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Thai Rice Market, Cooperation or Competition is Better? Linear and Goal Programming Approach

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Abstract: Rice is the most important agricultural product of Thailand. Thai government has been attempting to manipulate the rice market in order to lift Thai farmers out of poverty. Rice policies that have been used for decades (2010 to present), such as rice pledging and price guarantee, aims for the benefit of the farmer; however they significantly harm some participants. The purpose of this research is to introduce the new alternative policy to deal with this problem by analyzing the benefit of each participant in two cases; social maximization and individuals' maximization. Linear programming and Goal Programming methods are employed in the study using data from various sources gathered mostly from 2012 to 2014 by a value chain study. The research results reveal that most of participants receive better benefits under the social maximization case. This research, therefore, suggests that the participants in Thai rice market; farmers, millers, and traders, should cooperate in determining the optimal amount of each type of rice productions so as to maximize their benefits.

Key words: rice farmer; rice industry; rice policy; linear programming; goal programming
JEL codes: H320, L520, L660, Q120, Q180

1. Introduction

Rice is one of the most important products in Thailand. It is very important for Thai economy, politics, and society. For economy, it is crucial for both demand and supply side. For demand side, rice is the main agricultural product that Thai people consume. In Thailand, rice was consumed 10.6 million tons in 2015. With the population of 68 million, Thailand's rice consumption is 156 kilograms per person per year on average. For, supply side, Thailand is one of the main rice production and exporting countries. In 2015, Thailand produced 18.75 million tons of rice and exported around 21 percent of world rice market by value. For labor force, in Thailand, around 40 percent of labor force is in agricultural sector and more than 50 percent of that labor force is rice farmers. For politics, rice is also very important to all politicians because around 20 to 30 percent of labor force is rice farmers. Finally for society, since rice is the main source of food, agricultural product, and job for many Thai people, it also creates and involves in Thai culture and the way of life.

Thai government has been attempting to manipulate the rice market in order to lift Thai farmers out of poverty. Rice policies that have been used for decades (2010 to present), such as rice pledging and price guarantee, aim for the benefit of the farmers; however they significantly harm some participants. Since farmers are not only a

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large number of workers, but also a large number of voters, the politicians have to prioritize on them before the millers and traders.

Table 1 Thai Rice Production and Consumption in 2015

	Value
Rice Consumption (million tons)	10.60
Population (millions)	67.96
Rice Consumption per Person per Year (Kg)	155.98
Rice Production (million tons)	18.75
Rice Production per Population (Kg)	275.9

USDA and World Bank

In addition, the parties in rice industry have rarely cooperated together. In practice, only the close parties along the value chain have some participation among others. For example, farmers have some relationship with millers while millers have some relationship with traders. However, there is no relationship between traders and farmers.

Moreover, there is no any signal from the traders for both future price and quantity. In the fourth quarter of 2016, price of world Hommali (Thai premium rice) dropped dramatically from 987 US Dollars per ton in October 2015 to 787 US Dollars per ton in October 2016. The farmers and the millers got no sign or warning from the exporters who always monitor the price.

This is different from sugar industry in Thailand. There is the “Sugar Board” who will decide the quota for domestic and export market. The Sugar Board consisting of the members from domestic traders, exporters, sugar millers, sugar farmers, and government officers (as consumer representatives), make decisions together on the optimal quota, and sugar cane amount from the data and information provided by the Sugar Board Office.

The purpose of this research is to introduce the new alternative policy to deal with these problems. The co-decision similar to the Sugar Board might be one of such policy. Currently, all parties in rice industry; farmers, millers and traders, decide individually or “individual maximization”. The co-decision, which all parties have to optimize the social objectives or “social maximization”, has never been used in this industry. This study tries to compare and analyze the benefits of each participant in two cases; social maximization and individual maximization.

2. Model

Linear programming and Goal Programming methods are employed in the study using data from various sources gathered mostly from 2012 to 2014 by a value chain study. Therefore, in the first part of the model, the brief value chain of Thai rice industry will be introduced, followed by the model for normal situation (individual maximization). Lastly, the model for social maximization or the goal programming will be described.

