

# **EVALUATION OF POLICY PERFORMANCE AND PROFIT EFFICIENCY OF RICE PRODUCTION AND MARKETING AREAS IN TAIWAN**

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## **ABSTRACT**

*Under the requirements of the AMS reduction and competitiveness improvement in the rice sector, the government has been implementing the Rice Production and Marketing Areas (RPMA) program in Taiwan since 2005. It rewarded operation units with price that is higher than the guaranteed price of government through making contact with rice farmers, and to run a business model by integrated value chain. The purposes of this study are to evaluate the policy performance in terms of government expenditure and farmers' income, and estimate profit efficiency of operation unit in the RPMA program. It found that the program of the government's purchasing paddy reduction and expenditure savings has some effects. Farmers' income would be extra increased from participating in the program. Besides, profit efficiency of operation units which participated in the program is also higher compared to than non-RPMA. It revealed that the core strategy for the RPMA program is to enhance rice value-added.*

**Keywords:** rice, price support, profit efficiency, metafrontier model

## **INTRODUCTION**

Rice is the most important industry in the agricultural sector in Taiwan, and it is also an industry that invests the most resources and government expenditures. However, the government purchases rice at a guaranteed price that distorts market mechanism, reduces efficiency of resource allocation, and causes a heavy financial burden on the government. At the same time, it also faces pressure from the WTO to reduce AMS. Therefore, the government started to implement the "Rice Production and Marketing Area" (RPMA) program in 2005, hoping to reduce the government's purchase expenditure and AMS through reward payment for grain merchants to encourage making production contract with rice farmers. The RPMA program is accompanied by the common production operations and marketing activities and it can ensure the quality of domestic rice and establish its own brand. It is expected to benefit to the rice industry in terms of upgrading quality standards and competitiveness.

The purpose of this paper is to evaluate the RPMA program performance in terms of government expenditure, farmer's revenue and profit efficiency of grain merchants, so as to provide a reference basis for rice industry development and policy reforms in Taiwan. The rest of the paper is organized as follows. The next section briefly describes the features and current situation of RPMA. Section 3 evaluates RPMA by rice policy review and its influence on government's purchasing quantity and expenditures and farmers' revenue. Section 4, on the other hand, focuses on profit efficiency estimation and its determinations for grain merchants who participated in the RPMA program. Finally, the last section is the conclusion and outlook for the RPMA program.

## **I. Rice Production and Marketing Area (RPMA)**

### ***1.1 Features***

In order to avoid the impact from importing rice in the domestic rice industry Taiwan has the joined World Trade Organization in 2002 and emphasized domestic rice production with its own brand that symbolizes good quality. The government has been trying to do rice industry adjustment since 2005. The promotion of the RPMA program is one of the adjustment strategies. Government encourages Farmers' Associations and grain merchants as operation unit to coordinate with local rice farmers, nursery operators and millers to establish a RPMA which at least 50 hectares. It is expected to have

advantages in terms of the RPMA's production integration and economic scale.

The most important thing is that operation units have to make contract with participating farmers at higher price compared to the guaranteed price of government purchases. It could raise farmers' income and reduce government purchasing rice and expenditure. On the other hand, operation units can get reward payment from the government to implement the RPMA program to support higher price under contract and related spending on production integration, farmers' education and product marketing.

Although there are multiple meanings for rice farmers, the government, grain merchants and even consumers, the final target of the RPMA program is to enhance competitiveness and value-added for rice industry in Taiwan.

## 1.2 Implementation

The RPMA program has been in operation since 2005. It started with 27 operation units which included Farmers' Associations and grain merchants with 4,908 hectares total, then increasing to 63 operation units with a total of 23,292 hectares as shown in Table 1. Because of affording payment at higher contract price to participating farmers, the number of operation units failed to increase as expected. It still less than 7% in terms of total rice plant hectares. Fortunately, the number of operation units and participating hectares had significantly increased in the past two years.

