC_t) \tag{4}$$

where π_t^C is the firm's profit of commodity goods. TR stands for the total firm's revenue from commodity goods. TC stands for the total cost of producing commodity. A is the fixed farm land for commodity production. Then, substituting the formulas of total revenue and total cost into equation 4, such equation becomes

$$\pi_t^C = A(P_t.Q_t - AC_t.Q_t) \quad (5)$$

$$\pi_t^C = A(P_t - AC_t)\ Q_t \quad (6)$$

Given that the average cost and quantity of commodity goods are fixed in the short-run production, similar to fixed farm land, the expectation of firm's profit can be written as

$$E_t(\pi_t^c) = E_t\left[\overline{A}(P_t - A\overline{C}_t).\overline{Q}\right] \quad (7)$$

This implies that the profit expectation of firm equals the expected price of commodity goods in the short-run production as following.

$$E_t(\pi_t^C) = E_t(P_t) \quad (8)$$

Equation 8 can be written in terms of commodity price as

$$P^e = f(P_{t-1}, P_{t-2},\ldots) \quad (9)$$

This means that the expected price of commodity goods (P^e) is a function of the previous commodity price. Given that the average cost of production, supply of commodity goods, and farmlands are fixed, the past commodity price has an impact on the expected profit of commodity production and the expected commodity price.

3.1.3. Commodity Price Implication

The commodity price implication of this economy can be applied to equation 9, especially Thai local price of rubber. It is due to the fact that most rubber trading takes place in the future market, for example Shanghai Futures Exchange (SHFE), Tokyo Commodity Exchange (TOCOM), Singapore Commodity Exchange (SICOM), Indian Commodity Exchange Limited (ICEX), and Agricultural Futures Exchange of Thailand (AFET). In case of Thailand, the world rubber importers initially approach Thai rubber exporters in order to purchase ribbed smoked rubber sheet at the contract quantity, contract price, and delivery date. The price mechanism pass the free on board price through the central rubber market in Thailand, and the local rubber market, respectively. As a result, Thai farmers inevitably take such price as given because they probably are unable to manage demand and supply for natural rubber. It is because Thai rubber price does not depend on market mechanism as usual. Thus, for simplicity, the rubber farm price, P_f^e, presents the expected price of commodity goods, and the past world price of rubber, WP_{t-n}, denotes the previous rubber price. In other words, the expected farm price of rubber is

$$P_f^e = f(WP_{t-n});\ n = 1, 2, \ldots \quad (10)$$

Replacing the world price of rubber with the free on board price, then the expected rubber farm price is expressed as

$$P_f^e = f(P_{FOB,\,t-n}) \quad (11)$$

When considering the free on board price in terms of local currency, it equals the world's free on board price without transaction cost multiplied by exchange rate.

$$P_{FOB,\,t-n} = P_{FOB,\,t-n}^W.\mathrm{s}_t \quad (12)$$

where s defines as the exchange rate. However, equation 12 can be displayed in logarithm form by taking natural logarithm this equation as the following.

$$\ln(P_{FOB,\,t-n}) = \ln(P_{FOB,\,t-n}^W) + \ln(s_t) \quad (13)$$

In addition, equation 13 can be actually transform to derivative with respect to time t as follow:

$$\frac{d\ln(\mathrm{P}_{FOB})}{dt} = \frac{d\ln(P_{FOB}^w)}{dt} + \frac{d\ln(s)}{dt} \quad (14)$$

To summarize, the model of farm price's rubber shows that, in the short-run, the expected rubber profit of farmers depend crucially on the expected farm price of rubber. Moreover, a change in such price of rubber results from a change in the world price of rubber in the past period. It also implies that the free on board price in the past period has an impact on the expected farm price of rubber given the exchange rate.