2.1 Value Chain

Value Chain studies such as Somporn Iswilanonda (2011), Agrifood Consulting International (2005), Ammar Siamwala and Wiroj Na Ranong (1990), depicts Thai rice value chain as shown in Figure 1.

Figure 1 shows that the rice industry begins with the farmers who grow paddies by employing five main factors of production: land, soil, fertilizer, machinery, and seeds. They directly and indirectly sell their paddies to millers by trading through collectors. Millers transform paddy to rice by milling and they then sell it to traders

who supply two markets, the domestic and export markets. Millers can sell to traders directly or via agents called "Yong".

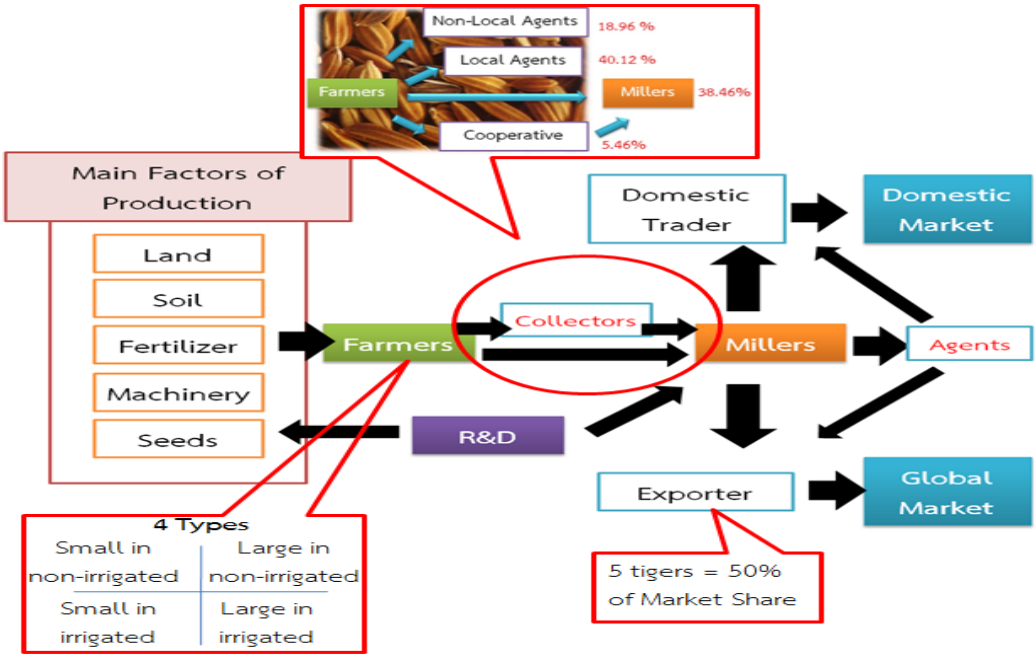

Figure 1 Thai Rice Value Chain

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

Farmers can be separated into four types by their size (small and large) and type of cultivated land (irrigated and non-irrigated land). Small farmers normally obtain a better yield per hectare than large farmers but gain lower benefit as a result of the smaller quantities and the inability to enjoy economies of scale. On irrigated land, farmers can grow off-season rice, which requires more water than seasonal rice. Although the seasonal rice can earn a higher price, it can be grown only one time a year in contrast to off-season rice, which can be harvested for at least two times a year.

For rice trading, more than 60 percent of paddy is traded via collectors. There are three types of collector: local agents, non-local agents and cooperatives. For Yong, there are many companies working in this area. Business and the market are so competitive that the Agents earn only one percent commission on the trade value. Although exporters have a very low margin, with a very high volume, they can obtain a large profit. As a case in point, there are 5 main exporters called "the five tigers". Each "tiger" specializes on a particular regional market and control around 50 percent of Thai export market.

