The Pricing Model of Rice: Evidence from Thailand

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Abstract: Although the rice market in Thailand is linked tightly with the world market, it is fraught with government intervention policies from time to time. In 2011 the Yingluck Shinawatra government embarked the rice pledging scheme that aimed to bid up domestic paddy prices above the global market. Such scheme set the premium of 40-50 percent higher than the world price. Nevertheless, the program was discontinued in 2014. This paper attempts to shed light on how the price structure in Thailand was affected by government intervention policies. In particular, we conducted a field survey to unearth the transmission mechanism that channel information about market factors on prices in various levels, ranging from world rice price to the wholesale paddy prices. The findings show that the paddy price was mainly determined by the rice mill, the central paddy market, the middleman, and the exporters. The government intervention policies could influence the paddy price temporarily, i.e., when the scheme was in place. In the long-run equilibrium, the paddy price is determined by a combination of the price at which the mills are willing to buy and the world price. Our empirical investigation, based on the Engel-Granger Cointegration test and the Error-correction model, confirms this conjecture. Moreover, the price expectation embedded in the millers' offer price played a significant role in the price discovery process. The causality test revealed that the expected future price causes the spot wholesale price in the Granger sense. It is also found that the causation is bi-directional implying that the flows of information between markets are essential in determining the equilibrium price in the rice market.

Key-Words: Rice Price, Pricing Model, Pledging, Error Correction Model

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1 Introduction

In 2011 the Yingluck Shinawatra government embarked the rice pledging scheme that aimed to bid up domestic paddy prices. Such scheme set the pledging price 40-50 percent higher than the global price. Despite being among the world major rice exporter, the price intervention policy hardly had any impact on the world price. However, whether such scheme has a long-lasting effect on domestic price, and consequently farmers' income, remain to be explored. To be able to uncover such effect, one needs to understand the structure of rice prices in Thailand first. In particular, one needs to disentangle the transmission mechanism that channel information about market factors on prices in various levels, ranging from world rice price to the wholesale paddy prices.

From 2001 to 2009, approximately 70 percent of rice production was consumed in Thailand. The domestic paddy production averages 32 million tons per year, while the production of milled rice averages 20 million tons per year. The processing, distribution and retailing all involve many parties, starting with farmers and progressing to rice mills, central markets, exporters, wholesalers and retailers, and finally to domestic and foreign consumers. The supply chain of rice also creates a linkage of prices in various layers.

In the past, the government implemented measures to control the price of various types of paddy. Isavilanon (2010a) categorized the subsidy schemes as follows

1) Price support for paddy. The principle of this measure is minimum pricing by the government to create artificial demand in the rice market. This measure has been in effect since 1955 with the establishment of the Warehouse Organization to go out to buy and collect paddy from farmers. After that, in 1974 the government established the Farmers Aid Fund and the Marketing Organization for Farmers which is an agency that purchases paddy from farmers.

2) Paddy Pledge. The operation started from the 1981/82 planting year. The government assigned this duty to the Bank for Agriculture and Agricultural Cooperatives (BAAC), but in the 1991/92 planting year, the paddy pledge was under-funded by the agricultural fund.

3) The Insurance Program of Rice Farmers' Income was an idea that came from the risk insurance principle due to the price volatility. It was a contractual agreement between the government and the farmers of which BAAC acts as a state representative. The farmers had to inform the BAAC about the amount of area, quantity of production and target price. As a result, at the harvest time, if the current quote was lower than the target price, the government paid the difference between the target price and the quote price.

However, the price pledging scheme of the Yingluck government in 2011 pushed the subsidy beyond all past measures. It set the pledging price about 50 percent above the market price and open to all offers without quantity limit. It is obvious that the pricing structure in Thailand was distorted during the period when the scheme was in place. The price pledging scheme was discontinued in May 2014 when the military staged the coup and abolished the program.

Though the program was short-lived but it worths the while to investigate how the price structure of rice market was affected by the scheme**.** Therefore, this study attempts to learn about the changing price structure in the past years, especially after the rice pledging scheme of the government was introduced. It also attempts to develop a model that explains how prices in the supply chain are determined, the role of the futures market in reducing price fluctuation, and the price discovery process. In the end, the study can deliver policy recommendations regarding the price intervention scheme based on empirical evidence.