3.2. Material and Methods

This paper not only examines the rubber pricing model but it also intends to show empirical findings. More importantly, it seeks to explore what factors specifically determine the expected farm price of rubber in the short-run. As a result, it also leads to a change in rubber profit's farmer, especially Thai farmer. Hence, there are several methods

First of all, a simple method to collect primary data is a survey research. The questionnaire is designed to catch up almost all characteristic of Thai's rubber farmer relating to general information of farmers, rubber production, rubber management, cost of rubber, rubber marketing, etc. Typically, the purposive sampling is applied for a sampling of three provinces where they regularly plant the most natural rubbers in each region of Thailand. These provinces consist of Bueng Kan in northeastern region, Chanthaburi in eastern region, and Songkhla in southern region so as to better understand the common characteristic of farmers as a whole. Such survey limits to thirty homogenous farmers in each province who are full aware about the facts concerning rubber. Secondly, the data for studying is derived from carrying out a survey and collecting secondary monthly data from World Bank Commodity Price Data and Office of Agricultural Economics, Thai government between January 1999 and December 2016, (a total of 216 months). Finally, it is consistent with a derived model that rubber price at farm gate and world rubber price in SICOM are taken as a unit root test, Granger causality, cointegration, vector error correction model, and forecasting error measurements.

4. Results and Discussion

The findings from a sampling of three provinces, 81 households in total after definitely cutting off the outliers, are shown in Table 1, the male farmers are 56.79% and females 43.21%. The educational levels in the collected sample of rubber farmers consists of those with primary education are 53.09%, high school education of 17.28%, and secondary education of 12.35%. It obviously indicates that percentage of Thai farmers with core income from rubber plant is 65.43%, and 30.86% of samples do not have their core income from rubber. More importantly, most of them also face a big debt problems, and just 23.46% of samples do not have any debts. Thai farmer normally produce many types of rubber products such as cup latex (53.09%), field latex (41.98%), and rubber unsmoked sheet (4.94%). This means that most rubber farmers frequently make the natural rubber instead of finished goods. As a result, they regularly sell their raw material via local middlemen, 69.14%, who always make the expected profit from the difference between rubber price at farm gate and wholesale price at central market. They also distribute their natural rubbers through central market, 16.05% and other marketplace, 11.11%. However, such farmers do not immediately offer available products to marketplace because they always wait for the market timing available especially increasing in future price. That is, farmers who frequently sell the natural rubber within less than one week consists of 12.35%, within 1-2 weeks 35.80%, within 3-4 weeks 7.41%, and within more than one week 1.23%. This implies that the behavior of Thai farmers shows that they usually look forward to the next higher price than current one. They normally sell their available product if they are satisfied with the previous price as sufficiently high. Similarly, a common characteristic of farmer is highly consistent with the rubber pricing model derived as equation 9, 10, and 11. Therefore, the empirical results definitely explores the determination of Thai rubber price (See Table 1).

The price of commodity market in the past period completely affects the price of rubber at local market as derived model before which takes account of a change in the Thai rubber price. To give more details, the rubber price in Singapore Commodity Exchange represents the world price (WP), and rubber price at farm gate stands for the rubber price at local market (FP). In other words, the previous studies indicate that the rubber price in SICOM has obviously transmitted its movement to other markets especially AFET comparing with SHFE, TOCOM, ICEX, and AFET. That is why this paper takes price in SICOM as the world price, but takes exchange rate as given. As a result, such price transmission possibly leads to a change in farm price of the Thai rubber. Thus, the co-movement between the world price and rubber price at farm gate shows that they move in the same direction as in the Figure 2

Figure 2 states that both rubber prices always behave in the same and such a way that they are closely correlated. For instance, both types of price change remains stable from January 1999 to December 2001. They suddenly fall down at the first month of 2002 before rapidly going up to the highest level of price in July 2008. Indeed, they also contract suddenly to the lowest level in December 2008 thanks to the subprime mortgage crisis and quickly expand to highest price again in March 2011. However, such prices continue to decline slowly until December 2016 due to the world economic downturn. Hence, the monthly price of ribbed rubber smoked sheet in SICOM (WP) and the average of monthly rubber price at farm gate in Thailand (FP) are highly volatile during 1999-2016 which result in a spurious regression problem. That is, both data series should be tested on a unit root for stationary by using Augmented Dicky-Fuller (ADF) test. This method applies Schwarz Information Criterion (SIC) with the lowest one criterion for selecting time lag. Then, the ADF test constructs a parametric correction for higher-order correlation as follows:

$$\Delta p_t = \alpha + \gamma p_{t-1} + \sum_{i=1}^{I} \Delta p_{t-i} + \varepsilon_t \qquad (15)$$

where p is the price of rubber ribbed smoked sheet in SICOM or the monthly rubber price at farm gate

i is the lag order of the autoregressive process.