Table 1. Implementation of the RPMA program during 2005-2017

Year	Participated area	Participated farmers	Reward payment	Contract price	Guaranteed price	Production
Unit	Hectares	People	NTD 10 thousand	NTD/KG	NTD/KG	MT
2005	4,908	2,301	3,873	22.37	19.88	26,863
2006	8,023	2,915	5,626	23.14	19.88	40,490
2007	10,480	4,828	4,854	22.79	19.88	57,582
2008	9,897	6,731	4,513	23.72	19.88	56,994
2009	10,487	4,170	4,859	23.67	21.88	59,881
2010	13,978	4,911	6,653	23.83	21.88	80,299
2011	14,356	5,329	6,838	26.53	21.88	90,913
2012	14,556	4,281	8,676	25.26	24.91	93,698
2013	15,103	4,555	8,465	26.21	24.91	79,471
2014	15,721	4,304	11,335	26.64	24.91	92,797
2015	16,451	5,180	7,159	26.40	24.91	98,943
2016	19,503	7,668	8,601	26.73	24.91	95,547
2017	23,292	12,974	12,778	25.05	24.91	136,049

Source: Agriculture and Food Agency, Council of Agriculture.

Basically, the reward payment provided by the government is a key factor to attract Farmers' Associations and grain merchants to participate in the RPMA program. The correlation coefficient is 0.86 between reward payment and participated hectares. The government could have a balance consideration on the reward payment and purchasing expenditure saving to decide whether to increase reward payment for expansion and exclusion of the participated hectares.

The operation units could be Farmers' Association and grain merchant with different business culture and objectives. There were 21 Farmers' Associations and grain merchants and 42 grain merchants who participated in the RPMA program in 2017. Under the consideration of market size and capital stock, Farmers' Association and grain merchants sell milled rice mainly and partly from what it purchased paddy rice from the RPMA, respectively.

Table 2 indicates that average contract price of Farmers' Association is 27.13 NTD/Kg, which is higher than grain merchants, 25.28 NTD/Kg. It reveals that Farmers' Association has been supporting farmers' income instead of just searching for profit maximization. The average participated area for Farmers' Association is 289 hectares, which is smaller than grain merchants, 413 hectares. It would affect benefit of economic scale. The average scale for each participated farmers' of Farmers' Association is 1.62 hectares, which is lower than grain merchants, 1.86 hectares, as well.

Table 2. Current situation of the RPMA program in 2017

	Number	Participated area		Production		Participated farmers	Reward payment	Contract price	Participated area	Farmers participated a
	Unit	Hectares	%	MT	%	People	NTD thousand	NTD/KG	Unit	Hectares
Farmers' Association	21	6,070	26	36,055	27	3,739	29,010	27.13	289	1.62
Grain Merchant	42	17,337	74	100,660	74	9,342	99,350	25.28	413	1.86
Total	63	23,292	100	136,049	100	12,974	127,780	25.98	370	1.80
North	12	1,362	6	7,571	6	652	13,890	25.27	113	2.09
Central	22	6,299	27	40,397	30	5,576	51,260	23.08	286	1.13
South	8	2,100	9	14,718	11	1,209	7,690	24.46	263	1.74
East	21	13,531	58	73,363	54	5,537	54,940	25.49	644	2.44

Source: Agriculture and Food Agency, Council of Agriculture.

The RPMA program is a kind of contract farming which is based on mutual benefit for farmers and operation units participation. It has been in existence for many years as a means of organizing the commercial agricultural production of both large-scale and small-scale farmers. Eaton and Shepherd (2001) pointed out contract farming is beneficial to farmers' price risk that is often reduced as many contracts specify prices in advance and can open up new markets which would otherwise be unavailable to small farmers. Operation units also gained more consistent quality and quantity which can be obtained than if purchases were made in the open market. There are more than 70% of operation units using brand that is endorsed by the RPMA program to increase rice price and competitiveness (Chen and Yang, 2007).

Since there are different production condition in Taiwan, there is only one crop season in the Northern part that is different from other parts with two crop seasons. Western farmers have been searching for quantity increase, unlike eastern farmers who emphasize quality improvement. Therefore, for regional distribution of participating in the RPMA program, the East part participate most, 58%, and contract price, 25.49 NT/Kg, which is also higher than other parts.

## II. Policy evaluation

### *Rice industry and policy*

Rice is staple food and the most important crop in Taiwan. Harvested area is 273,837 hectares, where first crop is 168,872 hectares and second crop is 104,965 hectares in 2017. Production quantity in terms of paddy rice is 1,587,776 MT.