2 Literature Review

The price structure of Thai rice has changed dramatically. Recently, Thailand has had to face important competitors, namely Vietnam, India, Pakistan, and the United States of America. A study by Chaokul et al. (2011) found that the proportion of rice exported and used in Thailand in the form of direct consumption and processed food was quite similar; about 45 percent of total production. It indicated that the Thai rice economy noticeably had to rely more on the world rice market. Consistent with the study of Isavilanon et al. (2009), it was found that the rice price level in the 2007/08 production year increased significantly from the 1987/88 production year, but the production cost inflated more than such price. As a result, most farmers in the rainwater fields suffered losses from rice production. However, the research results of Puapongsakorn and Jarupong (2010) indicated that the 5.24 million tons of the paddy project in 2005/06 caused the implicit costs and a loss of 19,130 million baht (597.81 million US$). The paddy pledge has led to changes in social welfare because this project transferred resources from taxpayers and consumers to producers. That is, welfare costs equaled between -16,609.94 million baht (-519.06 million US$) to -17,720.99 million baht (-553.78 million US$), which was lower than the loss. The results of a study on intervention in rice prices in Thailand differed from those in Vietnam. Ghosh and Whalley (2004) studied rice price controls in Vietnam and explained that the price control always generated income for the government. Once the state controlled the prices by setting the selling price of farmers' rice to be lower than the market price, this would increase the state's income. In addition, the control of rice prices was an appropriate measure in the situation of foreign market uncertainty. As a result, the price controls could protect the domestic market from any external fluctuations, as well as reducing the trading costs. Puapongsakorn et al. (2013) found that the amount of global rice consumption would increase slowly. Consequently, they proposed three solutions to the problem, namely 1) reducing production costs and/or increasing yield per rai[1](0.4 acre); 2) increasing yield per farmer; and 3) producing quality rice.

That is why Isavilanon (2010b) concluded that the state policies on rice shifted to subsidizing the paddy producers or rice farmers, such as the paddy price support policies, the paddy pledge policy, the rice farmers' income insurance policy, the rice insurance program, and the rice farmers' cost grant program. In addition, Duangthip (2010) showed that the farmers benefited more directly from the income insurance scheme than the rice pledging scheme. More importantly, the actual price in the rice market was severely distorted by the rice pledging scheme because the state set the pledging price much higher than the market price. In addition, there was a proposal for the government to adjust the price of

[1] One rai is approximately 0.4 acre.

the pledged mortgage to be more in line with the market price and take the pledge at the right time. This is consistent with the proposal of the Thailand Development Research Institute (TDRI) (2009). This study recommended that the government should insure the price risk by requiring the announcement of the insurance price at the beginning of the season. The declared insurance price must cover at least the cost of producing rice for the farmers. Then, the farmers have the right to buy insurance from the government.

In addition, Chanthaphong and Sirikanchanarak (2012) stated that the Thai government's intervention policy in the rice market was not able to provide the farmers with higher incomes, widely distribute benefits, or reduce the poverty in rural areas. In terms of policy proposal, the government should reduce intervention in the rice market. In fact, the support price should not be set higher than the price that farmers can sell in the fields. Furthermore, the study on the utilization of the agricultural futures market by Chaokul et al. (2011) indicated that although the export price, wholesale price and farm price of rice highly correlated with the one-month or two-month future price of rice, the amount of rice traded through this futures market was only 2.7 percent of the total rice production. As a result, the futures prices did not reflect the actual supply and demand of rice. The futures market price could not be used as a reference price for the actual market price either. However, Taylor et al. (1996) found that rice prices in the global market had no long-term relationship with rice prices in the futures market at the Chicago Rice and Cotton Exchange (CRCE), the rice prices in the spot market in Texas, and the 100% white rice prices from Thailand. Consistent with John (2013), this paper explained that the causality tests between the export prices of rice and the domestic prices of rice regarding the Thai rice market were not entirely clear.

3 Research Methodology

3.1 The Model

The economic analysis through mathematical models reflects the relationship between the key elements in the rice market, comprising farmers, millers, merchants, rice traders and governments. Such model will help towards an understanding of the mechanism of price transmission between upstream and downstream in this industry. It also provides a theoretical framework for evaluating the rice price support policy. In this section, the model presentation is divided into farmer, rice mill and merchant sections. It starts with the first part showing the interaction between the farmer and the mill which is considered the upstream part of the rice industry. The second part is a simulation of the interaction between the rice mill and the rice merchant which is the mainstream of the rice industry.