The null and alternative hypothesis are

$H_0 : \gamma = 0$ (Non-stationary)

$H_a : \gamma < 0$ (Stationary)

Table 1: Summary statistics for the characteristic of rubber farmers

		Aggregate(Persons)	Frequency (%)
Gender	Male	46	56.79
	Female	35	43.21
Educational level	Primary education	43	53.09
	Secondary education	10	12.35
	High school education	14	17.28
	Diploma	6	7.41
	Bachelor or higher	7	8.64
Rubber Income	Core income	53	65.43
	Non-core income	25	30.86
Debt of households	no	19	23.46
	yes	62	76.54
Type of production	Rubber unsmoked sheet	4	4.94
	Cup latex	43	53.09
	Field latex	34	41.98
Channel of product selling	Local middleman	56	69.14
	Central market	13	16.05
	Other marketplace	9	11.11
	No respond	3	3.70
Frequency of product selling	Less than 1 week	10	12.35
	1-2 weeks	29	35.80
	3-4 weeks	6	7.41
	More than 1 month	1	1.23
	other	34	41.98

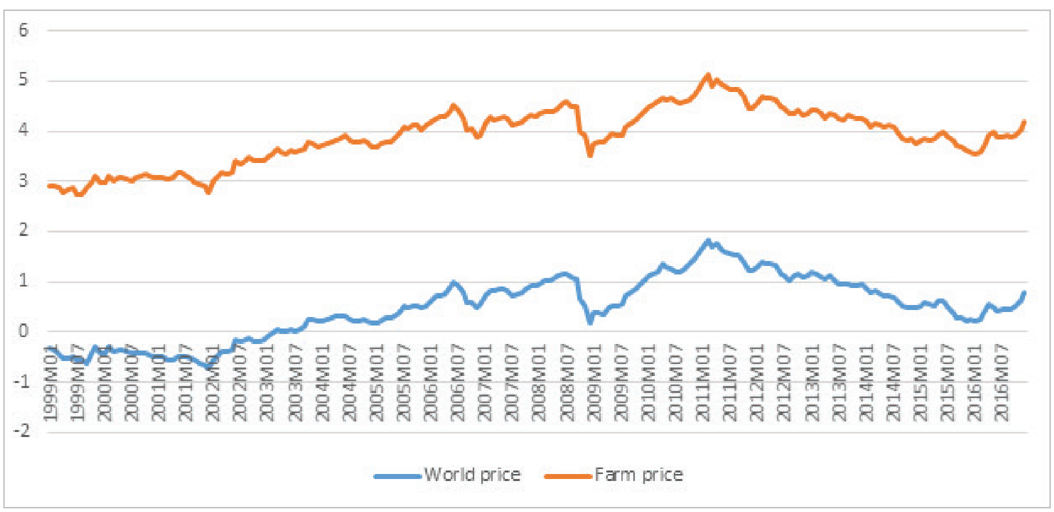

Figure 2: The co-movement between the monthly price of rubber ribbed smoked sheet in SICOM (World price) and the average of monthly rubber price at farm gate in Thailand (Farm price) from January 1999-December 2016 in form of logarithm
Source: World Bank Commodity Price Data and Office of Agricultural Economics, Thailand

The results display that WP and FP are non-stationary because the null hypothesis is not rejected. In other words, the calculated ADF test statistic is more than the critical value at significant level 1%, 5%, and 10%, then both data series are unit root. In contrast, lagged level of the WP and FP series are stationary because the null hypothesis is rejected. That is, the calculated ADF test statistic is actually less than the critical value at significant level 1%, 5%, and 10%. It implies that both data series are not unit root.