For ensuring food security and raising farmers' income, government has been implementing policy of purchasing paddy rice at guaranteed price which is higher than market price. The purchasing system is made up of three layers: planned purchase, guidance purchase and surplus purchase with different guaranteed price and quantities. The weighted average guaranteed price is 24.91 NT/Kg, which is higher than farm gate price 23.91 NT/Kg, as shown in Table 3. Government purchased paddy rice for 312,033 MT, which accounted for nearly 20% of total production in 2017.

Theoretically, quantity purchased by government depends on guaranteed price and price difference between guaranteed price and farm gate price. In the past, government raised guaranteed price several times to raise farmers' income. It also stimulated rice plant area and production expansion which resulted in the problem of much purchasing quantity and excess inventory. In 2011, government raised guaranteed price by 3 NT/KG. It brought about significant jumps in purchasing quantity 406,223 MT

and expenditure over 10 billion NTD in 2013.

Although there were many contributions on food security and farmers' income, there have also been many criticisms always on the policy of purchasing paddy rice at guaranteed price, including market mechanism distortion, government financial burden, resources allocation inefficiency and crops production imbalance, etc. However, due to political consideration, it is hard to terminate the policy. The reason for promoting the RPMA program is trying to partially substitute purchasing paddy rice at guaranteed price and solve some related problems.

Table 3. Government paddy purchase price and quantity

Year	Harvested area	Production	Quantity	Expenditure	Purchased price	Farm gate price
	Hectares	MT	MT	NTD thousand	NT/KG	NT/KG
2004	237,015	1,433,610	259,386	5,255,997	19.88	18.70
2005	269,023	1,467,138	207,230	4,232,397	19.88	19.49
2006	263,188	1,558,048	245,414	5,065,428	19.88	18.93
2007	260,116	1,363,458	215,246	4,390,569	19.88	18.38
2008	252,292	1,457,175	204,793	4,584,728	21.88	21.87
2009	254,590	1,578,169	182,452	4,171,559	21.88	22.12
2010	243,862	1,451,011	190,453	4,327,709	21.88	20.77
2011	254,255	1,666,273	345,400	8,678,807	24.91	21.60
2012	260,762	1,700,229	375,438	9,425,589	24.91	23.10
2013	270,165	1,589,564	406,223	10,192,801	24.91	22.17
2014	271,051	1,732,210	367,124	9,218,938	24.91	24.03
2015	251,861	1,581,732	294,686	7,403,341	24.91	23.08
2016	273,837	1,587,776	312,033	7,819,173	24.91	23.91

Source: Agriculture and Food Agency, Council of Agriculture (2017), Taiwan Food Statistics Book.

### Policy evaluation on the RPMA program

Since emphasizing on quantity increase rather than quality improvement under oriented by the policy of purchasing paddy rice at guaranteed price in Taiwan, the government continually promotes a series of rice industry adjustments, which includes the RPMA program. Based on experiences of farmers who participated in the planned purchase and guidance purchase, the estimated reduction of the government's purchasing paddy rice was 46,584 MT with expenditure saving 1.1 billion in 2017 as shown in Table 4. Compared with reward payment 0.12 billion. The government benefitted from a net expenditure savings of about 1 billion NTD.

Besides, farmers' income would be extra increased from contract price, which is higher than government's guaranteed price, by at least 0.1 billion total. For instance, farmers' income increased by 0.145 billion NTD total in 2017; in other words, each farmer's income increased by 11,178 NTD average, or each hectare increased by 6,227 NTD average.

Table 4. Policy benefit of the RPMA program

Year	Participated area	Equivalent of government purchase	Expenditure saving	Reward payment	Increase farmers as the r		
					Total	Per hectare	Per farmer
	Hectare	MT	NTD thousand	NTD thousand	NTD thousand	NTD/Hectare	NTD/Farmer
2005	4,908	9,541	191,539	38,730	66,969	13,644	29,104
2006	8,023	15,597	313,105	56,260	132,040	16,457	45,297
2007	10,480	20,373	408,981	48,540	167,527	15,985	34,701
2008	9,897	19,239	424,695	45,130	219,006	22,129	32,537
2009	10,487	20,387	450,028	48,590	107,039	10,207	25,669
2010	13,978	27,172	599,816	66,530	156,411	11,190	31,849
2011	14,356	28,712	699,792	68,380	423,089	29,470	79,394
2012	14,556	29,112	709,520	86,760	33,027	2,269	7,715
2013	15,103	30,206	736,186	84,650	102,999	6,820	22,612
2014	15,721	31,442	766,324	113,350	160,823	10,230	37,366
2015	16,451	32,901	801,876	71,590	147,330	8,956	28,442
2016	19,503	39,005	950,651	86,010	174,300	8,937	22,731
2017	23,292	46,584	1,135,352	127,780	145,029	6,227	11,178