3.1.1 Farmer and Mills

Suppose that there are many people working as farmers in this economy. Therefore, the number of peasants in the economy is a very valuable but finite positive real number. Farmers invest in the rice cultivation with production costs, that are equal to $c_0 > 0$. This cost includes the accounting cost and economic opportunity cost. Once the farmers harvest the paddy, they will sell their produce to the buyers where there are two alternatives. The first one is selling their paddy to the mill for which the price depends on the negotiation between the farmers and the mills. The second one is to sell it to the government scheme. In this analysis, the price that the state buys from the farmer is assumed to be equal to $\bar{p}$. As a result, if a farmer decides to sell his produce to government projects the price he receives is $\bar{p}$. Therefore, the decision of the peasants can be expressed in the form of a mathematical equation as follows:

$$\max[p, \bar{p}] \quad (1)$$

That is, the farmer will compare the price offer p which is received from the mill with the price that will be obtained from selling to government projects. If either option gives a higher value, the farmers will choose that option.

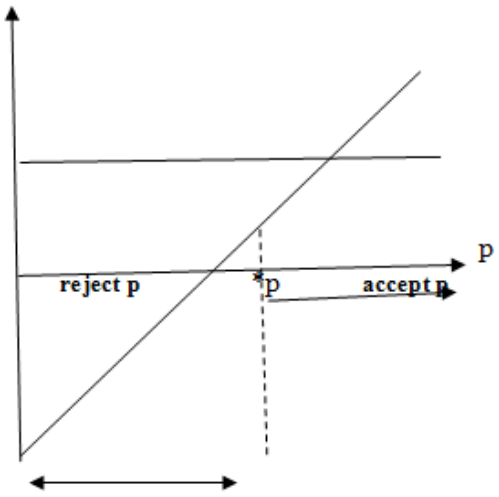

Fig. 1: The policy price from the government project

As can be seen from the figure 1, if the price is higher than the policy price from the government project, the farmer accepts the price quoted from the mills. Therefore, we write a price expression that farmers can receive as follows:

$$p = \bar{p} + \varepsilon_i \quad (2)$$

where $\varepsilon_i \geq 0$, $\varepsilon_i = 0$ when $p < p^*$, $\varepsilon_i > 0$ when $p > p^*$

With regard to the problems that the mill faces, this study assumes that the mill perceives a "signal" which is the information about the market trends, weather etc. at the beginning of the period. The received signal affects the generation of predictions about the price of rice in that period, then the mill recognizes the signal and generates a prediction of the rice price. He further calculates it as the highest price that it will be purchased from the farmer. p^e is given that the price of rice which the mill is expected to sell. This modeled economy also assumes that the price of paddy that the mill is willing to pay the most for is equal to $\psi \cdot p^e$. The mill acts as an intermediary between the farmer and middleman (Yong). The mill will buy the paddy to keep and will reproduce the paddy when he receives the definite orders from the middleman. Thus, the rice-mill will bear the cost of collecting the paddy while waiting for these orders. This required the creation of a forecast of the selling price. The future selling price will determine the purchase price of paddy $(\psi \cdot p^e)$ again. Once the mill and the farmer come to an agreement on the rice price, then the bargaining effect is based on Nash's bargaining model. In fact, the benefit required by both parties to compete is $\psi p^e - \bar{p}$. Given $A = \psi p^e - \bar{p}$ and further assuming that $\varphi > 0$. Such a parameter explains the bargaining power of the agreement made between the mill and the farmer. The problem of haggling between the mill and the farmer can be displayed in the form of the calculation ε_i that maximizes the product of the benefit of both parties as follow.

$$\max_{\varepsilon_i} (A - \varepsilon_i)^{\varphi} \varepsilon_i^{1-\varphi} \quad (3)$$

The first parenthesis in the above equation shows the benefits that the mill will gain from this bargain. The outcome of the mill is to buy the paddy at a price $\bar{p} + \varepsilon_i$ from the farmer i which is lower than the desired floor price (ψp^e), and ε_i shows the share of the total benefit the farmer receives from the bargain. This share is weighted by the amount $1-\varphi$. As a result, the equilibrium price at this stage of the supply chain is in the range $[\bar{p}, \psi p^e]$. As the mill quoted the price which is below the lower boundary, the farmer will certainly reject this offer, and he will sell his paddy to the government project instead. In addition, the highest price that the mill is regularly willing to buy will be no higher than the upper boundary price in the range. This reflects the expected selling price of the mill. The equilibrium price that the mill and the farmer are willing to trade is as follows:

$$p_i = \varphi \bar{p} + (1-\varphi) \cdot \psi p^e \quad (4)$$

That is, if the mill has more bargaining power $(\varphi \to 1)$, the price the farmer receives will be close to the price of government insurance $(p_i \to \bar{p})$. Still, if the peasant has more bargaining power $(\varphi \to 0)$, he will be able to sell rice at a price close to the highest price that the mill is willing to buy $(p_i \to \psi p^e)$.

