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The Impact of the Rice Pledging Policy: The Case of Thailand, A Linear Programming Approach[1]

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Abstract

The rice pledging policies had an enormous effect on the rice industry in Thailand as well as changing the political course of the kingdom. This study employs a Linear Programming technique to construct a model based on the operational concept of value chains of the Thai rice industry in both normal and pledging cases. The data and information from many sources are combined in the analysis. The paper compares the total and each party's profit from these two scenarios. The results found that the combined profit of all parties; farmers, large and small millers, traders and the government, is higher in the pledging case. However, only farmers and millers enjoyed the benefit, while the traders and the government, which represents the non-rice industry tax payers, lost from the program.

This model can be extended in many ways, such as finding the impacts for large and small farmers, or the effects of alternative policies such as price guarantees. The recommendations are that the government can run this policy but must be aware of the effect on traders. Moreover, there are alternative policies that can help the farming sector, for example, providing optimized growing information to the farmer.

Keywords: Rice Farmer, Rice Industry, Rice Pledging Policy, Linear Programming

1. Introduction

Rice is a crucial industry in Thailand, in which enormous budgets are always spent to support it. According to World Market and Trade, USDA, Thai people consumed 10.8 million tons of rice in 2014 or around 166 kilograms per person in that year[2]. For the labor ratio side, the data from the National Statistical Office (2014) and the Office of Agricultural Economic (2013) show that in the first quarter of 2014, there were 5.7 million farmers[3] in the Thai rice industry. For the industrial side, the Department of Industrial Work reported that there are 38,889 millers in Thailand. Therefore, the government and all political parties must pay great attention to rice policies.

The rice pledging policy, run by the Pheu Thai party, was one of those policies. Ministry of Finance announced that it spent more than 580 billion Baht (around 17.6 billion US Dollars) in three years (2011 to 2013) (Daily News, 2014). However, due to suspected corruption and an extremely high budget (5.25 billion US Dollars per year), this policy was attacked by anti Pheu Thai groups and some academics including economists.

Ammar Siamwala and Nipon Poapongsakorn (2011) condemned the policy saying that it is good only for rich farmers who own vast areas of land and cares only about the quantity, but not the quality of rice. Moreover, Siamwala and Poapongsakorn (2011) pointed out that the main problem is in implementation, where the government was unable to sell the rice. Finally, their conclusion advocated a price guarantee policy, which had previously been administered by the Democrat party, as a better alternative to pledging policy, since it does not harm the industry.

Moreover, Puapongsakorn, et al. (2013) applied economic model about rice market and the welfare cost to study and found that "although the farmer earn 560 billion Thai Baht from the program, most of the profit comes to the large farmer, the total welfare is lost for 123 billion Thai Baht. In addition,

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[2] On November 2014, Number of Thai populations are 65,096,559 people; Department of Provincial Administration

[3] There are 11.99 million farmers in Thailand; National Statistical Office (2014) Labor Forces Survey, and rice area is around 47.8 percent of agriculture area; Office of Agricultural Economic (2013).

Puapongsakorn, et al. (2013) also found that the program created the lost from corruption at 84.5 billion Thai Baht[4].

However, there is also some support for the pledging policy from both economists and others, for example Niti Iewsiwong (2011) and Pichit Likitkijsomboon (2011). Likitkijsomboon (2011) replied to Siamwala and Poapongsakorn (2011) by comparing pledging scheme with the guarantee policy. They stated that eventhough rich farmers are better off by owning bigger farms, poorer farmers one still gain much more than from the guarantee policy provided by the previous Democrat government. Likitkijsomboon (2011) argued that the guarantee policy also failed to deliver both quality and quantity. Finally, although Pheu Thai spent more than 0.3 trillion Baht of the government budget, it is much lower than the budget spent by the government under the Democrat party to pay for Bangkok International Banking Facilities (BIBF) in Thailand during the financial crisis in 1997. Unfortunately, eventhough the Ministry of Finance (2014) concluded the budget spent in the scheme at 0.58 trillion Baht, no one compared it with the benefits to farmer and millers or the external factors of the policy. In other words, none of them proved that pledging was good or bad.

Although there are some researches on pledging policy, most employ econometric tools to prove only some critical points of the scheme. For example, Chulaphan, Jatuporn, Chen, and Jiewiriyapant (2012) analyzed the long run equilibrium relationship between farm gate, wholesale, retail and export prices in Thailand and found that the largest impact of farm gate prices are on export prices follow by wholesale prices. Therefore, Chulaphan, Jatuporn, Chen, and Jiewiriyapant (2012) concluded that exporters should suffer most from producer

[4] Although focused on similar topics, this study is different from Puapongsakorn, et al. (2013). Puapongsakorn, et al. (2013) used the economics welfare model to explain the impact of pledging policy; however, this study applied the operation research method. This study focused on many other conditions in rice industry, especially for the different decision between large and small miller which will be changed, due to the pledging program, while Puapongsakorn, et al. (2013) does not focused. Many conditions omitted out by Puapongsakorn, et al. (2013) are taken into this study. Therefore, this study yield a different result from Puapongsakorn, et al. (2013)

support policies such as the pledging policy in Thailand[5]. Mahathanaseth (2014) estimated the degree of competition in the Thai rice export market to prove that Thai rice has no market power, in other words, Thailand cannot control or monopolize the market. Therefore, the government cannot boost the rice price by stocking it with the pledging policy. However, these two researches did not determine whether the pledging policy was a social benefit or not.

Since traditional methods, such as econometric models, cannot capture the whole industry and cannot answer the policy shock problem, alternative approaches such as Computable General Equilibrium (CGE) and Linear Programming (LP) methods are focused in this research. For CGE, there are some studies, for example Caecar Cororaton (2004) International Food Policy Research Institute (IFPRI) and the Center for Agro-Socioeconomic Research (CASER) (1997), and Rizwana Siddiqui (2007)'s research on rice policy in the Philippines, Indonesia and Pakistan, respectively. However, most of them were tariff setting policies and there were no policies similar to the rice pledging policy.