However, it can be seen that this value chain is rather complicated and might not be appropriate for model construction. Therefore, a shorter and clearer value chain model can be adopted. Figure 2 simplifies the value chain to be more convenient and easier to understand. In this figure, the details of the factors of production and types of farmer are included as farmers, and exporter and domestic traders are combined as traders. Both collectors and agents are ignored in the simplified model as they play a minor role and earn only a small margin. In addition, millers are separated into small miller and large millers since they play different roles in the pledging scheme, which will be explained later.

Furthermore, large millers can buy paddy before small millers. The rationale is time and cost saving. It saves time and transportation cost for paddy collectors and large farmers to sell paddy in bulk at one place. Therefore, it can be seen that only 5 percent of paddy are sold via cooperative organizations. In addition, regarding the change in number of millers between 2013 and 2015, the number of small and medium-sized millers decreased while the number of large millers increased. As a result, the players who are mostly impacted most from paddy shortage problems are smaller millers.

Table 2 Number of Millers between 2012 and 2015

	2013	2014	2015	Changes (%)
Total	1,097	1,108	886	-19%
Small	843	847	666	-21%
Medium	196	187	152	-22%
Large	58	74	68	17%

Source: Department of Business Development

Thereby, this study applies the Linear Programming (LP) and Goal Programming (GP) technique for every main player in the Thai rice industry consisting 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 sell it abroad or domestically. According to the Bank of Agriculture and Agricultural Cooperatives and Fiscal Policy Research Institute (BAAC and FPRI) (2013), farmers sell paddies to large millers before small millers. This is because they can save transportation cost as each larger miller can buy larger amounts, compared to the small ones, invariable reduces transportation cost.

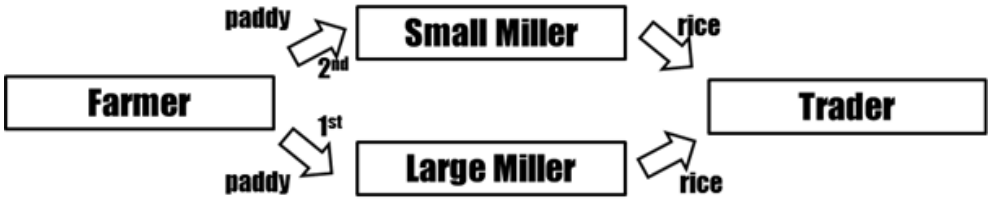

Figure 2 Value Chain of the Thai Rice Industry

2.2 Individual Maximization: Linear Programming Approach

Figure 3 shows the brief value chain of Thai rice industry. In this model, there is only one type of farmer who grows paddy and sells it to two types of miller, large miller and small miller. The large miller is the first buyer who buys paddy from farmers and mills it into rice. The small miller also buys paddy from farmers, transforms the paddy into rice, and sells it to traders. The trader buys rice from both types of miller and sells it in two markets, the domestic and export markets.

All of these players have their own objectives and conditions. This model will construct sub-models for all of the players supposing that the conditions of some players depend on other players' decisions. For example, one of the millers' conditions is the paddy that the farmer produces. Therefore, the steps of the models include the farmer's model, the large miller's model, the small miller's model, and the trader's model. The objectives and the conditions of all players are as follows.

2.2.1 Farmer's Model

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, seasonal and off-season paddy. These two types of paddy have different costs and prices. Therefore, the farmer's objective function can be written as:

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

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 different unit price (c_k^f). Therefore,

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

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 which will be shown later in part 4.2. In addition, to grow different types of rice requires different amounts of each resource.

So, the farmer's condition is subject to

$$\sum_{p=1}^{2} \gamma_{pk}^f Q_{pi}^f \le Z_k \qquad \forall_k$$

Therefore, the farmer's model can be written as

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

By choosing Q_p^f

subject to

$$\sum_{p=1}^{2} \gamma_{pk}^f Q_{pi}^f \leq Z_k \qquad \forall_k$$

2.2.2 Miller's Model

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, such as bran and germ, can be sold as by-products (b_r^m) for extra revenue.