3.1.2 Rice-Mill and Merchant

The next part is considered the interaction between the rice-mill and merchant. This section assumes that the rice merchant receives the orders and forwards those to the middleman (Yong) providing the required amount of rice from the mills. These orders might come from an international market. or the domestic market. Thus, the price of the rice which is set to be purchased from the rice merchant is equal to p^W. Such a model also supposes that there are many mills in the economy system. Each mill buys the rice from local farmers at different prices, then they also offer the price to the middlemen at different prices. Therefore, the price of rice is distributed, which can be expressed by the distribution function. $F(p) \geq 0$, which indicates the proportion of mills in the market that offer a lower selling price p. The middleman is aware of this distribution function; in other words, he knows that there are different mills that offer different prices in the rice market. If someone offers the middleman a certain level of selling price, he will know the chances of getting a lower offer price. Since the rice merchant receives the price of the final sale of rice equal to p^W, they would not want to buy rice from the mill at a higher price than p^W. At the same time, the mill has a minimum

selling price to be willing to offer $(\hat{p})$; indeed, he buys the paddy from farmers to keep it for milling. The processing cost consists of the interest rate, converting paddy into rice, etc. We assume that the total cost of the mill concerning the rice purchased from the farmer i is proportional to the purchase price (p_i). Hence, the minimum price for a mill to be willing to offer rice (selling price) to the middleman would be:

$$\hat{p} = p_i(1+\hat{r}) \tag{5}$$

where $\hat{r}$ consists of the interest rate and unit cost of rice processing. Defining the interaction between the mill and the rice merchant in this middle market as a model of Burdett and Judd (1983), so the middleman would randomly ask the mill for the selling price and will choose to buy from the mills who offer the lowest prices. The mill is aware of middleman's strategy. However, the middleman makes a bid decision without knowing what offer the mill has received. Another, such model assumes that the mill sets the selling price in order to maximize the expected profit which can be expressed in a mathematical equation as follows:

$$\Pi(p) = \begin{cases} (p-\hat{p})\sum_{k=1}^{\infty} q_k k(1-F(p))^{k-1}, & if \quad p \le p^W \\ 0, & if \quad p > p^W \end{cases} \tag{6}$$

Given that q_k represents the probability, the middleman will randomly ask for a price from the number of mills k. Then the profit the mill expects to receive from setting the selling price at p is derived from the product of two components. The first part is the difference between the selling price and the minimum price $(p-\hat{p})$. It means that if the price p is set too high, the difference is greater. The second part comes from the probability that the buyer will actually buy rice from the mill. It implies that if the mill sets the price p too high, the chances of the middleman getting a higher asking price are much greater. Consequently, the chances of selling rice are smaller. It means that the higher the price, the less opportunities to sell rice. and causing the expected profit to decrease in this second part. The study of Burdett and Judd (1983) shows that if the buyer (or middleman) has the cost of randomly selecting the asking price in equilibrium, the buyer will randomly choose to ask for prices from no more than two sellers. More importantly, there is a price range in equilibrium that gives the seller the same expected profit. Accordingly, this causes the distribution of the selling price, and the rice prices in equilibrium are distributed as follows:

$$F(p) = \begin{cases} 0, & if \quad p \le p_L(q) \\ 1-\left[\dfrac{p^W-p}{p-\hat{p}}\right]\left[\dfrac{q}{2(1-q)}\right], & if \quad p_L(q) < p \le p^W \\ 1, & if \quad p \ge p^W \end{cases} \tag{7}$$

Where $p_L(q) = \hat{q}\cdot p^W + (1-\hat{q})\cdot \hat{p}$

$$\hat{q} = \frac{q}{2-q}$$

It can be seen that the selling price, arising from the rice trading between the mill and the middleman, is in the range $[p_L(q), p^W]$ because the price in this range gives the profit expectation. Therefore, the mill can choose such a price and always receive the predicted profit. The estimated price at which the mill will sell rice is equal to

$$Ep = \int_{p_L}^{p^W} p dF(p)$$

3.2 Price Transmission Process and Policy Implications

This section analyzes the process of transmission of prices. arising from external factors and how it passes the impact onto other levels of prices, whether it is sent downstream or sent back to the upstream. The analysis of transmission is considered in two case studies: the price of rice in the final stage of supply chain changes; and the case of increasing the purchase price of paddy by the government policy.