For LP, there are some researches that employed this method with regard to rice. For example, .G. Laborte, R. Roetter, and C.T. Hoanh (1999) and Hossein Jafari, Qhorbanali R. Koshteli and BabakKhabiri (2008) used linear programming to analyze the optimal amount of land use in rice farms in the Philippines and Iran. In both researches, farmers selected land to grow rice and other crops such as sugar cane, subject to the inputs of production such as urea and potash. However, both of them studied only the farmers, not the whole industry, and were not interested in pledging policy. Frank Rose (1997) studied the impact of rice subsidy policies on farmers, millers and exporters in Sierra Leone,

It is evident that there has been no research focusing on pledging policy. In addition, CGE and LP are more interesting than econometric tools, since econometric models can address only a few points of the scheme. Finally,

[5] Although, the main methodology of Chulaphan, Jatuporn, Chen, and Jiewiriyapant (2012) is to investigate the price transmission, Chulaphan, Jatuporn, Chen, and Jiewiriyapant (2012) applied the results to explain the impact of pledging policy in Thailand.

LP is more appropriate in the sense that it can be more focused on the rice industry and can reveal abundant and scarce resources, which can be employed in formulating agricultural policy. Therefore, LP is selected for this study.

Table 1. Comparison of Econometric Model, Computable General Equilibrium (CGE), and Linear Programming (LP)

CGE	LP
Pros: consists of the whole economy and is very popular *Cons:* - contains many issues unrelated to rice equations - all situations are assumed to be in equilibrium, no resources are regarded as abundant and no scarce resources are shown	- Can answer pledging and guarantee policy problems - Shows abundant and scarce sand also can determine the shadow price of the scarce resources - Does not contain unrelated equations

Source: Author

Hence, this study will apply LP approaches which never been used for rice pledging policy in Thailand to compare both the total profit and the profit of each party in two cases, under the normal situation and the pledging scheme. These results will show who gained, who lost, and a quantitative explanation of the pros of the policy as stated by Likitkijsomboon (2011), and the opposition as stated by Siamwala and Poapongsakorn (2011), and other academic studies such as Chulaphan, Jatuporn, Chen, and Jiewiriyapant (2012) and Mahathanaseth (2014**). Moreover, LP can reveal scarce resources which are useful for both policy formulation and future study and never been study on this policy in Thailand before. In addition, this method can also suggest the optimal amount of paddy and rice productions and compare to the real situation**.

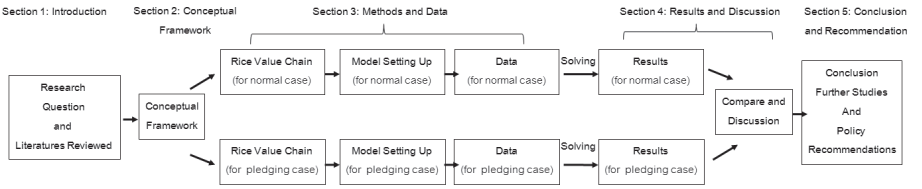
2. Conceptual Framework

In section 1 of this research an LP model will be constructed to determine the gains of each party that participates in the industry in two cases, the normal situation and under the pledging scheme. The total profit, which is the summation of all parties' profit, is the key measurement. In other words, pledging will be decided as a better policy, if the total profits in the pledging case are higher than in the normal situation. Moreover, if the result shows that a gain in total profit leaves no party worse off, that policy is Pareto optimal. However, if there are some parties who are worse off, in that is to say, gain a lower profit or a loss, a subsidy policy will be recommended.

However, according to Hamdy A. Taha (2011), LP is an optimization technique which requires three steps: understanding the mechanism and modeling, gathering the data, and solving the problem. In the first two steps, this study will employ the Value Chain technique as a framework to understand the mechanism and to gather the data. The Value Chain study will focus mainly on the structure of the rice industry and the operational conditions, such as the resources required in production, their availability, and other critical conditions.

Therefore, this study follows the steps as shown in Figure 1. Research question and literatures reviewed focusing on the related work shown in the "Introduction" and the conceptual framework will be constructed based on the Introduction is shown in this section 2, "conceptual framework". The value chain and the model set-up for both cases will be explained in the "Method and Model" section. The data will be explained in the "Data" section, while result comparisons and the solutions will be presented in the "Results" section. Finally, discussions and policy recommendations are presented in the last section, "Discussion, Further Studies and Policy Recommendations".

Figure 1. Study Framework



Source: Author

3. Methods and Data

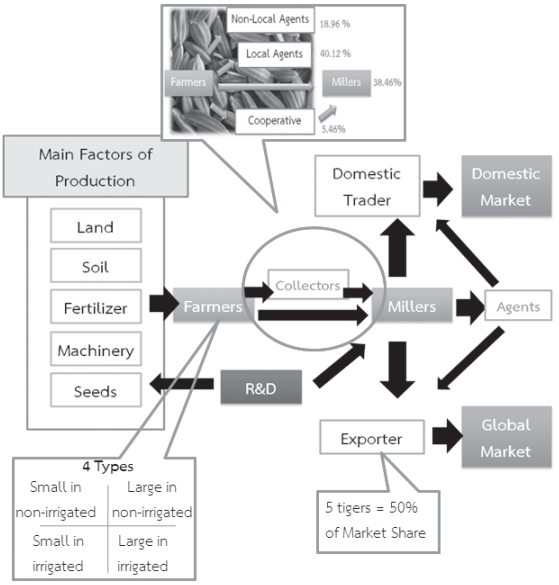
As shown in the conceptual framework, this study will compare the results of two cases, the normal situation and the situation under the pledging policy. This part will be separated into two sub-sections presenting the normal and pledging situations.

3.1 Under the Normal Situation

3.1.1 Method and Model

As shown in section 2, this study will begin with value chain study. In short, to construct the value chain figure, this study summarized and adopted many study for example Somporn Iswilanonda, 2011[6], Agrifood Consulting International (2005), Ammar Siamwala and Wiroj Na Ranong (1990) to construct the Thai rice value chain in figure 2.

Figure 2. Thai Rice Value Chain



Source: Adapted from Somporn Iswilanonda, 2011, Agrifood Consulting International (2005), and Ammar Siamwala and Wiroj Na Ranong (1990)

[6] Somporn Iswilanonda, 2011, Thai Rice: Industrial and Market Structural Change

Figure 2 shows that the rice industry begin with the farmers who grown paddy from five main factors of production which are land, soil, fertilizer, machinery, and seeds and sell their paddies to millers both directly and indirectly by trade trough collectors. For millers, they transform paddy to rice by milling and sells to the traders who supply two markets, domestic and export market. Millers can sell to traders directly or via the agents, called "Yong".