In addition, the next step is the Granger causality test to explore the direction of relationship between the prices of rubber ribbed smoked sheet in SICOM or the rubber price at farm gate in Thailand. In fact, this study uses a length of lag 1-5 for two variables in order to carry out the relevance of all past information. The null hypothesis is

$$H_0\text{: x does not Granger-cause y} \tag{16}$$

Such test presents that the null hypothesis is rejected for what the lag-1 of WP Granger-cause FP, but it is not rejected for what the lag-1 FP Granger-cause WP. This means that Granger causality runs one-way from WP to FP and not the other way round. That is, the price of rubber ribbed smoked sheet in SICOM at $t - 1$ only Granger-causes the rubber price at farm gate in Thailand at significant level 0.10. The Granger causality test also shows that the null hypothesis of lag-2, lag-3, lag-4, and lag-5 WP are rejected; besides, the null hypothesis of lag-2, lag-3, lag-4, and lag-5 FP are rejected. This obviously means that both types of prices Granger-cause each other; indeed, it appears that there are two-way causes. Therefore, the next empirical result of cointegration test for a long-run equilibrium relationship among the variables define WP as the control variable and FP as the dependent variable.

According to Engle and Granger (1987) who suggest that a linear combination of two or more non-stationary series might be stationary, cointegration test is precisely applied to conduct the long-term equilibrium among WP and FP (See Table 2 and Table 3).

Table 2 shows that the estimated coefficient on WP equals 0.88 which is statistically significant at a 0.01 significance level. The t- statistics is larger than 2 (90.99), an average R-squared is 0.97, and standard error is 0.0097. That is, 97% of the variance of FP is accounted for, or the Change in WP able to explain the change in FP of 97%. Table 3 demonstrates the unit root test of residual of regression FP that the null hypothesis is rejected because the calculated ADF test statistic is exactly less than the critical value at significant level 1%, 5%, and 10%, respectively. Hence, such residual of regression has a stationary process so that both series of prices has a long-run equilibrium relationship. This means that FP and WP are actually in cointegration. As a result, Vector Error Correction Model (VECM) would be applied to discover the short-run relationship between FP and WP and speed of adjustment as the following.

$$\Delta FP_t = \alpha_0 + \sum_{j=1}^{\infty} \alpha_j \Delta FP_{t-j} + \sum_{h=1}^{\infty} \beta_h \Delta WP + \gamma \hat{e}_{t-1} + \varepsilon_t \tag{17}$$

Table 2: Regression result of FP for cointegration test

	Constant	**WP**
	3.4754	0.8888
Std. Error	(0.0077)	(0.0097)
t-Statistic N = 216	[451.1369]	[90.9950]
R^2 = 0.97	F-statistic = 8280.089	Durbin-Watson stat= 0.2119

Remarks: ( ) denotes the standard errors.
[ ] denotes the t-statistic.

Table 3: Unit root test of residual of regression FP

variable	ADF-test	Lag	1% Critical Value	5% Critical Value	10% Critical Value
residual	-3.7759	4	-2.5758	-1.9423	-1.6157

Table 4: Vector Error Correction Model (VECM) of the rubber price at farm gate in Thailand

Variables	Estimated Coefficient	Standard Error	t-statistic
$\hat{e}_{t-1}$	γ = -0.2111	0.0668	-3.1564
ΔFP_{t-1}	α_1 = -0.5621	0.1575	-3.5692
ΔFP_{t-2}	α_2 = -0.0443	0.1594	0.2781
ΔWP_{t-1}	β_1 = 0.9103	0.1779	5.1165
ΔWP_{t-2}	β_2 = 0.0548	0.1887	0.2908
α_0	α_0 = 0.0044	0.0060	0.7442

