ESSAYS ON THE ECONOMICS OF THAI RICE POLICIES

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ABSTRACT

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Recent debate among Thai policymakers has focused on trade-offs between two rice policies, the price support program (PSP) and the deficiency payment program (DPP). The PSP is currently operating but has been criticized for large budgetary costs, corruption in implementation, and unequal distribution of program benefits. To inform this debate, this dissertation provides quantitative measures of the trade-offs between these programs, and the ranking of farmers' preferences towards them. In addition, the relationship between program participation, production technology choice, and levels of technical efficiency are also investigated.

The first essay in this dissertation investigates welfare impacts of PSP and DPP measured in terms of changes in producer surplus, consumer surplus, and deadweight loss by applying a partial equilibrium model to calculate counterfactual market prices and quantities. The 2005/06 cropping season is used as a base for the calculations because of data availability. The results indicate that DPP is more efficient than PSP because the program results in a larger percentage increase in producer surplus and smaller deadweight loss generated for a given amount of Government spending. The increase in producer surplus and the deadweight loss are estimated to be93-97% and less than 1%, respectively under DPP compared to 28-51% and 11-14% under PSP. Consumers, especially domestic consumers, are much worse off under PSP as their surplus shrinks considerably, while it increases under DPP.

The second essay investigates the preference ranking of a representative rice farmer in Thailand towards PSP and DPP using stochastic efficiency with respect to a function (SERF). SERF ranks the farmer preferences based on the certainty equivalent (CE) values associated with the stochastic profits under each policy scenario. Profit is stochastic because of yield variability, price volatility, and the risk of delayed payments under PSP. The preference ranking by SERF indicates that a risk-averse farmer clearly prefers DPP to PSP when support and target prices are much higher than the market price. However, the farmer is largely indifferent between the two programs when the price differential is small. In addition, it is shown that the farmer is better off under PSP compared to a no intervention scenario, even if their choice is to not participate, because of increases in the market price brought by the program.

The third essay investigates production technologies and levels of technical efficiency among program participants and non-participants of the PSP, as well as key determinants of farmers' decisions to participate in the program. The participation decision is included in the model to account for possible selection bias in estimating stochastic production frontiers and technical inefficiency levels. Results indicate that key factors in the participation decision include land size and the financial position of the farm. Results also show there is no strong evidence to support the presence of selectivity bias in the stochastic frontier estimates. In addition, a likelihood-ratio test indicates that participants and non-participants use the same frontier production technology. However, the analysis of technical efficiency reveals that participants are more technically efficient than non-participants. The findings therefore suggest that larger farmers participate more in the PSP and that these program participants tend to be more technically efficient farmers, although the analysis was not able to determine the direction of causality for this association.

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KEY TO ABBREVIATIONS

AC	Additional costs of program participation under PSP
AR	Autoregressive model
BAAC	Bank of Agriculture and Agricultural Cooperatives
CE	Certainty equivalent
CS	Total consumer surplus
CS_D	Domestic consumer surplus
CS_F	Foreign consumer surplus
DIT	Department of Internal Trade
DPP	Deficiency payment program
DWL	Deadweight loss
EXPS	Operating expenses under PSP
FAO	Food and Agriculture Organization
FMO	Farmer Market Organization
FSD	First-degree stochastic dominance
LOAN	Total BAAC loans issued to farmers under PSP
OAE	Office of Agricultural Economics
PSP	Price support program
PS	Producer surplus
PMT	Total deficiency payments
PWO	Public Warehouse Organization
PE	Loss in production efficiency

RD	Loan repayments/redemption of pledged rice
$SALE_P$	Sales of non-redeemed rice in paddy-rice-equivalent value
$SALE_M$	Sales of non-redeemed rice (milled rice)
$SALE_B$	Sales of rice byproduct
SDRF	Stochastic dominance with respect to a function
SERF	Stochastic efficiency with respect to a function
SFM	Stochastic frontier model
SSD	Second-degree stochastic dominance
TS	Loss in trade surplus
TE	Technical efficiency
USDA	United States Department of Agriculture
VAR	Vector autoregressive model

CHAPTER 1: A COMPARISON OF THE WELFARE IMPACTS OF THAI RICE PRICE SUPPORT AND DEFICIENCY PAYMENT PROGRAMS

1.1 Introduction

Rice is the most important sector in Thai agriculture in terms of area planted and number of farm households and Government policy has played a significant role in influencing rice prices and farmer returns. During the 1970s and 1980san export tax was applied to keep domestic prices low in an environment of rising food prices as the economy was thriving. However, manufacturing and other sectors eventually surpassed rice and other agricultural products in terms of export revenue share, and rising food prices became less of an issue. So the orientation of rice policy changed towards stabilizing farm incomes through a price-support program. Government involvement in the price-support program has increased significantly since 2000 due at least in part to the intensity of political competition for farmer votes. Two main policies emerged as a result, namely the price support program (PSP) and deficiency payments program (DPP). Debates among policymakers and politicians about PSP and DPP are centered on the questions of which program is most “suitable” in the current rice market environment, and which has the most exposure in terms of Government expenditure.