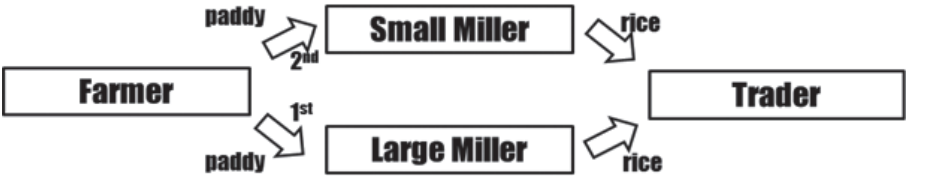
The farmers can be separated into 4 types by their size (small and large) and types of land area (irrigated and non-irrigated land area). The small farmer normally earns a better yield per rai than the large miller but gain lower benefit for a smaller quantity and non economy of scale. For irrigated land area, farmers can grow off-season which required more water than the season rice. Although the season rice gain a higher price but it can be grown only one time a year comparing to the off-season which can be harvested for at least two time a year.

For the rice trading, more than 60 percent of paddies are traded via the collectors. There are three types of collectors, the local agent, non-local agent, and the cooperative. For Yong, there are many companies work in this business and the market is very competitive when the agent earn only one percent of trade value for their commission. Although the exporters gain a very low margin, with a very high volume they get a large profit. For example, there are 5 main exporters, called "the five tigers". Each "tiger" are keen on different markets, but these five gain around 50 percent of the Thai export market.

It can be seen from this value chain that the Thai rice market is rather complicated. So, this study has to modify figure 2 it into a simpler diagram as figure 3. In this figure 3, the details of factors of production and types of farmers are concluded in the farmers, as well as exporter and domestic trader is put together as trader. Both collectors and agents are carving out from the model, since they play as only the supporter and earn only small margin. In addition, the millers are separated into small and large miller, since they play different roles in pledging scheme, which will be explained later.

Therefore, this study applied the LP technique for every main player in the Thai rice industry, which consists of the **farmers** who grow and harvest paddy on their farms, the **small and large millers** who mill the rice, and the **traders** who buy the rice from millers and decide to sell it abroad or domestically. According to the Bank of Agriculture and Agricultural Cooperatives and Fiscal Policy Research Institute (BAAC and FPRI) (2013), farmers will sell to large millers before small millers since large millers can buy more paddy which reduces transaction cost. Therefore, the processes of the study are (1) to optimize farmer objectives (2) to optimize large miller objectives (3) to optimize small miller objectives and (4) to optimize trader objectives for the normal case, as shown in Figure 3.

Figure 3. Value Chain of the Thai Rice Industry



Source: Author

The farmer's model consists of two parts, the objective and the conditions. The farmer's objective is to maximize profit when selling his paddy. Farmers can choose to grow two types of paddy, season and off-season paddy. These two types of paddy have different costs and prices. Therefore, the farmer's objective function can be written as:

$$Max:\ \pi^{f} = \sum_{p=1}^{2} (P_p^f - C_p^f) Q_p^f \tag{1}$$

By choosing Q_p^f

Where P_p^f = price of paddy "p"

Q_p^f = amount of paddy "p"

C_p^f = cost of paddy "p"

p = 1; seasonal paddy 2; off-season paddy

Moreover, the cost of paddy derives from many resources (k) for example land rental, seed, fertilizer, and pesticide. To produce one ton of paddy requires different amounts of resources (γ_{pk}^{f}) and each resource has a different unit price (c_k^f). Therefore,

$$C_p^f = \sum_{k=1}^{8} \gamma_{pk}^{f} c_k^f \qquad \forall_p \tag{2}$$

Where c_k^f = cost of one unit of resource "k"

k = 1; land
2; seed
3; fertilizer
4; fuel
5; pesticide
6; labor for seedling
7; labor for harvesting
8; irrigated land

For the condition, the farmer can grow as much as the resources permit. In other words, the farmer cannot use more resources than he has available. All of the resources are limited at some amount (Z_k) which will be shown later in data section. In addition, to grow different types of rice requires different amounts of each resource. So, the farmer's condition is subject to

$$\sum_{p=1}^{2} \gamma_{pk}^{f} Q_{p\,i}^{f} \leq Z_k \qquad \forall_k \tag{3}$$

For the miller, according to the Department of Industrial Work (DIW) (2006), Kittipong Chaiwongsa (2014), Onruedee Sritarapipat (2013) and the interview with Hengpoontana Rice mill, (presented in chapter 2) the miller's objective is to maximize profits which are the summation of all profits from each type of rice produced. Rice is produced by milling the paddy. So, his two main costs are the paddy price (P_p^f) and the milling cost (c_r^m). In addition, some parts of the paddy are rice (R) and the others, for example bran and germ, can be sold as by-products (b_r^m) for extra revenue.

In addition, there are three main types of rice which are fragrant rice, which is made from seasonal paddy, white rice, which is made from off-season paddy, and par-boiled rice which is also made from off-season paddy but requires other processing and special machines to produce. Given "δ" as the chance of unbroken rice, then the objective function can be written as:

Objective: *Max*: $\pi_s^m = \sum_{r=1}^{3} (P_{rs}^m - C_{rs}^m) Q_{rs}^m \quad \forall_s$ (4)

By Choosing Q_{rs}^m

Where π_s^m = Profit of miller "s"

P_{rs}^m = Price of Rice "r" miller "s" received

C_{rs}^m = Cost of miller "s" producing rice "r"

Q_{rs}^m = amount of rice "r" produced by miller "s"

r = 1; Fragrant rice
= 2; White rice
= 3; Par-Boiled rice

s = 1; large miller
= 2; small miller

The cost of producing rice consists of input (paddy) cost and operation cost, and there is also extra revenue from by-products. As mentioned above, not all paddy becomes rice, and there is a chance of broken rice. So the paddy amount for making one ton of rice "*r*" is

$$Q_{rs}^m = \delta R Q_p^f \text{ or } Q_p^f = \frac{1}{\delta R} Q_{rs}^m \tag{5}$$