Equation 17 indicates that the VECM for FP which consists of two parts. The first part reports the short-run impact of change in the past period *FP* and *WP* on the *FP* $\left[\sum_{j=1}^{\infty} \alpha_j \Delta FP_{t-j} + \sum_{h=1}^{\infty} \beta_h \Delta WP\right]$, the second term describes long-run force towards the equilibrium relationship, $\gamma \hat{e}_{t-1}$, which is also call the error correction terms. Table 4 presents that the estimated coefficient of regression residual is -0.2111. Such a size of cointegration expresses behavior which deviates from long-run equilibrium relation of the rubber price at farm gate in Thailand; nevertheless, the period $t-1$ deviation slowly converge to the steady state again. In particular, this fluctuation will be eliminated by 21.11 percent each month, then it returns to its previous level. Apart from a long-run behavior, a change in the price of rubber ribbed smoked sheet in SICOM in the period $t-1$ has a statistically significant effect on a change in the rubber price at farm gate in the period t in the short run. It has a strongly positive impact of 0.9103. Additionally, a change in the rubber price at farm gate in the period $t-1$ has a significantly negative effect on a change in the rubber price at farm gate in the period t in the short run, also. It illustrates that, if other things are equal, each one percentage-point increase in the period $t-1$ rubber price at farm gate results in the decrease of 0.5621 percentage points in the period t in the rubber price at the farm gate. This means that the past period price of rubber ribbed smoked sheet in SICOM play more important role than the previous price of rubber at the farm gate in Thailand in determining the current price of rubber at the farm gate. In other words, there is a high link between Thai local market of rubber and SICOM. Thus, VECM as the equation 17 is a strongly appropriate model for rubber price in case of Thailand (See Table 4).

What the rubber pricing model forecasts about the future values of rubber price is usually evaluated by different measures of forecast accuracy; root mean squared error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and the Theil inequality coefficient (U). This paper carry all measures out to perform accuracy of such model. The findings state that equation 17 does closely match with the observed data well, so that it is a suitable pricing model for predicting the Thai rubber price. The values of all evaluated methods are very close to zero; indeed, RMSE, MAE, MAPE, and Theil inequality coefficient equal 0.1183, 0.0838, 2.4253%, and 0.0149, respectively.

In more details, Theil inequality coefficient describes the size of forecasting residual which means that the closer the value of U is to zero, the better the forecast method. It consists of bias proportion of 0.0006 and Variance Proportion of 0.0362 which are close to zero. The covariance proportion equals 0.963; in fact, this value is close to one. This indicates that the forecasting residual is obviously consistent with the observed value.

5. Conclusion

This paper establishes the rubber pricing model especially Thai natural rubber. The model is derived from the household side which is composed of homogenous agents that supply labor to firms and save over time by holding one-period pure discount bond. A representative agent maximizes utility function with commodity goods. Such rubber model is also populated by infinitely homogenous firms which produces commodity goods. The firm profit-maximization of commodity goods is solved to derive rubber pricing model. The result shows that, given other things are constant, the period $t-1$ commodity price affects the expected commodity price and the expected profit of commodity production. More importantly, a change in the world price of rubber in the past period leads to a change in expected price of rubber in the short run which also influences the expected profit of rubber. That is, the past-period is free on board price affects the expected farm price of rubber given at an exchange rate. It is consistent with the survey results that Thai farmers normally wait for the market timing available especially increasing in the future price. They sell their available natural rubber once the world price in the past period actually reach the high level.

In addition, the price of ribbed smoke sheet 3 in SICOM and farm price of rubber in Thailand are obviously in long-run equilibrium relationship. In fact, a change in price of ribbed smoke sheet 3 in SICOM has a significantly positive impact on a change in the farm price of rubber in Thailand. Moreover, the result particularly reveals that the past period price of rubber ribbed smoked sheet in SICOM play an important role in determining the current price of rubber at farm gate in Thailand. In other words, a change in the price of rubber ribbed smoked sheet in SICOM in the period $t - 1$ has a statistically significant effect on a change in the rubber price at farm gate in the period t in the short run. Hence, the government should redesign the rubber policy to commodity storage for the next period volatility because he is not definitely capable to manage the local market price of rubber. Moreover, VECM of price of rubber at farm gate is the most appropriate model for rubber price in the context of Thailand. However, this model is just a general equilibrium of commodity goods. Therefore, the dynamic stochastic general equilibrium should be applied for further research.