Besides, 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: $\pi_s^m = \sum_{r=1}^{3} (P_{rs}^m - C_{rs}^m) Q_{rs}^m \qquad \forall_s$

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 rice production consists of input (paddy) cost and operation cost. Also, there is extra revenue from by-products. As mentioned above, however, not all paddies become rice and there is a chance of broken rice, so the paddy amount for making one ton of rice "r" is

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

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

$$C_{rs}^{m} = \frac{1}{\delta R} P_{p}^{f} + c_{rs}^{m} - b_{rs}^{m} \qquad \forall_{\mathrm{r}}$$

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"

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

$$Q_{11}^{m} \le \frac{1}{\delta R} Q_{p}^{f}$$

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

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

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

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

and

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

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

$$\sum_{r=1}^{3} Q_{rs}^{m} \le K_{s} \qquad \forall_{\mathrm{s}}$$

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

$$Q_{31}^{m} \le K_B$$

Therefore, the miller's model is

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

By Choosing Q_{rs}^m

Subject to

$$Q_{11}^{m} \le \frac{1}{\delta R} Q_p^f$$

$$Q_{12}^{m} \le \frac{1}{\delta R} Q_p^f - Q_{11}^m$$

$$Q_{21}^{m} + Q_{31}^{m} \le \frac{1}{\delta R} Q_2^f$$

$$Q_{22}^{m} \le \frac{1}{\delta R} Q_2^f - (Q_{21}^m + Q_{31}^m)$$

$$\sum_{r=1}^{3} Q_{rs}^m \le K_s \qquad \forall_s$$

$$Q_{31}^{m} \le K_B$$

2.2.3 Trader's Model

Traders also aim to maximize profit from selling the rice that they bought from millers. Traders buy rice from both small and large millers at the same market price, but they sell it at different prices to domestic and export markets[1]. The traders' profit equation can be written as

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

By Choosing Q_{rjs}^t

Where π^t = Profit of trader

[1] Although Erwadee Premasatian (2014) 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 Mahathanaseth (2014) is more appropriate for this study. Therefore, this study assumes that price is static.

P^t_{rjs} = Price of Rice "r" buying from miller "s" in market "j"

C^t_{jrs} = Cost of Rice "r" selling in market "j" by miller "s"

Q^t_{rjs} = 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" consists of the price of rice bought from millers and the operation cost, the cost of rice "r" in market "j" is

$$C^t_{jr} = (1 + c^t_{jr}) + P^m_r \qquad \forall_r$$

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

$$\sum_{i=1}^{2} Q^t_{jr} \le \sum_{s=1}^{2} Q^m_{rs} \qquad \forall_r$$

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

$$Q^t_{jr} \le X_{jr} \qquad \forall_r \text{ and } \forall_j$$

Then, the trader's model can be written as

$$\text{Max: } \pi^t = \sum_{j=1}^{2} (\sum_{r=1}^{3} (P^t_{rjs} - C^t_{jrs}) Q^t_{rjs})$$

By Choosing Q^t_{rjs}

Subject to

$$\sum_{i=1}^{2} Q^t_{jr} \le \sum_{s=1}^{3} Q^m_{rs} \qquad \forall_r$$

$$Q^t_{1r} \le X_{1r} \qquad \forall_r$$

$$Q^t_{2r} \le X_{2r} \qquad \forall_r$$

2.3 Socials' Maximization: Goal Programming Approach

In section 2.2, the cases of main rice policies implemented in Thailand were studied with the normal Linear Programming (LP) method. In this section, the new alternative policies will be examined with the Goal Programming method.

The main difference between the Linear Programming and the Goal Programming are their objectives. In Linear Programming, the main objective is to maximize individual objective. In Goal programming, the objective is not for individual purpose but for the whole society (or industry). While the LP targets to solve each objective

one by one, the goal programming aims is to solve the multiple objectives simultaneously.