To make rice, millers have both cost and revenue from selling by-products which are bran, germ and husk. In addition, the operation cost for each type of rice (b_{rs}^m) is different. For example, the process of making par-boiled rice is more complicated than white rice, so the operation cost for par-boiled rice is higher. Given "c_{rs}^m" as the operation cost of miller "*s*" for making rice "*r*", the miller's cost function is

$$C_{rs}^m = \frac{1}{\delta R} P_p^f + c_{rs}^m - b_{rs}^m \quad \forall_r \tag{6}$$

Where C_{rs}^m = milling cost of rice "*r*" of miller "*s*"

b_{rs}^m = by-product price of miller "*s*" from making one ton of rice "*r*"

c_{rs}^m = operation cost of miller "*s*" from making one ton of rice "*r*"

In rice processing, there are some conditions. Firstly seasonal paddy can yield only fragrant rice, so the miller cannot produce more fragrant rice than the seasonal paddy grown, and the large miller can buy rice before the small miller. So, the large miller's condition can be written as

$$Q_{11}^{m} \leq \frac{1}{\delta R} Q_{p}^{f} \tag{7}$$

The small miller can buy only what the large miller has left for them[7]. So,

$$Q_{12}^{m} \leq \frac{1}{\delta R} Q_{p}^{f} - Q_{11}^{m} \tag{8}$$

As the off-season paddy can be made into both par-boiled and white rice, the second condition can be written as

$$Q_{21}^{m} + Q_{31}^{m} \leq \frac{1}{\delta R} Q_{2}^{f} \tag{9}$$

and

$$Q_{22}^{m} \leq \frac{1}{\delta R} Q_{2}^{f} - (Q_{21}^{m} + Q_{31}^{m}) \tag{10}$$

Next, the miller cannot produce more of all types of rice than the total capacity (K_s), which can be written as

$$\sum_{r=1}^{3} Q_{rs}^{m} \leq K_{s} \qquad \forall_{s} \tag{11}$$

Finally, only some millers can produce par-boiled rice. Given "K_B" as the Capacity for Par-Boiled Rice, then the fourth condition is

$$Q_{31}^{m} \leq K_{B} \tag{12}$$

[7] There are two main reasons for this assumption. First of all, more than 60 percent of paddy trade via collector. Rationally, these collectors will reduce their transaction cost by selling to the large miller who can buy with a large amount of paddy instead of the small miller. Secondly, the data from department of business development (DBD) shows that the number of small and medium-sized millers decreased at 21 and 22 per cent, respectively, but the number of large millers increased from 58 to 68 millers between 2013 and 2015. This data can confirm that there is not enough paddy for small and medium-sized millers, but there are plenty for large miller.

Traders also aim to maximize profit from selling the rice he bought from millers. Traders buy rice from both small and large millers at the same market price, but he sells it at different prices to domestic and export markets[8]. The trader's profit equation can be written as

$$\pi^{t} = \sum_{j=1}^{2}(\sum_{r=1}^{3}(P_{rjs}^{t} - C_{jrs}^{t})Q_{rjs}^{t}) \tag{13}$$

By Choosing Q_{rjs}^{t}

Where π^{t} = Profit of trader

P_{rjs}^{t} = Price of Rice "*r*" selling in market "*j*"

C_{jrs}^{t} = Cost of Rice "r" selling in market "*j*" by miller "*s*"

Q_{rjs}^{t} = Amount of rice "*r*" buying from miller "*s*" selling in market "*j*"

j = 1; Export market

= 2; Domestic market

Since, the cost of rice "*r*" selling in market "*j*" consist of the price of rice bought from millers and the operation cost, the cost of rice "*r*" in market "*j*" is

$$C_{jr}^{t} = (1 + c_{jr}^{t}) + P_{r}^{m} \qquad \forall_{r} \tag{14}$$

However, traders cannot sell more rice than the millers produce. So,

$$\sum_{i=1}^{2} Q_{jr}^{t} \leq \sum_{s=1}^{2} Q_{rs}^{m} \qquad \forall_{r} \tag{15}$$

Also, traders cannot trade each type of rice more than the market size (X_{jr})

$$Q_{jr}^{t} \leq X_{jr} \qquad \forall_{r} \text{ and } \forall_{j} \tag{16}$$

[8] Although Erwadee Premasatian (2012) estimated that rice export and paddy prices affect the rice export quantity, the study did not focus only on the rice market, but also on other crops especially sugar cane and cassava, and constructed a combined agricultural model. However, Mahathanaseth (2014) tested the model with the necessary econometric tests, so the model of Mahthanaseth (2014) is more appropriate for this study. Therefore, this study assumes price is static.

3.1.2 Data

Since the LP requires many types of data, for example, required resources, resource availability, resource cost and price, this study employs many sources of data.

For the **farmer**, the data for the cost of land, fertilizer, and fuel come from BAAC (2013), the cost of seed from the rice department (2014), pesticide from Prang Pakpanich (2012), and labor costs from the Labor Forces Survey (2014), and the price of rice from the Thai rice miller association (2014). To produce one ton of paddy, the non-irrigated and irrigated land data were collected from OAE (2014)[9], the fertilizer, the fuel and labor data from BAAC (2013), and the seed data from the Rice Department (2014). Lastly, for the resource availability data, the OAE (2014) provided data for land, the Ministry of Energy for fuel, the Department of Rice for seed, UNCTAD and OIE for fertilizer, and the Labor Force Survey for labor data.

For the **miller**, DIW (2006) provided data for large miller operation costs. The Thai Rice Miller Association (2014) announced the average rate of by-product percent and price. Kittipong (2013) provided the operation cost, by-product, and percent of unbroken rice data for small millers.

For **traders**, the data from the Thai Rice Exporter Association (2014) has been used for export price and the data from the Department of Interior Trade (DIT) (2014) has been used for domestic price.

3.1.3 Data Discussions

With the data shown above, there are three important issues that need to be discussed and understood. The first issue is time consistency. The second issue is the difference in the definition of each organization. Lastly is the difference in value for each source of data.

[9] OAE define seasonal rice (paddy) differently from this research. The OAE define seasonal rice as any paddy grown between May and October, while off-season is any paddy grown from November to April. Therefore, the real off-season amount is twice the OAE report, and the seasonal amount has to be subtracted from that amount.