Note: Experience of participation rate of planned purchase and guidance purchase is 80% and 60%, respectively. Policy requirement on 1<sup>st</sup> crop and 2<sup>nd</sup> crop of planned purchase is 2,000 KG and 1,500 KG, respectively, and on 1<sup>st</sup> crop and 2<sup>nd</sup> crop of guidance purchase is 1,200 KG and 800 KG, respectively,

Source: the author's estimation.

## OPERATION PERFORMANCE EVALUATION

### Considerations of operation units

Participants of the RPMA program are government, farmers, operation units (i.e. Farmers' Association and grain merchants). In the above analysis, the program is beneficial to government's expenditure saving and raising of farmers' income. However, the key factor is operation unit participation. If operation units would improve their efficiency and profit, it is expected that more operation units would participate in the RPMA program in the future.

Contrast to production efficiency estimation used inputs and out data, this paper emphasizes profit efficiency estimation used cost and revenue data, which is consistent with operation units consideration about profit objective.

O'Donnell, Battese and Rao (2008) suggested application of Metafrontier model to estimate profit efficiency of operation units with different scale, area and business culture.

### Model specification

Assume the form of profit function of operation units is random translog. We can build a profit Metafrontier function as follow (Battese et al., 2004; O'Donnell et al., 2008):

$$\ln \pi^* = \beta_0 + \sum_{i=1}^3 \beta_i (\ln w_i^*) + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \beta_{ij} (\ln w_i^*) (\ln w_j^*) + \beta_4 (t) + \beta_5 (t^2) + \sum_{i=1}^3 \beta_{6i} (\ln w_i^*) (t) + v - u$$

Where  $\pi$  is operation unit's standardized profit deflated by milled rice sale price,  $W_1$ ,  $W_2$  and  $W_3$  are

standardized paddy rice purchase price, process cost and salary, respectively.  $\beta$  are parameters. Error term consists of random error ( $v_{it(j)}$ ) and profit inefficiency ( $u_{it(j)}$ ), the former assumed to be normal distribution and the latter is actual profit for the  $i$  operation unit in  $t$  year which might deviate from optimal profit in the group  $j$ ; i.e, it means profit inefficiency. It is assumed that  $v_{it(j)}$  is independent of  $u_{it(j)}$ .

We will estimate profit efficiency step by step. Firstly, application of Stochastic Frontier Analysis (SFA) and Maximum Likelihood Estimation (MLE) to estimate profit efficiency of the  $i$  operation unit in group  $j$ . Secondly, constitute random profit function of each group as follow:

$$\pi_{it(j)} = f(P_{it(j)}^y, w_{it(j)}, t; \beta_{(j)}) e^{v_{it(j)} - u_{it(j)}}$$

Where  $i=1,2,\dots, N_j$ ,  $t=1,2,\dots,T$ , and  $j=1,2,\dots,K$  represent different operation unit, time and group, respectively.

The purposes of random profit function are to estimate profit efficiency of the RPMA or not and its profit efficiency ratio. Thirdly, we then judge estimated profit efficiency difference by Likelihood ratio. If reject null hypothesis, it means there is different profit efficiency in participation of the RPMA program or not. Finally, application of GAUSS software suggested by Battese et al. (2004) incorporate estimated parameters of each group into linear programming (LP) and quadratic programming (QP) to estimate optimal parameter of profit Metafrontier as follow:

$$\pi_{it}^* = f(P_{it}^y, w_{it}, t; \beta^*) \equiv e^{f(P_{it}^y, w_{it})}$$

Where  $\pi_{it}$  is profit on Metafrontier. It represents potential profit for operation unit with optimal resource allocation and as a basis for Metaprofit efficiency and Metaprofit ratio calculation.