Assuming all parties are prioritized equally, the social profit (the objective of all parties in the rice industry) can be written as

$$\pi^s = \pi^f + \pi_1^m + \pi_2^m + \pi^t$$

Where π^s is the social profit

Recalling the equations in section 2.2; the social objective is to

Max:

$$\pi^s = \sum_{p=1}^{2}(P_p^f - C_p^f)Q_p^f + \sum_{r=1}^{3}(P_{r1}^m - C_{r1}^m)Q_{r1}^m + \sum_{r=1}^{3}(P_{r2}^m - C_{r2}^m)Q_{r2}^m + \sum_{j=1}^{2}(\sum_{r=1}^{3}(P_{rjs}^t - C_{jrs}^t)Q_{rjs}^t)$$

By choosing

$Q_p^f, Q_{r1}^m, Q_{r2}^m$, and Q_{rjs}^t

All parties are still facing the same conditions as in Individuals' Maximization (LP) case. The difference is only that in GP case all conditions are solved simultaneously. Therefore, the conditions are

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

$$Q_{11}^m \le \frac{1}{\delta R}Q_p^f$$

$$Q_{12}^m \le \frac{1}{\delta R}Q_p^f - Q_{11}^m$$

$$Q_{21}^m + Q_{31}^m \le \frac{1}{\delta R}Q_2^f$$

$$Q_{22}^m \le \frac{1}{\delta R}Q_2^f - (Q_{21}^m + Q_{31}^m)$$

$$\sum_{r=1}^{3}Q_{rs}^m \le K_s \qquad \forall_s$$

$$Q_{31}^m \le K_B$$

$$\sum_{i=1}^{2}Q_{jr}^t \le \sum_{s=1}^{3}Q_{rs}^m$$

$$Q_{1r}^{t} \leq X_{1r} \qquad \forall_{r}$$

$$Q_{2r}^{t} \leq X_{2r} \qquad \forall_{r}$$

3. Data

In section 2, the model was introduced. This section will present the data used in the model. This section will begin with the source of data showing how and where the variables come from and the value of them. Then, in the second part, the problems of each type of data will be discussed.

3.1 Source of Data

Because the linear programming and the goal programming method required many types of data, this study collects data from many sources. This part will separate data sources in two types, the source of data for farmers and the source of data for millers and traders. Then, all these sources of data will be summarized in Table 3.

For farmers, BAAC (2013)[2] data is used for cost of land, fertilizer, pesticide, labor, and fuel, and also fertilizer, pesticide and labor required for producing one ton of paddy. The Ministry of Interior (2015) data is used for the cost of normal land and irrigated land. The rice department (2014) provides the data for cost, amount of seed, and also the amount of seed required for producing one ton of paddy. Prang Pakpanich (2012) provides the data for pesticide cost and pesticide used for producing one ton of paddy. The agriculture labor data comes from the Labor Force Survey of the National Statistical Office (NSO). The data from OAE (2014)[3] is used for land area and land used for growing one ton of paddy. UNCTAD (2016) provides data for fertilizer and pesticide import, and OIE provides data for fertilizer production domestically.

For traders and millers, Thai Rice Miller Association (2014) provides data for by-product ratio of the large miller, and the market prices of the unbroken rice and the by-product. Kittipong Chaiwongsa (2013) provides data for the small miller by-product ratio. Thai rice exporter (2014) provides the data for exported price and Department of Interior Trade (DIT) (2014) for domestic price. The Department of Industrial Work (DIW) (2006)[4] computed the different operation costs for small and large miller. Finally, USDA and UNCTAD (2016) provide data for both exported and domestic market size.

3.2 Data Discussion and Problems

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. The last issue is the difference in value for each source of data.

For the time difference issue, most of the data in this study were collected between 2012 and 2013, 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.

[2] BAAC (2013) was an in-depth interview study with more than 50 farmers in 9 regions, Upper-North, Lower-North, Central, Eastern, West, Upper-North East, Lower-North East, Upper South, and Lower South. The question on fertilizer usage relates to the amount of fertilizer used per hectare, which can be converted to yield per hectare and is shown in the table.