Under the PSP, farmers are allowed to sell their paddy rice to the Government at the support price, which is administratively determined. Then farmers are given four months to redeem the pledged paddy (pay the Government back), otherwise they have to deliver the paddy to the Government. Unlike PSP, DPP requires the Government to make deficiency payments to farmers when the market price falls below a specified target price. The Government does not buy rice under DPP. The deficiency payment amount equals the product of a provincial fixed yield and the difference between the target price and the *estimated* market price. Thus, the DPP program payments depend on how much land farmers have in rice production, and the Government's estimates of yield and market price. Critics argue that the Government not only has to bear the high costs running the PSP, but that it also creates market distortions throughout the rice supply chain. Furthermore, most program benefits are likely to accrue to large-sized farms and wealthy farmers due to the nature of program participation. Due to these differences in program attributes and operations, it would be valuable to compare the impacts of both programs on the Thai rice market, rice farmers, and Government expenditures.

One approach to assessing the economic impacts of PSP and DPP is to use aggregate-level data on prices and quantity, together with estimated elasticities of supply and demand, to calculate the changes in producer surplus (PS), consumer surplus (CS), Government expenditure, and deadweight loss (DWL) associated with each program. Poapongsakorn and Charupong (2010) have provided estimates of these welfare components under PSP for the 2005/06 cropping season. They noted that only 624,428 farm households participated in the program. According to their study, the estimates of the changes in CS and PS respectively range from -11,106 to -19,871 and 12,514 to 22,391 million baht. The DWL less sales of Government stocks of rice was estimated between 16,609 and 17,720 million baht. Although, the results from their study suggest that the PSP is very costly and inefficient in term of the distribution of program benefits, no comparison between the PSP and other alternative policies has been made. In addition, their results are limited in that no distinction is made between white rice, jasmine rice, and glutinous rice. Failure to disaggregate results by rice type could affect the welfare results since jasmine and glutinous rice represent a significant portion of rice production in the country.

The objective of this study is to compare welfare impacts under PSP and DPP by applying a computational model to calculate counterfactual values of quantity and price that would have been observed had the former been replaced by the latter. The 2005/06 cropping season is used as a base for the calculation as the information on revenue and cost of the PSP is available in this period, and it was a typical year for rice production. In addition, the weighted-average values of price and quantity from all three types of rice are used in the calculation in order to improve accuracy.

1.2 Background on the Thai rice economy

This section provides a brief background of Thai rice economy including its production, marketing, and policy interventions. First we discuss the production environment of major rice varieties grown in different geographical locations across the country, and the importance of the rice sector in the overall economy. Next we discuss the rice market system in Thailand. Then we conclude by giving a historical background of major Government interventions in the rice market.

1.2.1 Rice production in Thailand

Rice production in Thailand used to be mainly for household consumption and a small marketable surplus but many farmers nowadays have become more commercialized. For instance, 90% of harvested crop was sold in the market in 2000, while the share was only 60% in 1980 (Shigetomi, 2009). Thailand currently produces approximately 30 million tons of paddy rice each year. Nearly half of total production is used for domestic consumption and the rest is exported or kept in stock. Although Thailand's rice production represents only a small portion of total world production (4.45% in 2011), the country had been the world's top rice exporter for almost three decades (30% of exports in 2011). However, Vietnam surpassed Thailand in exports in 2012 due to a large amount of unsold stock held by the Thai Government. Interestingly, the Thai ending stock in 2014 is projected to be around 14.11 million tons (milled basis) which can feed the country for at least 15 months, while the world average stock is less than 3 months (USDA and author's calculation).

Rice exports have lost their dominance in the share of total export value in Thailand; it accounted for only 2% of the Thai gross domestic product in 2011, down from 6% in 1980. The share of rice was only 3% of total exports in 2011, a considerable decline from 15% in 1980 (Shigetomi, 2009). Despite the declining importance of rice in terms of the macro economy, a considerable percentage of the population still engages in rice cultivation. In 2003, agricultural labor for wet-season rice production accounted for more than 40% of the total labor force, and nearly 70% of farm households were engaged in paddy cultivation. In term of land use, as much as 60% of total cultivated area was used for rice production in 2001-2007.