For the time difference issue, most of the data in this study were collected between 2012 and 2014, subject to data availability. The problem of time consistency is that many types of data, for example the required resources, are not collected monthly or yearly. Many types of primary data are collected occasionally. Therefore, a question of time lag occurs.

However, this kind of variable does not change much over five to ten years. For example, the resources required to grow rice changes only when the farmer has new, better technology or knowledge, but (1) there is no new innovation for paddy farming and (2) the farmers already have accessed the current technology or advanced machinery by buying, renting or hiring persons who have the knowledge to work on their farms. Therefore, this type of variable can be assumed to be unchanged.

Another problem is the definition of each source of data. This study tries to convert all different definitions into the same format. For example, the definitions of seasonal and off-season paddy from OAE are different from this study. OAE defines seasonal paddy as all paddy harvested from May to October, no matter whether it is photosensitive paddy or not. This study has to convert this amount to only photosensitive paddy more reliable. However, in the case that both sources are reliable, the study will apply the middle value.

Finally, there are some data that provide different values from different sources. This study tries to select data from only one source, which is significantly

3.2 Under the Pledging Scheme

3.2.1 The model

In the pledging scheme, the government intervened in the market by buying all paddy from farmers, hiring the large millers[10] to produce rice, and selling the rice to traders. Therefore, this situation is different from the normal situation in three ways: the paddy prices, large miller rice prices, and the government budget. In other words, only the farmers, large millers, and government are changed in this situation.

[10] Since there are many conditions for the scheme, especially having sufficient standard silo spaces, most small millers cannot join the program.

For farmers, the rice price is changed to the pledging price (P_p^{fp}). However, only the amount of paddy sold via large millers (Q_{p1}^f) is paid at the pledging price; the small miller still pays for the amount of paddy bought (Q_{p2}^f) at the normal price. In addition, the large miller who joined the program can choose to buy either at the market price or the pledging price. However; the decision to join the program is the farmer's. Selling at the pledging price provides better benefits but there is a need to wait for the money for one to two months. The farmer who cannot wait would decide not to join the program. The DIT provided the amount of paddy in the program for the 2014 period: 4.8 million tons of seasonal paddy and 17.6 million tons of off-season paddy. In other words, only 4.8 million tons of seasonal paddy and 17.6 million tons of off-season paddy can wait for better profit. The rest is the amount of paddy that cannot wait for the money to be transferred from the program.

Therefore, the farmer's decision model can be modified as

$$\pi^f = \sum_{p=1}^{4} (P_p^f - C_p^f) Q_p^f \tag{17}$$

Where

p = 1; seasonal paddy for non-scheme
2; off-season paddy for non-scheme
3; seasonal paddy for scheme
4; off-season paddy for scheme

For large millers, his decision model is changed to

$$\pi^m = \sum_{r=1}^{6} (P_{r1}^m - C_{r1}^m) Q_{r1}^m \tag{18}$$

Where

r = *1*; fragrant rice for non-scheme
2; white rice for non-scheme
3; par-boiled rice for non-scheme
4; fragrant rice for scheme
5; white rice for scheme
6; par-boiled rice for scheme

$$C_{r1}^{m} = \frac{1}{\delta R} P_{p}^{f} + c_{rs}^{m} - b_{rs}^{m} \qquad \text{For } r = 1 \text{ to } 3 \qquad (19)$$

P_{r1}^{m}= ex-miller market rice price For $r = 1$ to 3 (20)

$$C_{r1}^{m} = \frac{1}{\delta R} P_{p}^{fp} + c_{r1}^{m} - b_{r1}^{m} \qquad \text{For } r = 4 \text{ to } 6 \qquad (21)$$

$$P_{r1}^{m} = \frac{1}{\delta R} P_{p}^{fp} + c_{r1}^{m} + g_{r} - b_{r1}^{m} \qquad \text{For } r = 4 \text{ to } 6 \qquad (22)$$

g_r = milling fee the government paid per ton of rice, which is equal to 500 Thai Baht

In addition, the scheme of Phue Thai involved pledging all paddies. Therefore, the new condition for large millers (who are assumed to be in the program) is the amount of both seasonal and off-season paddy in the program that must be used. Then the new conditions are

$$Q_{11}^{m} \leq \frac{1}{\delta R} Q_{3}^{f} \text{ and } Q_{11}^{m} \geq \frac{1}{\delta R} Q_{3}^{f} \qquad (23)$$

or

$$Q_{11}^{m} = \frac{1}{\delta R} Q_{3}^{f} \qquad (24)$$

and

$$Q_{21}^{m} + Q_{31}^{m} = \frac{1}{\delta R} Q_{3}^{f} \qquad (25)$$

Small millers cannot join the program due to many conditions, especially having sufficient standard silo spaces to meet the program's conditions. The small miller's objective function and the conditions remain unchanged under the "no government intervention case". This is similar to traders who buy from both the government and millers and sell to the unchanged markets (export and domestic) at the same market price as in the "no government intervention case". Therefore, the small miller and the trader model are the same model as the no government intervention case.

Lastly, the government budget is computed from the difference between the pledging rice price and the market price and the amount of rice under the scheme. In this case, the government buys rice from millers at the

pledging price, but sells to traders at the market price[11,12]. In addition, the scheme does not cover by-products. The government let the millers sell or manage it to their benefit. In other words, the pledging price only refers to the unbroken rice price. Thus the model is

$$\pi^{G} = \sum_{r=1}^{3} (P_{r1}^{m} - P_{r1}^{pm}) Q_{r1}^{m} \tag{26}$$

3.2.2 Data

The pledging paddy price comes from the government program announcement, Department of Interior Trade (2012), which gave 15,000 Baht per ton of off-season paddy, and 20,000 Baht per ton of season-paddy. The rice pledging price comes from the Department of Interior Trade (2012) which stated that the government paid 500 Baht per ton for the milling fee.

4. Results

With the model and data shown in section 3, the results can be shown for both individuals and the whole industry as follows.

4.1 Farmers

In normal case, the model found that farmers decide to produce 22 million tons of season paddy and 19.5 million tons of off-season paddy to maximize profit. With this amount of production, the farmer gains a total profit of 217 billion Thai Baht. This total profit can be separated into157 billion Thai Baht from selling seasonal paddy and 60 billion Thai baht from off-season paddy.