3.2.1 The Increase in the Price of Rice in the Final Stage of Supply Chain

Suppose that the price of rice in the world market has increased. It is obvious that this change affects the distribution of the price traded between the middleman and the mill. Once the world price of rice increases, it causes the distribution function $F(p)$ to drop down to the original range. The upper boundary of selling price will move up accordingly p^W and its lower boundary will move up accordingly $p_L(q)$. Consequently, the width of price range will increase from the original because the bottom edge changes only $\hat{q}\Delta p^W$, but the top edge moves up Δp^W. Thus, the support of these scatter function changes will result in Ep that goes up significantly. The mill is willing to buy rice from farmers in a wider price range than before, when the price at which the mill had expected to sell to the

middleman has increased. Therefore, the upper boundary of the acceptable price range of rice has moved upwards $p_t^w = \alpha + \beta p_t^{FOB} + e_t$ also. The above analysis shows the transmission of the downstream price back to the upstream paddy price. The essential conclusions are consistent with what appears in the Thai rice market. That is, when the price of rice in the world market is high in the production season, the purchase price at which the mill buys paddy from the farmer will also be pulled higher. Such a model in this section describes the mechanism that results in an increase in paddy prices:

3.2.2 The Government Increases the Purchase Price of Paddy

This section analyzes the effects of government policies that intervened in the price mechanism in the paddy market. Initially, the government announced that they would buy paddy from farmers at a higher price. This also assumes that a price increase is still below the highest price level at which the mills will be willing to buy paddy from farmers. Once the government increases the price support, the price of paddy will increase in $\overline{P}$. As a result, the price of trading between the mill and the farmer goes up accordingly. It also affects the prices in other parts of the supply chain, namely $\hat{P}$ and $p_L(q)$, respectively. In contrast, it may not affect the price at which the mill sells the rice to the middleman, if the selling price at which rice is sold to them is still in the range $[p_L', p^W]$. In fact, the mill sells rice to the rice traders at a price p at the beginning, when $p \in [p_L(q), p^W]$. Then, the government raises the purchase price of rice to $\overline{P}'$ that has an influence on prices in the supply chain to $\hat{p}'$ and $p_L(q)'$. However, as the price p is still in the range $[p_L(q)', p^W]$, it means that the sale of rice at the same price still makes the anticipated profit. unchanged. Such a model indicates that the price characteristics in the midstream have more price stickiness than in the downstream. Therefore, the policy implication of this model is: if the government increases the purchase price of rice from farmers where the price is lower than p^e, it does not cause the middle stage of trading price to fall out of the price range $[p_L', p^W]$. Such a price-support policy does not affect the export price, and does not undermine the competitiveness of rice exporters or cause trouble for the consumers. As happened in the case of the pledging policy, the government bought whole grain rice at a higher price than the world price. Accordingly, the support price $\overline{P}$ was higher than p^W and p^e causing the mills to be unable to buy rice from the farmers. Finally, the rice supply chain received the negative impact until the trading process in the free market failed.

3.3 Rice Support Policy

This section considers the government's policies to help the farmers with the method of purchasing paddy directly or accepting paddy pledges from farmers. Both policies aim to enable farmers to sell rice at higher prices. As described in the previous section, that assumes that the farmer produces rice at cost $c_0 > 0$. This section adds more detail to the model; that is, requiring the farmer to have two options after harvesting the crop: the first is to keep the rice in the barnyard to be sold later, and the second is to sell the rice to the mills immediately. The further assumption is that the storage cost of rice kept for sale is $c_1 > 0$. The farmer with an urgent need for money will choose to sell immediately, whereas the farmer who can wait to sell will choose to store the rice in the barnyard to sell it at a better price. As a result, the farmer who keeps their rice has their preference correspond to the following conditions:

$$U(p) < \beta_0 U\left(\frac{p - c_1}{1+r}\right) \tag{8}$$

$$U(p) > \beta_1 U\left(\frac{p - c_1}{1+r}\right) \tag{9}$$

However, the second group of farmers have different preferences as in equation 9, which leads them to choose to sell rice immediately. The function $U(\cdot)$ represents the utility of the two groups; β_0 and β_1 represent the different discount factors between the two groups of farmers. Both equations want to reflect a situation in which each farmer has a different urgency to sell their produce. Some farmers want to sell rice quickly because they need money urgently, while others can wait to sell their rice. p can be defined as the selling price that the farmer will receive when the rice is sold later, given that q is the price that the farmer will receive if the rice is sold immediately. In addition, the future price will be worth the storage cost and opportunity cost, such that:

$$p \geq q(1+r) + c_1 \tag{10}$$

With each type of farmer, there is a different urgency in consumption. Moreover, the price of rice that each type of farmer will be willing to sell as soon as the harvest is harvested is not lower than p_i , which can be obtained from this condition:

$$U(p_i) = \beta_i U\left(\frac{p - c_1}{1+r}\right), \qquad i = 0,1 \qquad (11)$$

Equation 11 shows that p_0 is the minimum price for the type of farmer who wants to sell immediately and p_1 is the lowest price for the type of farmer who can wait to sell it. Hence, the minimum price of the first group will be lower than the minimum price of the second group with the above condition, ($p_0 < p_1$).

In actual fact, some farmers have an urgent need to spend money, and do not want to keep their product for a long time. They try to instantly sell rice in exchange for money for shopping; therefore, these farmers are willing to sell rice at low prices. This can be seen from the above equation that shows the factors affecting the selling price of paddy, which the farmer receives from the sale to the mill. Whether it is higher than the cost, such a price depends on how much bargaining power the farmers have. As the bargaining power of farmers is low, the mill will be able to force the purchase price of paddy down in order to be close to the production cost.

Therefore, the government tries to use a policy to support the selling price of paddy, or find a way for the farmers to keep their rice in the barn and sell it later when the price of rice increases. That is, the price at which the government will buy must be higher than p_0 , and at such a level that farmers who are not in a hurry would immediately sell their product.

4 Empirical Results

We presented findings from both primary and secondary data sources. The primary data used in this section is from our field survey covering 330 farmers in 11 provinces. The secondary data were collected from various sources, including the Office of Agricultural Economics, the Department of Agriculture, the Department of Agricultural Extension, the Rice Research Center, the National Statistical Office, and the Bank of Thailand (BOT).

4.1 Findings from Field Survey

We conducted a field survey using quesionaires to gain insights about farmers' characteristics, rice production, paddy stock management, product cost, farmer revenue, and rice prices, etc. in key rice-growing provinces[2] all over Thailand. There are 11 provinces in our servey and we sampled 30 farmers from each province to cover every sub-district, resulting in 330 farmers in total.

Regarding the cost of rice production, the total cost in the 2013 production year averaged 4,124.44 baht per rai (128.89 US$), an increase of 30.77% compared to the total cost in the production year 2008, which averaged 3,153.88 baht per rai (98.56 US$). The structure of rice cultivation cost in both years are similar. That is, the chemical fertilizer costs, rental costs, harvest costs, rice seed cost, and soil preparation costs occupied around 70 percent of the total cost.

Meanwhile, the rice farmers were able to sell rice in the 2013 production year at an average price of 9,304.71 baht per rai (290.77 US$). Compared to the average selling price of 5,466.76 baht per rai (170.84 US$) in 2008, the paddy price in 2013 increased by 70.21 %. On average the farmer earned more revenue, net of cost, per rai around 5,180.27 baht in 2013, compared to merely 2,312.88 baht per rai (72.28 US$) in 2008.

The survey also found that the paddy price in each location is primarily determined by the rice mills, the central paddy markets, and the local middlemen. This reflects the bargaining power of the local traders in paddy price determination. This influence remained intact even in the period when the government implemented the paddy pledging scheme. The interview with the local middlemen reveals that the offer price is determined solely by the export price or world price. Thus, neither cost of production or the government-price-floor has significant influence on the wholesale paddy price.

4.2 Econometrics Model of Rice Price Determination

In this section, we applied Engel-Granger Cointegration test to investigate the long-term relation between the domestic paddy price and the world rice price, represented by the FOB export price, during 2002-2015. Once we are able to

[2] Provinces in our sample include Pathumthani, Singburi, Chainat, and Suphanburi from the Central region, Nakhonsawan, Kamphaengphet, Phisanulok, and Phichit from the North, Surin from the South , Khonkaen, and Roiet from the North-east.

establish the long-run relationship between prices, we construct the error-correction model to analyze the short-term movement of the domestic and the world price.