[3] OAE defined seasonal rice (paddy) differently from this research. The OAE defined 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 that of the OAE report, and the seasonal amount has to be subtracted from that amount.

[4] DIW (2006) “Industrial Sector Code of Practice for Cleaner Technology”.

Table 3 Sources of Data

Variables	Cost	Resources Used	Availability	Price
Land	Ministry of Interior and BAAC	OAE	OAE	
Seed	Rice Department	Rice Department	Rice Department	
Fertilizer	BAAC	BAAC	OIE and UNCTAD	
Pesticide	BAAC and Pakpanich	BAAC and Pakpanich	UNCTAD	
Labor for Seedling	BAAC and LFS	BAAC	LFS	
Labor for Harvested	BAAC	BAAC	LFS	
Irrigated Land	Ministry of Interior	OAE	OAE	
Fuel	BAAC	BAAC	Energy Department	
Unbroken Rice			Farmer's Model	Thai Rice Miller Association
By-product			The By-product ratio is from Thai Rice Miller Association and Chaiwongsa	Thai Rice Miller Association
Operation cost				DIW
Export Rice			Miller's Model	Thai Rice Exporter Association
Domestic Rice			Miller's Model	DIT
Market Size			USDA and UNCTAD	

Source: collect by the Author

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 or better technology and knowledge. Nevertheless, (1) there is no new innovation for paddy farming and (2) the farmers have already 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 instance, 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, whether it is photosensitive paddy or not. This study has to convert this amount to only photosensitive paddy.

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 more reliable. However, in the case that both sources are reliable, the study will apply the middle value.

4. Results

Comparing the result in Goal Programming (GP) equally weighted with the Linear Programming (LP). The results can be shown for each party as follow.

For the farmers, the GP and LP cases show no difference between the two cases. In both cases, off-season paddy is produced at 23 million tons and season paddy is produced at 20 million tons. These amounts of productions provide the profit for farmers in two cases at 217 billion Thai Baht.

The reason for closely similar result is the scarce resources in two cases, which are unchanged. The farmer still faces the same conditions about scarce land for both normal and irrigated land area. In addition, other variables such as price are also unchanged. With these same circumstances, the farmer decisions and profit are unchanged.

Table 4 Results for the Farmer in LP and GP-Equally Weighted Cases

Unit: Tons of Paddies

	GP	LP
Off-Season Paddy	23,109,243.70	23,109,243.70
Season Paddy	20,270,270.27	20,270,270.27
Profit (million Baht)	217,092.65	217,092.65

Source: Model Calculation

Different from farmers, millers in GP and LP cases decide differently. Since large millers have a power to buy a large amount of paddy in one place most of the farmers go to sell at large millers before the small ones. In LP case, this normal situation is assumed to persist. Therefore, the results are on large miller preference. The large millers decide to produce 10.6 million tons of fragrance rice, which equals to their capacity, and provide the remaining paddies to the small millers. Hence, the small millers decide to produce 12 million tons of white rice and 65 thousand tons of fragrance rice. These decisions cause them to gain profit 35 billion Thai Baht for large millers and 20 million Thai Baht for small millers.

In GP case, the large and small millers have rights to decide together. To maximize the profit of all millers (large and small), the best decision making is to let the more efficient miller decide first. The small millers[5] have more efficiency because they have smaller scale and more time for production elaboration, especially in reduction of broken rice ratio[6]. Thus, the small millers can decide first in GP. However, as previously explained, Thailand is over supplied with small millers, there is no paddy left for large millers. Therefore the decision is the small millers produce 13.8 million tons of fragrance rice and 12 million tons of white rice, while the large millers produce nothing, and the small millers received 111 billion Thai Baht profit.