## Empirical results

### Profit efficiency

Estimated parameters of operation units in the PRAM, non-PRAM and total are shown in appendix table A1. There are 8-9 estimated parameters are 10% significant, and 1% significant by likelihood ratio testing on total operation units. It means that there is significant difference among operation units. Therefore, it is inappropriate estimation by random profit function and should apply profit meta-frontier model for profit efficiency analysis.

We used LP and QP to estimate parameters in the profit meta-frontier model. Since both results are similarity, hereafter, we will only show empirical results by LP estimation.

Because of operation units purchased paddy rice mostly/partially from contract production under the RPMA program, we can divide them into RPMA and non-RPMA with different production and marketing mode. It is assumed both modes have different profit performance and group profit efficiency frontier. Then, there is a frontier that is an envelope in both groups' profit efficiency frontiers. The Group Profit Efficiency (GPE) is ratio of operation unit's actual profit to optimal profit on their group profit frontier. Table 5 shows that the GPE of operation unit in RPMA and non-RPMA is 0.9100 and 0.7242, respectively. In other words, operation unit used non-RPMA mode with lower profit efficiency. It should do something in both increasing price and lowering cost to shorten the distance to optimal profit.

Table 5. Total and group profit efficiency estimation and testing

Group	GPE	MPE	Testing	MPE/GPE	Testing
RPMA	0.9100	0.8065	RPMA > non-RPMA***	0.8863	RPMA > non-RPMA***
Non-RPMA	0.7242	0.5760		0.7954	
Total	0.8148	0.6913		0.8484	

Note:\*, \*\*, \*\*\* represent 10%、5%、1% significance.

Source: the author's estimation.

Since belonging to different group frontier, both group's GPE cannot directly make comparison. We consider Meta Profit Efficiency (MPE) which is able to incorporate all operation units together. MPE is ratio of operation unit's actual profit to potential profit on profit meta-frontier. The MPE is 0.6913 which means there is 30.87% of profit inefficiency to be improved. On the other hand, the MPE

of operation unit in RPMA and non-RPMA is 0.8065 and 0.5760, respectively. Based on non-parametric Mann-Whitney testing, MPE in RPMA is significantly higher than in non-RPMA. Although contract price and processing cost are higher in RPMA than in non-RPMA, sale price is much higher in RPMA than in non-RPMA. The key factor is how to increase rice value-added. It could be a core strategy for developing the RPMA program in the future.

The MPE/GPE ratio also estimated for operation unit in RPMA and non-RPMA is 0.8863 and 0.7954, respectively. It indicates that Farmers' Association and grain merchant both participating in the RPMA program could significantly improve their profit performance.

### Determinants of profit efficiency

For exploring determinants of profit efficiency, it is supposed to be relevant to number of rice species, brands, channels, and channel types. We specified Tobit regression equation as follow:

$$y_{it} = \alpha_0 + \sum_{k=1}^N \alpha_k x_{it} + \varepsilon_{it}, \quad i = 1, 2, \dots, n$$

Where  $y_{it}$  is a vector of GPE, MPE and GPE/MPE of  $i$  operation unit in  $t$  year,  $x_{it}$  is vector of rice species, brands, channels, and channel types, respectively.  $\alpha_k$  are coefficients of relevant variables.  $\varepsilon_{it} \sim N(0, \sigma^2)$  is error disturbance.

Regression results are shown in Table 6. We learned that variety of rice species, brand concentration and home delivery would enhance GPE of operation unit in the RPMA and non-RPMA program. In addition, variety of rice species and less brands of operation unit would improve its MPE and MPE/GPE. Those channels located in department stores, organic stores, and home delivery has better performance in terms of profit efficiency. We can conclude that the RPMA program not only emphasize business model innovation, but also has to consider rice species, focus branding and choice of channel type in order to achieve the core objective, profit maximization, of operation unit.