Rice farming in Thailand is comprised of mostly small-scale farmers (total of 3.7 million farm households) with an average landholding of 3.7 hectares per farm household and a family size of about 4 persons per household (Office of Agricultural Economics, Thailand Ministry of Agriculture and Cooperatives). Rice is grown throughout the country. The Northeastern part of the country has the largest share of area planted and production. Since the region is located in a plateau, its rice production relies on rainfall which allows only one crop per year. Household rice production in the region is mostly for food self-sufficiency with a small surplus which can be sold in the market. In contrast, rice farms in the Central Plain and Lower Northern parts tend to be large scale commercial operations. Only 23.9% of cultivated areas are irrigated, most of which are in the Central Plain and Lower Northern part of the country. In fact, only 5% of agricultural lands in the Northeastern part of the country are irrigated, yet its planted area and number of farm households are the largest in the country.

The share of consumer expenditure on rice has been decreasing. According to Isvilanonda and Kongrith (2008) the average per capita rice consumption of Thai households is 101 kg which is two-third of what was consumed in the 1980s.

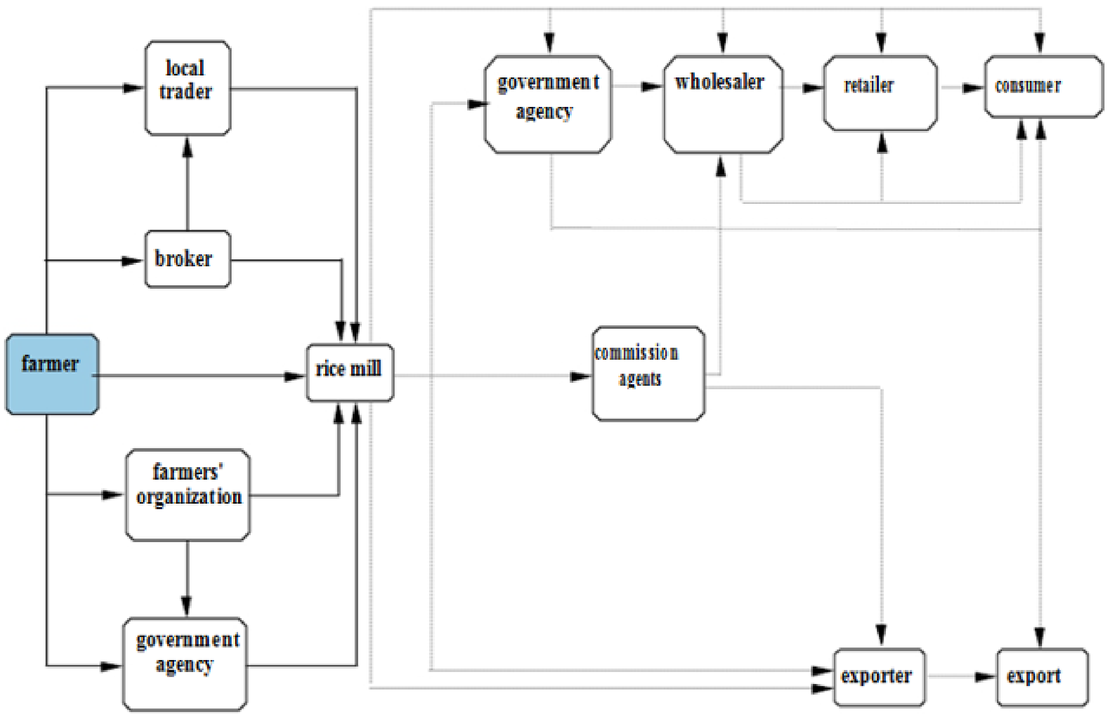
In Thailand, farmers used to produce only two crops: wet-season (June to August) and dry-season (January to May) crop. But farmers in well-irrigated areas now are able to grow a second dry-season crop. The main variety used to be those which take 120 days until harvest. Farmers now prefer the short maturity date variety of 90 days, especially following the implementation of the PSP (Poapongsakorn, 2010). The wet-season paddy is cultivated from June to August, and harvested during October to January. The dry-season paddy used to start from February and end in April, and there was no rice cultivation from September to December due to the high water level during the rainy season, an unfavorable condition for the dry-season variety. However, thanks to the introduction of pumps and drainage facilities, farmers now can lower the water level enough to grow rice during this time period which becomes the first dry-season paddy. The second dry-season paddy is cultivated from January to April. This means many farmers can now grow rice all year long (Shigetomi, 2009).