To test the long-run relationship between two time series data, one needs to check first if both series are non-stationary, or contain unit root. Therefore, we applied the Augmented Dickey-Fuller method to test whether the domestic paddy price and the world price are non-stationary. The test method is performed by estimating the coefficients in the characteristic equation as shown below.

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{i=1}^{I} \Delta y_{t-i} + \varepsilon_t \qquad (12)$$

That is, the coefficient of the lagged value of variable of interest, β, is estimated and test whether it is significantly different from zero. If we are unable to reject such null hypothesis, then that time-series is non-stationary. Our econometric test found that the estimated coefficients are not significantly different from zero for the wholesale price as well as the world price. Therefore, both series are non-stationary.

The next step is to test whether the two series have a long-run relationshop, or test whether they are cointegrated. The Engle-Granger Cointegration test applied the Augmented Dickey-Fuller method to test the stationarity property of the OLS residuals from the following regression.

$$p_t^w = \alpha + \beta p_t^{FOB} + e_t \qquad (13)$$

If it is found that e_t is stationary, then the wholesale paddy price (p_t^w) is cointegrated with the world price (p_t^{FOB}). In other words, both prices have a long-term relationship, thus; they tend to move together.

Table 1 below reports the estimation of the cointegration equation 12. The coefficient of the domestic paddy prices moves in line with FOB export prices, as shown in the positive coefficient, and are significantly different from zero.

Table 1. The result of coefficient estimation of regression model of the paddy price

	Constant	**FOB Price**
Paddy price	56.4	0.48
SE	(1.88)	(0.008)
N = 144		
$R^2 = 0.96$	F(1,142) = 359.06	

Source: *Calculation*

The Augmented-Dickey-Fuller test on the residual series, e_t, showed that the series is stationary, which implies that the domestic price and the world price have long-term relationship. Thus, the observed comovement of the two price series are not spurious.

We are able to construct a model describing short-term movement of cointegrated variables. In case that one has interest in predicting the short-term variation of the wholesale paddy price, one can construct an error-correction model as follows:

$$\Delta p_t^w = \alpha_0 + \sum_{j=1}^{n} \alpha_j \Delta(p_{t-j}^w) + \sum_{h=1}^{n} \beta_h \Delta(p_{t-h}^{FOB}) + \gamma \hat{e}_{t-1} + \varepsilon_t(p^e) \qquad (14)$$

The error-correction model for the wholesale price states that the determinants of the short-term movement can be decomposed into three parts, i.e., its own past (p_{t-j}^w), past values of the world price, (p_{t-h}^{FOB}), and the adjustment towards the long-run equilibrium, $\gamma \hat{e}_{t-1}$. It should be noted here that indicates the speed of adjustment towards long-term equilibrium so that its value is negative. The result of estimating the coefficients in the above equation are shown in Table 2.

Table 2. The result of the error-correction model of the world rice price.

	Estimated coefficient	**Standard Error**	**t-stat**
$\hat{e}_{t-1}$	**-0.327**	0.816	-4.00
Δp_{t-1}^w	0.298	0.13	2.30
Δp_{t-1}^{FOB}	0.09	0.11	0.84
α_0	0.002	0.004	0.48

Source: *Calculation*

The error-correction model has brought adaptation to return to long-term equilibrium, helping to explain the adjustment in domestic paddy prices. As can be seen from the estimated coefficient $\hat{e}_{t-1}$, the deviations from long-term relationships that occur in previous periods are corrected and gradually adjusted to long-term equilibrium, with one-third (-0.327) of that deviation eliminated based on the coefficient of $\hat{e}_{t-1}$. Comparing the two domestic paddy prices, the finding displays that the rice price obtained from the error-correction model is close to the actual data.

This shows an appropriate model to explain price changes.

4.3 Expectation and Price Discovery in Thailand White Rice Market

Our model in the previous section shows that the equilibrium paddy price is determined in part by the expected selling price of the millers. To investigate such relationship, we chose the option price of white rice 5% (BWR5) in the Agricultural Futures Exchange of Thailand (AFET) , both put and call prices, as a representation of p^e in equation (4). Under the efficient market hypothesis, the future market plays a crucial role in price discovery process since it digests all the available information about future price and reflects what market participants foresee about the future paddy prices.

In our empirical study here, we use the wholesale price of white rice 5% in the Bangkok market (WP5) for p and the price of white rice 5% in the agricultural futures market (BWR5) for p^e in equation (4). Both series are tested for stationary property by using the daily price data between April 2, 2007 and September 14, 2011. The unit root test results show that both series contain unit root. A further investigation reveals that the first-difference of both series are stationary. Thus, the Granger Causality test is applied to find the causal relationship between the changes in wholesale price of white rice 5% in the Bangkok market and the changes in the corresponging option prices in the AFET.