Table 6. Results of Tobin regression: determinants of GPE and MPE

	GPE		MPE		MPE/GPE	
	RPMA	Non-RPMA				
Constant	0.8614*** (0.1224)	0.7972*** (0.1910)	0.5361*** (0.1552)		0.6950*** (0.2401)	
Rice species	0.0243** (0.0096)	-0.0024 (0.0393)	0.0612* (0.0320)		0.0295* (0.0160)	
Brands	-0.0163* (0.0092)	-0.0234* (0.0140)	-0.0136* (0.0072)		0.0339 (0.0256)	
Channels	0.0068 (0.0055)	0.0253* (0.0134)	0.0135 (0.0105)		0.0256* (0.0145)	
E-commerce	0.0430 (0.0337)	0.0488 (0.0371)	0.1536 (0.1053)		0.0531 (0.0474)	
Home delivery	0.0156* (0.0085)	0.1177 (0.1071)	0.1183** (0.0497)		-0.0100 (0.0361)	
Department stores & organic stores	-0.0217 (0.0301)	- -	0.0909* (0.0493)		0.0195* (0.0113)	

Note: Number in parenthesis is standard error. Dummy variables for e-commerce, home delivery, department stores & organic stores, respectively. \*, \*\*, \*\*\* represent 10% , 5% , 1% significance.

Source: the author's estimation.

## CONCLUSIONS AND OUTLOOK

Rice industry is the most important industry in Taiwan's agricultural sector. The government has been spending a lot by purchasing rice at guaranteed price, which causes financial burden, market mechanism distortion and resources misallocation. Under requirements of AMS reduction and competitiveness improvement, the government began implementing the Rice Production and Marketing Areas (RPMA) program in 2005. It rewarded operation units to make contact with rice farmers at a higher price than the government's guaranteed price, and to run a business model by integrated value chain. The purposes of this study are to evaluate policy performance in terms of government expenditure and farmers' income, and estimate profit efficiency of operation unit in the RPMA program.

The RPMA program has been in operations since 2005. It started with 27 operation units which included Farmers' Associations and grain merchants and 4,908 hectares total, then increasing to 63 operation units with a total of 23,292 hectares total. Basically, the reward payment provided by the government is a key factor to attract Farmers' Associations and grain merchants to participate in the RPMA program. The correlation coefficient is 0.86 between reward payment and participated hectares. Government could have a balance consideration on reward payment and purchasing expenditure saving to decide whether to increase the reward payment for participated hectares expansion or not.

Regarding the policy evaluation on the RPMA program, it has achieved the objectives of government's purchasing paddy rice reduction. For example, we estimated reduction of government purchasing paddy rice at 46,584 MT and expenditure saving 1.1 billion in 2017. Government benefitted from a net expenditure saving of about 1 billion compared to 0.12 billion from reward payment. Besides, farmers' income would be extra increased from contract price, which is higher than government guaranteed price by at least 0.1 billion total. For instance, farmers' income increased by 0.145 billion NTD total in 2017; in other words, each farmer's income increased by 11,178 NTD average, or each hectare increased by 6,227 NTD average.

Participants of the RPMA program are government, farmers, operation units (i.e. Farmers' Association and grain merchants). As analysis above, the program is beneficial to government's expenditure saving and farmers' income raising. However, the key factor is operation unit participation. If operation units would improve their efficiency and profit, it is expected that more operation units would participate in the RPMA program in the future.

We applied the Metafrontier model to estimate profit efficiency of operation units. Empirical results showed that the GPE of operation unit in RPMA and non-RPMA is 0.9100 and 0.7242, respectively. In other words, operation unit used non-RPMA mode with lower profit efficiency. It should do something in both increasing price and lowering cost to shorten the distance to optimal profit.

In addition, we consider Meta Profit Efficiency (MPE) which is able to incorporate all operation units together. MPE is ratio of operation unit's actual profit to potential profit on profit meta-frontier. The MPE is 0.6913 which means there is 30.87% of profit inefficiency to be improved. On the other hand, the MPE of operation unit in RPMA and non-RPMA is 0.8065 and 0.5760, respectively. Based on non-parametric Mann-Whitney testing, MPE in RPMA is significantly higher than in non-RPMA. Although contract price and processing cost are higher in RPMA than in non-RPMA, sale price is much higher in RPMA than in non-RPMA. The key factor is how to increase rice value-added. It could be a core strategy for developing the RPMA program in the future.

This paper made regression on profit inefficiency, it showed that variety of rice species, brand concentration and home delivery would enhance GPE of operation unit in the RPMA and non-RPMA program. Those channels located in department stores, organic stores, and home delivery have better performance in terms of profit efficiency. We can conclude that the RPMA program not only emphasize business model innovation, but also has to consider rice species, focus branding and choice of channel type in order to achieve the core objective, profit maximization, of operation unit.