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[11] Although there are some rice schemes that used the government to government (G to G) trading process, G to G price is computed based on the market price minus or plus other expected fringe benefits; (from interviews with Mr. Wanchai, Department of Interior Trade and Mr. Siridev, Department of Foreign Trade officer). Therefore, the G to G price is assumed to be the market price.

[12] For simplification and for the future implementation, the assumption that the government accept the lost by selling rice at the market price, instead of speculate the rice price which cannot be success (since Thai rice has no market power)

Table 2. Farmer's Optimal Decision under No Government Intervention

	Price (Thai Baht)	**Production Amount** *(Tons)*	**Cost** *(Baht per ton of paddy)*	**Profit** *(Million Baht)*
Seasonal Paddy	15,000	23,109,243.70	8,214.33	156,811.70
Off-Season Paddy	8,000	20,270,270.27	5,026.14	60,280.95
Total Profit				**217,092.65 Million Baht**

Source: Model Calculation

In pledging case, farmers decide to grow and harvest a total of 43.4 million tons of paddy. This amount can be separated into four types; seasonal paddy in the program, off-season paddy in the program, non-program seasonal, and non-program off-season paddy. The amount of seasonal paddy in the program is 4.8 million tons and the amount of off-season paddy in the program is 17.6 million tons. For the non-program paddy, there were 8.3 million tons of seasonal paddy and 2.6 million tons of off-season paddy which were not in the program and were sold at the market price. With this decision, the total profit of the farmer is calculated at 427.4 Billion Baht, with 297 Billion Baht from the scheme and 130 Billion from non-scheme production.

Table 3. Farmer's Optimal Decision under the Pledging Scheme

	Price per Ton	**Amount Grown**	**Cost per Ton**	**Profit**
Scheme				
Seasonal Paddy	20,000	4,827,909	8,214.33	56,900.14
Off Season Paddy	15,000	17,648,687	5,026.14	176,025.53
Non-Scheme				
Seasonal Paddy	15,000	17,466,220.57	8,214.33	117,096.75
Off Season Paddy	8,000	2,621,583	5,026.14	5,853.63
Total		**42,564,399.57**		**355,876.05**

Source: Model Calculation

4.2 Millers

For normal case, there are two types of miller in the model. So, this part will show the results of the large miller followed by the small miller. The results are as follows.

According to the model assumption, large millers can buy the paddy before small millers. Therefore, large millers can decide the amount of fragrant rice, white rice, and par-boiled rice to maximize profit. The optimal amount of fragrant rice is 10.2 million tons. The miller decides not to produce white rice and produces 375,634 tons of par-boiled rice. The total profit for the large miller is 22.8 billion US dollars.

Table 4. Large Miller Optimal Decisions under No Government Intervention

	Price (Thai Baht)	**Production Amount (Tons)**	**Cost (Thai Baht per Ton)**	**Profit (Million Thai Baht)**
Fragrant Rice	29,540.00	10,223,444.22	27,358.56	22,301.86
White Rice	12,790.00	-	11,535.18	-
Par-Boiled Rice	12,740.00	375,634.12	11,398.79	503.80
Total Profit				**22,805.66 Million Baht**

Source: Model Calculation

Small millers will decide the optimal amount of rice products to maximize profit. From the results, it can be seen that large millers left no seasonal paddy for small millers, and only the off-season paddy is left. The small miller's decision is based on the amount of off-season paddy the large miller left. The model found that the optimal amounts of rice production are 11.2 million tons of white rice and no production of par-boiled rice. The reason for no par-boiled rice production is that in this case, the small miller is assumed not to be able to produce par-boiled rice since there are specific techniques for producing par-boiled rice. The production yields 17.9 billion Thai Baht for small millers.

Table 5. Optimal Decisions for Small Millers under No Government Intervention

	Price (Thai Baht)	**Production Amount (Tons)**	**Cost (Thai Baht per Ton)**	**Profit (Million Thai Baht)**
Fragrant Rice	23,772.38	0.00	11,181.40	0.00
White Rice	29,540.00	11,164,271.50	12,790.00	17,958.89
Total Profit				**17,958.89 Million Baht**

Source: Model Calculation

For pledging case, the profit optimized for large millers is computed at a total of 12 billion Thai Baht. 11.2 billion Thai Baht is from the scheme and 0.8 billion Thai Baht is from non-scheme paddy. In this case, the miller decide to produce 2.2 million tons of fragrant rice, 3.5 million tons of par-boiled rice, and 4.3 million tons of white rice in the scheme and allows 0.24 million tons for non-scheme fragrant rice.

Table 6. Large Miller's Optimal Decision under the Pledging Scheme

	Price per Ton	**Amount Produce**	**Cost per Ton**	**Profit**
Non Scheme				
Fragrant Rice	29,540.00	241,200.00	26,009.67	851.51
White Rice	12,790.00	0	11,531.70	0
Par-boiled Rice	12,740.00	0	11,395.31	0
Scheme				
Fragrant Rice	40,331.67	2,224,842.86	0	2,413.95
White Rice	24,720.96	4,633,035.48	39,246.67	5,026.84
Par-boiled Rice	24,875.35	3,500,000.00	23,635.96	3,797.50
Total	**12,089.81**			

Source: Model Calculation

Table 8. Trader's Optimal Decision under the Pledging Scheme

	Price per Ton	Amount Trade	Cost per Ton	Profit
Fragrant Rice Export	33,958	2,000,000.00	30,558.74	6,798.52
White Rice Export	14,129	6,202,845.83	13,163.87	5,986.55
Par-boiled Rice Export	14,138	2,797,154.17	13,214.14	2,584.18
Fragrant Rice Domestic	32,000	11,000,000.00	30,500.00	16,500.00
White Rice Domestic	14,700	0	13,181.00	0
Total				**31,869.25**

Source: Model Calculation

4.4 Government

Because of the decisions of farmers and large millers mentioned above, the government budget is computed to be "122.2 billion Thai Baht" in deficit. These large amounts of deficit are from white rice at 55.2 billion, par-boiled rice at 42.5 billion and from fragrant at 24.4 billion Thai Baht.