Since farmers usually bring paddy to market immediately after harvest, the larger supply of paddy causes low paddy market price in December. There are two reasons that explain why farmers rush to sell their paddy. First, most farmers borrow money to purchase inputs so they need to pay off such debt as well as other debts. Second, the lack of storage facilities makes it impossible to delay sales of paddy later in the season when the market price rises. Paddy is brought to market in around December, during which the sales price of paddy is the cheapest. Then the price gradually increases until April as there is high demand from the international market, while production is less. The price falls again when the paddy from the dry season is brought to market around July. However, the price of dry-season paddy is usually lower than that of the wet season, because the production of the former is lower. The price increases sharply in August due to limited supply (Poapongsakorn, 2010).

1.2.2 Rice marketing chain in Thailand

The marketing chain for rice in Thailand comprises of two levels, namely, the paddy market and the milled rice market as shown in **Figure 1.1**

Figure 1.1: Rice marketing system in Thailand



Source: Wiboonponse and Chaovanapoonphol (2001)

Paddy traders collect paddy from farmers and sell to millers or the central market. They usually own barns for keeping paddy and trucks to arrange transportation. The majority of farmers do not have trucks so that they have to depend on the traders to transport the paddy to the market. This is especially true in remote areas. These traders play an important role in the Lower Northern and Central region where the highest volume of paddy is produced. They sometimes provide credit and farm inputs to farmers at the beginning of the planting season. Repayment of their loans can be made either with paddy or in cash with an interest rate which is normally higher than those charged by formal lending institutions. Some farmers organize into farmer groups or cooperatives, with the purpose of cooperating and supporting members' production and marketing needs, such as financial transactions, purchase and transportation, buying equipment, and building rice barns. The difference between these organizations is that the former sell paddy to millers while the latter often deliver paddy to bigger agricultural cooperatives with a milling house. Some cooperatives are capable of milling and marketing rice.

Central markets are both established by Government agencies, such as the Bank of Agriculture and Agricultural Cooperatives (BAAC), or the business sector, and located primarily in main production areas. The BAAC, through the Farmer Market Organization (FMO) and the Public Warehouse Organization (PWO), provides facilities such as weighing machines, drying lawns, and warehouses under the PSP. Private marketplaces are used as a meeting place for farmers, paddy traders, and millers to negotiate and make transactions. Millers play a role in both production and marketing. As a production unit, millers turn paddy into milled rice. As a marketing unit, millers purchase paddy from farmers, paddy traders, and the central market before distributing milled rice to consumers, brokers, wholesalers, retailers, and Government agencies. Brokers connect millers to wholesalers or millers to exporters by searching for rice with certain quantity and quality as demanded by exporters. In fact, most millers market rice to wholesalers and exporters through brokers (Maneechansook, 2011). Export of Thai rice is conducted in two forms; Private to Private sales and Government to Government sales.

1.2.3 Government intervention in the rice market

Prior to the 1980s, the Thai Government had targeted rice price intervention policy to assist domestic consumers through several measures that effectively lowered the domestic price. This policy was perceived as a way to support the growth of the industrial sector which was very labor intensive. Among these policies, the most effective device for pushing down price was the rice premium (1954-1986), under which exporters were required to pay a premium in order to get an export license. Until the 1970s, the rice premium accounted for 20-30% of the export price in Bangkok (Shigetomi, 2009). Other frequently applied programs include the rice reserve requirement (1960-1985) and export tax (1952-1985). The former required rice exporters to sell a certain amount of rice export volume to the Government at an officially fixed price which was usually lower than the market price (Maneechansook, 2011). The latter was an ad valorem tax levied on rice exports. However, these programs were abolished by the mid-1980s when the Government changed its rice price intervention goals from consumer assistance to producer assistance.

The PSP was first introduced in 1982 but it was not until 2001 that it was implemented at the national level. The Thai Rak Thai party, founded by former Prime-Minister Thaksin Shinawattra, had won a landslide general election in 2001 and changed the face of the PSP in several important respects. New features included increasing the target quantity purchased by the Government from 2.5 million tons to 8.7 million tons; allowing farmers to receive loans worth up to 100% of the paddy value with a maximum payment of 350,000 Baht per household, and raising the support price 30 percent above the market price. The 2006 military coup, followed by the ban of the Thai Rak Thai Party by the Constitutional Court of Thailand due to violations of electoral laws during the 2006 legislative elections, put the Democrat Party back in power after almost a ten year hiatus. The Democrats repealed the PSP and replaced it with the DPP, which lasted from 2009 to 2011 before the PSP was brought back after the “new” Thai Rak Thai Party had won a general election in 2011.