The RPMA program has been running for 14 years in Taiwan. Participation of grain merchants, farmers, and areas has constantly grown. However, participated area is only 8.5% of rice plant area. Since the program has effects of government purchasing paddy rice reduction, government expenditure saving and farmers' income raise, government should actively encourage more grain merchants to participate in the program. Grain merchants will also improve its profit efficiency, build its own brand and have a better business performance after participating the program. We can say the RPMA program is a win-win-win program which is beneficial to government, farmers and grain merchants. Furthermore, products under the RPMA should be required by Taiwan Good Aquaculture Practice (TGPA), which ensures rice quality and safety. Actually, the RPMA program is also good for



consumers.

From this year, the Taiwan government started implementing rice direct payment program, which is an alternative to government purchasing paddy at guaranteed price for farmers. This is if more rice farmers decide to take direct payment instead of selling to government at guaranteed price. The influence of government purchasing paddy at guaranteed price on purchased quantity and expenditure will decrease. We can expect that rice industry would move towards high quality and value-added development.

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## APPENDIX

Table A1. Estimation results of parameters and its standard error

Variables	Random Frontier Model			Joint Frontier Model	
	PRAM	Non-PRAM	Total	LP	QP
Constant	6.0732* (3.3944)	23.8684*** (8.2383)	18.2067* (10.6602)	10.5827* (5.1192)	15.0356* (8.6672)
$\ln w_1^*$	-3.9960* (2.0770)	-15.5183*** (2.6341)	-12.6414* (7.1014)	0.7391 (0.5113)	-4.0193* (2.2774)
$\ln w_2^*$	2.3520** (1.0878)	18.4683*** (7.1364)	7.8930** (3.1025)	2.3288** (1.1497)	5.9905* (3.3943)
$\ln w_3^*$	-2.5534 (6.0026)	-1.2243 (8.7925)	-3.2902 (6.9321)	6.6035 (5.9991)	2.6947 (4.8674)
$(\ln w_1^*)^2$	-4.3156* (2.4914)	-50.8708*** (8.8913)	4.5998* (2.7149)	-1.3954* (0.8115)	-3.9270** (1.7541)
$(\ln w_2^*)^2$	2.3968** (1.0691)	6.3253** (2.7292)	2.2823** (0.9654)	0.4937* (0.2791)	0.9724 (3.0326)
$(\ln w_3^*)^2$	-2.6917* (1.4433)	-11.3352** (5.0395)	1.3868 (3.4017)	-0.5122 (3.8863)	2.4104 (2.6092)
$(\ln w_1^*)(\ln w_2^*)$	2.2731** (1.0511)	6.1642** (3.0637)	3.6531*** (1.1958)	-0.3429 (5.4944)	-0.7123 (4.0355)
$(\ln w_1^*)(\ln w_3^*)$	-1.2161 (2.8282)	0.8242 (8.5154)	-2.4031* (1.2807)	8.5485** (4.1708)	7.6072*** (1.7314)
$(\ln w_2^*)(\ln w_3^*)$	-0.5740 (1.8030)	-1.0751* (0.6041)	-1.5023 (2.0630)	0.4579 (3.7980)	0.7269 (4.5771)
t	0.3143 (1.7016)	-0.3377 (1.1756)	0.3459 (1.5068)	0.4358 (2.7876)	0.5230 (5.1850)
t <sup>2</sup>	-0.1451 (0.5848)	0.1405 (0.3699)	-0.0732 (0.5046)	0.0812 (0.5087)	-0.1894* (0.1117)
$(\ln w_1^*)t$	-1.0316* (0.5896)	-1.4313** (0.7006)	-1.0605** (0.4498)	-1.1528** (0.5549)	-1.2450** (0.4600)
$(\ln w_2^*)t$	0.0910* (0.0510)	0.4081** (0.2057)	0.2063* (0.1035)	0.4002* (0.2417)	0.7604** (0.3631)
$(\ln w_3^*)t$	-0.2523 (0.6719)	0.0933 (0.5558)	-0.0397 (0.5476)	0.0746 (0.7831)	-0.1342 (1.1355)
Likelihood ratio	-104.987	-82.337	-224.119		

Note: number in parenthesis is standard error, and \*, \*\*, \*\*\* represent 10%、5%、1% significance. Standard errors in LP and QP are estimated by Booth-strapping method.

Source: the author's estimation.

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