The test results reject that the null hypothesis that the price of white rice 5% with both options in the AFET does not Granger cause on the wholesale price of white rice 5% when the 1-day, 2-day, 3-day and 5-day lag are included. This result supported the conjecture of our model in Section 3 that the equilibrium wholesale price is determined partly by the expectation of the millers' selling price. However, the causality test in the opposite direction also found that the option prices in the AFET Granger causes the wholesale white rice price. Therefore, we concluded that information flow back and forth between markets in such a way that the prices in spot and future market has bi-directional influence on each other.

Despite the bi-directional relation, we found that the spot and future prices have a long-term relationship. This finding is obtained from the cointegration test reported in Table 3. We ran the OLS regression between WP5 and BWR5 and conducted the ADF test on the residual of the regrssion. It is found that the residual series is stationary, implying the spot and futures prices of white rice are cointegrated.

Table 3. The result of coefficient estimation of regression model of wholesale price of white rice 5%

	Constant	**Price of white rice 5% with both options**
Wholesale price of white rice 5% (WP5)	0.4083	0.9448
Std. Error	(0.0599)	(0.0037)
t-Statistic	[6.8179]	[254.4294]
N = 1051		
$R^2 = 0.98$	F(1,142) =4734.30	Durbin-Watson stat= 0.4071

Source: *Calculation*

An additional step for the price analysis of rice is to find what exactly determines the rice price in Thai market as follows:

$$\Delta WP5_t = \phi_0 + \sum_{i=1} \phi_i \Delta WP5_{t-i} + \sum_{l=1} \phi_l \Delta BWR_{t-l} + \delta \hat{u}_{t-1} + \nu_t \quad (15)$$

Equation 15 presents an error correction model which is applied to explain the short-term relationship between both types of prices. The result shows that when the spot price of white rice 5% (WP5) temporarily deviates from the long-term equilibrium, the adjustment to restore the equilibrium is swift, as seen in the estimation of δ. Table 4 below shows that the error-correction parameter is estimated to be -12.81, implying that 12.81 percent of deviation from L-R equilibrium is eliminated within a day.

Table 4. The result of the error-correction model of the wholesale price of white rice 5%.

	Estimated coefficient	**Standard Error**	**t-stat**
$\hat{e}_{t-1}$	**-0.1281**	0.0206	-6.2274
$\Delta WP5_{t-1}$	0.2117	0.0376	5.6228
$\Delta WP5_{t-2}$	-0.200	0.0365	0.5483
$\Delta BWR5_{t-1}$	0.1360	0.0315	4.3149
$\Delta BWP5_{t-2}$	-0.0488	0.0312	-1.5658
α_0	0.0037	0.0082	0.4459

*Source***:** *Calculation*

5 Conclusion

Though the rice market in Thailand is linked tightly with the world market, various governments intervened the domestic market from time to time. The most notable intervention policy in recent times in the 2011 rice price-pledging scheme, of which offered to buy unlimited paddy at the premium of 40-50 percent above the world price. The program successfully raised the domestic paddy price above the would-be equilibrium level under lessez faire. However, the distortionary scheme could possibly left its mark on the price structure of Thailand for a long while. This paper attempts to investigate whether the Yingluck Shinawatra government policy could affect the subsequent price structure in the rice market by using data from both primary and secondary sources. The findings from our field survey show that the paddy price was mainly determined by the rice mill, the central paddy market, the middleman, and the exporters. The government intervention policies could influence the paddy price temporarily, i.e., when the scheme was in place. In the long-run equilibrium, the paddy price is determined by a combination of the price at which the mills are willing to buy and the world price.

Using long time-series on the wholesale level and the FOB price allows us to conduct a cointegration test, to see whether there exists a long-run relationship between the wholesale paddy price and the FOB export price. The empirical findings confirm the field survey finding, i.e., there is a long-run relationship between the domestic wholesale price and the world white rice price. Moreover, the price expectation embeded in the millers' offer price played significant role in the price discovery process. The causality test revealed that the expected future price causes the spot wholesale price in the Granger sense. It is also found that the causation is bi-directional implying that the flows of information between markets are essential in determining the equilibrium price in the rice market. This study has unearth the linkage of rice price in various layers and found that distortionary price support policies did not alter the determination of rice price in the longer term.

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