Table 9. Government Budget under the Pledging Scheme

	Market Price	Amount in Program	Pledging Price	Profit
Fragrant Rice	29,540	2,224,842.86	40,509	-24,403.19
White Rice	12,790	4,633,035.48	24,723	-55,286.61
Par-boiled Rice	12,740	3,500,000.00	24,878	-42,481.32
Total				**-122,171.12**

Source: Model Calculation

In summary, the pledging case brings a profit to farmers of 138 billion Baht, but the government lost 122 billion Baht. The main changes in this situation are for the two types of miller. The large miller changes their decision due to the conditions of the program. These changes leave more seasonal paddy to the small miller. The small miller profits more from the increase in the amount of seasonal paddy. Finally, the small miller, who normally has

lower capacity, a better unbroken rice rate creates more fragrant rice[13], so the trader can trade more fragrant rice and also benefit more. Therefore, the whole society benefits from the increase.

Although it seems that the policy is worthy, some parties also lost from the program. In addition, the program supports wealthier farmers more than the poorer ones. Lastly, rice delivery is also the big issue for this scheme. Therefore, a pledging scheme could be applied with care in practice. It needs to beware of some issues, for example, how to compensate the losers who should gain more benefit; how to deliver the rice, and the corruption problem.

Table 10. Summary of Results (Profits) for the Three Cases

Unit: Millions Baht

Players	**No Scheme**	**Pledging**
Farmers	217,092.65	355,876.05
Large Millers	22,805.66	12,089.81
Small Millers	17,958.89	60,170.44
Traders	31,793.54	31,869.25
Government		-122,171.12
Total	**289,650.74**	**337,834.43**

Source: Model Calculation

[13] Mr. Adulya Clonebhandhu claimed in "TRF Forum Series 1 : Agricultural Cooperation is one of the Solution for Farmer" 21 December 2016 that his small miller gain a better rate than the large miler. To do that he has to mill the husk out and rest the milled but unpolished paddy for more than a day before polishes the bran out again. This resting process is to reduce the heat from the milled paddy, before polished. This process can reduce the broken rate, but take time. The large miller that operates for twenty-four hour has no time for this resting process. Therefore, the small miller yields a better rate than the large miller.

5. Discussion

The results indicate that there are some issues that need to be discussed especially when making comparisons with the real situation.

First is the farmer's revenue. OAE (2014) shows the amount of seasonal and off-season paddy grown and harvested by the farmer. With the same price and cost for both types of paddy in the model, the real profit is computed at 162 billion Baht, which is lower than 217 billion Baht in the model. The lower amount in reality comes from the "non-optimized decisions" of farmers. Therefore, it is worth the government pursuing policies to encourage optimization for farmers.

However, the assumption that all parties optimize their profit makes the model different from the real situation. There are differences not only for the farmer, but also for the miller. To optimize profit under the conditions assumed in the model, large millers decide not to produce white rice and bought the entire seasonal paddy to produce fragrant rice, so small millers can produce only white rice. This result is different from the real situation in which small millers can also produce fragrant rice and large millers produce both white and fragrant rice.

The difference results from two reasons. The first reason is that neither type of miller optimizes their decisions in reality. So, they decide to buy and produce any type of paddy and rice as long as they still gain a profit. The second reason could be that there are other important conditions excluded from the model, for example, some informal rules or traditions of the miller association and informal contact between small and large millers.

Secondly, it has been found that the pledging policy showed a slightly better profit compared to normal circumstances. Therefore, this result supports the pledging program and economists like Pichit (2011), especially for the greater benefits for farmers.

However, the economists who do not support the scheme like Siamwala and Poapongsakorn (2011) and Puapongsakorn, et al. (2013) are not completely rejected. There are some losers in the program, especially millers. The model shows that the program takes from the small miller's hand. However, the

program left the seasonal paddy instead of off-season paddy in the normal case. Therefore, the small miller gains benefits, but the large miller does not. This might be different in reality as many small millers have left the market since they had no paddy to process. This difference affects traders' decisions. There is also no white rice in the domestic market. This is also different from the real situation. However, this case assumes that all parties have to maximize benefit without any other conditions, which is not represented in the model.

For the traders, the model found differences from Chulaphan, Jatuporn, Chen, and Jiewiriyapant (2012) who stated that traders will suffer from a production subsidy, such as the pledging program, in the sense that traders gain a small benefit in this case. In addition, the results of this model are slightly different from Mahathanaseth (2014). Although the model is based on the result of Mahathanaseth (2014) who found that the rice price is unchanged in the pledging case, the program shows a slight benefit, especially for farmers.

Moreover, in practice, it has been found that this pledging policy has been condemned by the non-rice industry parties, who are taxpayers who have no direct benefit from the program but finance huge government spending. In addition, this program has also been criticised by traders who have not received rice from government stocks. In contrast, the program is supported by the farmers who gained benefit from the program. This is in keeping with this study which reveals positive impacts for farmers and millers and negative impacts for taxpayers and traders in the rice stocking case. However, although the rice millers gain the most from the program, there is no response from them.

For the government budget, the model found a lower budget compared to the real situation. The model calculated the government budget at 122 billion Baht, or 37 per cent lower than the real budget spending of 580 billion Baht for the three year program which is on average 193.33 billion Baht a year, according to the Ministry of Finance (2014). These differences may result from many reasons, for example, management cost, and corruption, which are not included in this study.

Finally, the government budget in the program is mostly spent on off-season paddy, which is grown in irrigated land areas. In other words, the

programs support the wealthier farmer, not the poorer one. This result is also similar to Puapongsakorn, et al. (2013)

6. Conclusions and Recommendations

In conclusion, this study shows the slight overall benefit of the program, and high positive impact for farmers and large millers; however, the government (tax payer) and traders suffer from the program. According to these results, the pledging scheme would be appropriate if it could control the budget.

In addition, due to the fact that in this optimization technique the farmer(s) gain a 41 per cent profit increase, the government should help them decide and optimized their resources for better profit.

Furthermore, the main reason for higher social benefit in pledging scheme is the pattern change. In pledging scheme, small miller has more fragrance rice to operate and with the lower broken rice rate the small miller is more effective. Therefore, the recommendation is that the government should implement the small miller enhancement programs. The programs are, for example, technological development, machine improvement, and also support farmers to join stock in small miller businesses. This jointed stock company will encourage farmers to sell rice to small miller. This can benefit in two ways; (1) guarantee that the small miller can be operated and earn profit and (2) increase the income of farmers.