Table 5 Productions and Profits for Large and Small Millers in GP-Equally Weighted and LP Cases

Unit: Tons of Rice

	GP	LP
Large Millers' Fragrance Rice	0	10,599,078.34
Large Millers' White Rice	0	0
Large Millers' Par-Boiled Rice	0	0
Small Millers' Fragrance Rice	13,837,870.48	65,415.39
Small Millers' White Rice	8,637,886.39	12,137,886.39
Small Millers' Par-Boiled Rice	3,500,000.00	0
Profit of Large Millers (Millions Baht)	0	35,544.01
Profit of Small Millers (Millions Baht)	111,655.59	19,973.62
Profit of All Millers (Millions Baht)	111,655.59	55,517.63

Source: Model Calculation

[5] In this study the small millers represent the small and medium-size millers that have more time to elaborate the rice production, especially for reduction of broken rice ratio. These small millers are different from the very small millers with production capacity at around only one to five ton per day. The study does concern that those very small millers are very inefficient, due to a very high broken rice ratio.

[6] Mr. Adulya Clonebhandhu claimed in "TRF Forum Series 1: Agricultural Cooperation is one of the Solution for Farmer" on 21 December 2016 that his small miller gain a better rate than the large miler. To do so, he has to mill the husk out and rest the milled, but unpolished paddy for more than a day before getting polished the bran out again. This resting process is to reduce the heat from the milled paddy, before being polished. This process can reduce the broken rate. However, 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.

From the decisions of millers, the decisions in LP and GP cases for traders are different. In LP, the exporters will decide to export 2 million tons of fragrance rice and 9 million tons of white rice, while the domestic traders will decide to trade 8.7 million tons of fragrance rice and 2.3 million tons of white rice domestically. These decisions provide the profit of 15.6 billion Thai Baht to exporter and 17.2 billion Thai Baht to domestic trader.

In GP case, the exporters will decide to export 2 million tons of fragrance rice, 5.5 million tons of white rice, and 3.5 million tons of par-boiled rice. The domestic traders will trade only 11 million tons of fragrance rice domestically but trade no white rice in Thailand. The decisions make the profit yield of 15.8 billion Thai Baht for exporters and 17.3 billion Thai Baht for domestic traders.

Table 6 Results for Exporter and Domestic Traders in LP and GP-Equally Weighted Cases

Unit: Tons of Rice

	LP	GP
Fragrance Rice Export	2,000,000	2,000,000
White Rice Export	9,000,000	5,500,000
Par-Boiled Rice Export	0	3,500,000
Fragrance Rice Domestic	8,664,494	11,000,000
White Rice Domestic	2,335,506	0
Profit of Exporter (Million Baht)	15,661.30	15,873.05
Profit of Domestic Trader (Million Baht)	17,200.86	17,311.80

Source: Model Calculation

In conclusion, the profits of all parties are shown in Table 7. It reveals that the profits of farmers are no different between two cases meanwhile the profits for domestic trader and exporter are different only little (one to two hundred million Thai Baht). The big differences are on millers' profit. In LP case, both large and small millers earn profits; however, the large millers gain more. Still in GP case, large miller earns no profit (since there is no production), while the small millers earn much larger profit than in LP case. Thus, the total profits for all parties, which can also be called *the social or industrial profit*, are different. The reason is that the GP case changes the trade pattern from going to large miller, who can buy a large amount of paddies in one time, first to going to small miller, who have more efficiency, first. *The GP case is more preferable in the sense that it yields a higher profit at 356.5 billion Thai Baht, compared to 305.5 billion Thai Baht in LP case*.

Table 7 Profits of All Parties in GP-Equally Weighted and LP Cases

Unit: Million Baht

	LP	GP
Total Profit	305,472.44	361,933.09
Farmer Profit	217,092.65	217,092.65
Large Miller Profit	35,544.01	0
Small Miller Profit	19,973.62	111,655.59
Exporter Profit	15,661.30	15,873.05
Domestic Trader Profit	17,200.86	17,311.80

Source: Model Calculation

5. Discussion and Conclusion

5.1 Discussions

There are many points to be discussed in this case. Firstly, the overall results showing that the GP or "the social maximization" method is more preferable than the LP or "individual maximization" case because the total profits in GP case is higher than the total profit in LP case for 17 percent (356 billion to 305 billion Thai Baht).