References

Arseneau, D. M., & Leduc, S. (2013). Commodity price movements in a general Equilibrium model of storage. *IMF Economic Review*, 61, 199–224.

Arunwarakorn, S., Suthiwartnarueput, K., & Pornchaiwiseskul, P. (2019). Forecasting equilibrium quantity and price on the world natural rubber market. *Kasetsart Journal of Social Sciences,* 40(1), 8-16. https://doi: 10.1016/j.kjss.2017.07.013

Boonkomrat, T., & Chancharoenchai, K. (2011). Futures Basis of RSS3 in agricultural futures exchange of Thailand. *Applied Economics Journal,* 18(1), 2011. Retrieved from https://so01.tci-thaijo.org/index.php/AEJ/article/view/10427

Chen S. L., Jacksony, J. D., Kimz, H. & Resiandinix. P. (2010). What drives commodity prices? *Auburn Economics Working Paper Series auwp2013-03*, Department of Economics, Auburn University.

Cherdchoongam, S., & Rungreunganun, V. (2016). Forecasting the price of natural rubber in Thailand using ARIMA Model. *KMUTNB International Journal of Applied Science Technology,* 9(4), 271-277.

Deaton, A., & Laroque, G. (1992). On the behaviour of commodity prices. *Review of Economic Studies,* 59, 1-23. https://doi.org/10.2307/2297923

Deaton, A., & Laroque, G. (2003). A model of commodity prices after Sir Arthur Lewis. *Journal of Development Economics,* 71, 289–310.

Engle, R. F., & C. W. J. Granger. (1987). Co-integration and error correction: Representation, estimation and testing. *Econometrica,* 5(2), 251-276. https://doi: 10.2307/1913236

Go, Y.-H., & Lau, W.-Y. (2014). Asymmetric information spillovers between trading volume and price changes in Malaysian Futures Market. *Journal of Asian Finance, Economics, and Business,* 1(3), 5-16. https://doi.org/10.13106/jafeb.2014.vol1.no3.5.

Knudsen, O., & Nash, J. (1990). Domestic price stabilization schemes in developing countries. *Economic Development and Cultural Change,* 38(3), 539-558. https://doi.org/10.1086/451814

Miao Y., Wu, W., & Funke, N. (2011). Reviving the competitive storage model: A holistic approach to food commodity prices. *IMF Working Paper,* 11/64. Washington, DC: International Monetary Fund. doi: 10.5089/9781455228065.001

Oktora, S. I., & Firdani, A. M. (2019). Natural Rubber Economics between China and Southeast Asia: The impact of China's economic slowdown. *Journal of Asian Finance, Economics, and Business,* 6(2), 55-62. http://dx.doi.org/10.13106/jafeb.2019.vol6.no2.55

Ortiz, J., Xia, J. & Wang H. (2015). A VAR model of stimulating economic growth in the Guangdong province P.R. China. *Journal of Asian Finance, Economics, and Business,* 2(2), 5-12. https://doi.org/10.13106/jafeb.2015.vol2.no2.5.

Romprasert, S. (2009). Forecasting model of RSS3 price in futures market. *Kasetsart University Journal of Economics*, 16(1), 54-74.

Wang, N., & Lu, Y. (2013). Adapted autoregressive model and volatility model with application. *Journal of Data Science,* 11, 655-671.

Williams, J.C., & Wright, B. D. (1991). *Storage and Commodity Markets.* Cambridge. UK: Cambridge University Press.

Yimlamai, S., Phromchana, N., & Kao-ian, S. (2011). Efficiency analysis of rubber price in agricultural futures exchange of Thailand. *Journal of Graduate Studies Valaya Alongkron Rajabhat University,* 5(2), 21-30.

Endnotes

[1]The weighted-average Interbank Exchange Rate as of April 22, 2020 is equal to 32.530 baht per dollar. This paper assumes that dollar exchange rate is always fixed over the period 2002-2017.

[2]One rai equals 0.395 acre