However, this study lacks some conditions and can relax more assumptions, which could be developed in further studies. For example, the farmers in this model are assumed to be only ones, and that there is no difference between large and small farmers. Ananchanok Sakontawat (2012) claimed the rice cultivation area is the significant factor for the poverty condition of farmers[14].

Finally, this study is focused only on one policy, the pledging scheme. According to Montian Satimanont (2006) and Manita Rakotoarisoa (2006),

[14] Kanok Katikarn also commented that this model should be modified to answer the impact on two types of farmer for further study.

there are many traditional rice policies that can be employed in the Thai rice industry. For example, another 'amber box' policy like a price guarantee policy, or a 'green box' policy like research and development and agricultural infrastructure development, such as increasing the irrigated land area, which is the scarce resource in the study, can be applied. Therefore, these types of policies are recommended for further study.

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4.3 Trader

From the model, the trader will maximize the profit by selling 2 million tons of fragrant rice, 8.4 million tons of white rice and 0.38 million tons of par-boiled rice to the export market and selling 8.2 million tons of fragrant rice 2.8 million tons of white rice domestically. With that traded amount, the trader will obtain a profit (which mostly comes from domestic fragrant rice) of 31.8 million Baht.

Table 7. Trader's Optimal Decisions under No Government Intervention

	Price	**Traded Amount**	**Cost**	**Profit**
Fragrant Rice Export	33,958.00	2,000,000.00	30,558.74	6,798.52
White Rice Export	14,129.00	8,387,715.72	13,163.87	8,095.24
Par-Boiled Rice Export	14,138.00	375,634.12	13,214.14	347.03
Fragrant Rice Domestic	32,000	8,223,444.216	30,500	12,335.16
White Rice Domestic	14,700	2,776,555.784	13,181	4,217.58
Total				**31,793.54**

Source: Model Calculation

In the pledging case, the program changes not only farmers' profit, but the amount of rice that is milled. This can also change the traders' profit. Under the scheme, the traders' profit is in total 31,869 million Thai Baht. The profits are from selling 2 million tons of fragrant rice, 6.2 million tons of white rice and 2.8 million tons of par-boiled rice abroad, and 11 million tons of fragrant rice domestically.

Appendices

Table A1. Cost of Resources for Growing Paddy

Variables	Cost (Baht)	Unit	Sources
Land	1,000	Rental fee per year per Rai	Ministry of Interior and BAAC
Seed	29	Per Kilogram	Rice Department
Fertilizer	800	Per 50 Kilogram Bag	BAAC
Pesticide	1,120	Per Rai	Pakpanich
Labor for Seedling	300	Per day which is equal to 15 Rai	BAAC and LFS
Harvested fee	300	Per Rai	BAAC

Source: collected/computed by Author

Table A2. Resources Used to Grow One Ton of Paddy

Variables	Resources Used	Types of Paddy	Sources
Land	2.38 Rai	Seasonal	OAE
Land	0.74 Rai	Off-Season	OAE
Irrigated Land	0.74 Rai	Off-Season	OAE
Seed	25.17 Kilograms	Seasonal	Department of Rice
Seed	28.86 Kilograms	Off-Season	Department of Rice
Fertilizer	1.51 of 50 Kilogram Bag	Seasonal	BAAC
Fertilizer	1.3 of 50 Kilogram Bag	Off-Season	BAAC
Fuel	2.52 Litters	Seasonal	BAAC
Fuel	1.442 Litters	Off-Season	BAAC
Pesticide	2.53 Litters	Seasonal	BAAC
Pesticide	1.52 Litters	Off-Season	Pakpanich
Labor for Seed	0.17 Man Days	Seasonal	BAAC
Labor for Seed	0.05 Man Days	Off-Season	BAAC
Labor for Harvesting	0.05 Man Days	Seasonal	BAAC
Labor for Harvesting	0.01 Man Days	Off-Season	BAAC

Source: collected/computed by Author

Table A3. Amount of Farmer's Resources

Resources	Availability	Units	Sources
Land	70,000,000	rai	OAE
Seed	1,290,000,000	Kg	Rice Department
Fertilizer	130,000,000	Bag	OIE and UNCTAD
Fuel	1,422,000,000	litre	Energy Department
Pesticide	36,756,643,000	litre	UNCTAD
Labor for Seed	30,040,144	Man day	LFS
Labor for Harvesting	1,728,100	Man day	LFS
Irrigated Land	15,000,000	rai	OAE
Non-Irrigated Land	55,000,000	rai	70,000,000 minus 15,000,000 rai

Source: collected/computed by Author

Table A4. Price of Rice and By-Product by Type

Unit: Baht

	Fragrant Rice	White Rice	Par-Boiled Rice
Unbroken Rice	29,540.00	12,790.00	12,740.00
By-product	6,618.50	6,052.13	6,197.52

Source: Thai Rice Miller Association

Table A5. Cost of Rice Production

Cost Types	Miller Types	Rice Types	Cost per Ton of Rice (THB)	Source
Operation cost	*Large*	Fragrant Rice	255.00	DIW
		White Rice	226.00	DIW
		Par-boiled Rice	235.00	DIW
	Small	Fragrant Rice	565.39	DIW
		White Rice	565.39	DIW
		Par-boiled Rice	565.39	DIW
By-product	*Large*	Fragrant Rice	6,618.50	Thai Rice Miller Association
		White Rice	6,052.13	Thai Rice Miller Association
		Par-boiled Rice	6,197.52	Thai Rice Miller Association
	Small	Fragrant Rice	2,745	Thai Rice Miller Association and Chaiwongsa
		White Rice	2,745	Thai Rice Miller Association and Chaiwongsa
		Par-boiled Rice	2,745	Thai Rice Miller Association and Chaiwongsa

Source: collected/computed by Author

Table A6. Rice Trading Prices

Types of Rice and Market	Prices (Thai Baht)	Source
Export Fragrant	33,958.00	Thai Rice Exporter Association
Export White	14,129.00	Thai Rice Exporter Association
Export Par-Boiled	14,138.00	Thai Rice Exporter Association
Domestic Fragrant	32,000.00	DIT
Domestic White	14,700.00	DIT

Source: collected/computed by Author