The reason based on the data that small millers who have more efficiency in reducing the broken rice ratio have more bargaining power in GP case, but no power in LP case. Therefore, the whole industry enjoys the more efficiency in the system and it reflects the total industrial profit.

In addition, it can be seen that there are more varieties of rice for export market, but less varieties of rice for domestic market in GP case. In GP case, the small millers who earn benefits from par-boiled rice more than white rice have an opportunity to produce rice in place of large miller. Hence, the small miller decides to produce par-boiled rice more than the white rice. This decision makes more par-boiled, but less white rice in the market. With this small amount, white rice is sold to the export market first, so there is no white rice left for the domestic market. Therefore, there is par-boiled rice in export market, but no white rice for domestic market in GP case. On the other hand, there is no par-boiled rice in export market, but white rice in domestic market in LP case. In other words, for variety of rice products in the market, GP case is good for export market (fragrance, white, and par-boiled rice are available), but not good for domestic market (no white rice available) and LP case is good for domestic market (both fragrance and white rice are available), but not good for export market (no par-boiled rice available).

It can be seen that the GP case harms the large miller. Although, the whole society gets benefit from the decision, the large millers lost all profits in the case. This issue can be discussed in many ways. First of all, it is impossible that the large millers will agree on the decision. Secondly, this decision does not take the transportation cost into account. Although, the small miller is more efficient, the large miller can reduce the transaction cost of farmer by selling to only one miller at once instead of many small millers. Therefore, in reality, the decision has to leave some benefit for the large miller.

Finally, both cases provide better results than reality. OAE (2014) shows the amount of seasonal and off-season paddies grown and harvested by the farmers. 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, for the government, it is worth to pursue optimization encouragement policies for farmer.

5.2 Conclusions

In conclusion, it can be seen that the GP case provides a better social benefit than the LP case. In other words, the social's maximization is more preferable than the individual's maximization for Thai rice market. Therefore, the main recommendation for a new policy is to encourage farmers, millers, and traders to cooperate.

However, the GP case is not perfectly superior to the LP case as the large miller loses in social's maximization case. To make the large miller cooperates in the decision, some measures and compensation should be provided. In comparison to impact of LP case, the GP case is better because it does not let the large millers who comparatively inefficient produce rice. Nevertheless, in reality, the large can reduce the transportation cost of farmers by accepting a large amount of paddies per time. This advantage of large miller convinces that the adoption of measures or policies to save transaction cost by getting cooperation of large millers is still necessary.

In addition, there are many small millers who have capacity around one ton of paddy per day yielding a very low rate of unbroken rice. In other words, this type of miller is not efficient. However, with some mistakes, there are many small milling machines sold around the countries. Many farmers, who are not specialized in milling and selling rice, are encouraged to be the small miller. Owing to a lack business skills, knowledge, and efficient machine, some small millers cannot survive in the market. The data from Department of Business Development (2016) shows that there were 843 small millers in 2013, but it reduced to only 666 small millers in 2015.

Therefore, the first recommendation is to encourage or establish the "Rice Board" that consists of all parties in the industry and provide them the equal power. One of the objectives of this Rice Board is to determine the paddy and rice amount production in each stage for the benefit of society. This is also to guarantee the paddy amount for middle size miller.

Secondly, the large miller should provide or sell the business shares to small and middle-size miller. This business sharing will keep many small and middle millers in one place that can reduce the transportation cost which is the weakness of them. Also, it can increase the efficiency of large millers which is also the weakness of them. Alternatively, the large miller can allow the small and middle size miller to rent the sub-factory (land, worker and machine), instead.

Finally, the farmers should own a share in the small or middle size miller business, which have a share or rent from large miller. In this policy, the farmers, who have no benefits or differences from two cases, can receive the extra benefits from the share. For the small and middle size millers, the no-paddy-to-mill problem resulting from farmer's preference to sell to large millers first, can be solved. This policy will encourage the farmers who own a share in the small or middle size miller business to sell paddies to the millers they earn profits. This policy is more appropriate than encouraging farmers to be the millers or businessman that they are not "born to be".

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