The PSP is currently operational and has been a stalwart of Thai farm policy since 2001, except for 2009-2011 when the DPP was used. The objective has clearly been to increase farm income. As a result, the program has been criticized for its populist agenda aimed at gaining political support from the poor, particularly rice farmers, and for its large economic and budget costs. By observing current market price and the support price, farmers choose whether to sell their product in the market or to the Government. In the latter case, the Government assigns BAAC to lend farmers money equivalent to the value of the pledged paddy times the support price. The paddy serves as collateral and can be redeemed within 4-6 months at the net rate of interest of 3% per annum; the Government has to subsidize 5% interest to the BAAC to make up for the total loan rate of 8% per annum. Farmers with barns or storages also earn additional income from storage fees from the Government. For those lacking storage facilities, pledged paddy are either kept at Government-authorized mills or at public storage facilities organized by the FMO and the PWO. The Government pays storage fee as well as milling fee to these millers Poapongsakorn and Charupong (2010).

The DPP was first implemented in 2009. The objective was to stabilize farm income without severely distorting the market. Unlike the PSP, farmers do not have an option to sell to the Government. The Government sets a target price calculated in a way that yields farmers a guaranteed profit equivalent to 40% of production costs after accounting for transportation cost. The Government uses the estimate of market price, which is calculated based on the net market value of milled rice and the average of seven-day historical prices, to determine whether the market price exceeds the target price. Then the difference between the target price and the estimated market price establishes the per unit deficiency payment for participants. Total payment is a product of the per unit deficiency payment and the quantity produced under the program. The latter is calculated as the total planted areas multiplied by average provincial yield. This means farmers earn revenue primarily from market sales sometimes supplemented by deficiency payments.

The large increases in support prices since 2001 not only resulted in a large subsidy to farmers at taxpayer expense, but also created rent-seeking activities by agents throughout the rice supply chain, including rice millers and exporters. Farmers receive an interest subsidy as well as the difference between the support price and the market price. It is also argued that wealthy farmers have captured more benefits from the program than poor farmers since their production is larger and located in irrigated areas where crops can be planted more than twice a year. Rice millers receive milling fees and do not need to borrow money to procure paddy, since the Government does it for them. Exporters receive storage fees, as well as the difference between the export price and the successful bidding price offered for Government rice. Poapongsakorn and Charupong (2010) argued that the rents captured by the exporters came from collusive bidding since the bidding prices from all bidders were unrealistically low and the winner of the big lots always comes from the same group.

1.3 Model Analysis

In this section we develop a graphical analysis which conceptualizes the impact of both PSP and DPP on economic welfare, including producer and consumer surpluses and deadweight loss. The magnitude of the impacts is determined by the changes in price and quantity which are depicted through a shift in demand and supply curves.

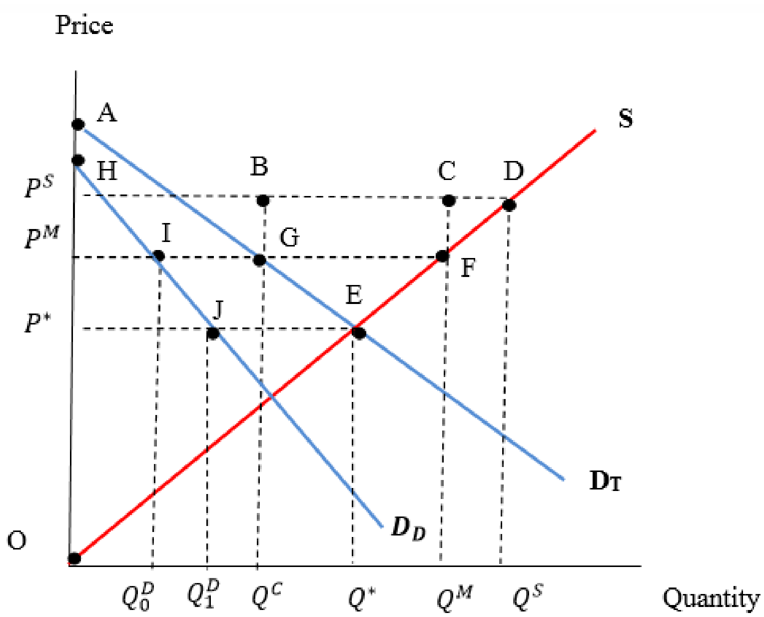
1.3.1 Welfare impact under a price support program (PSP)

Since Thailand is a major rice exporter, a change in the domestic price of Thai rice is assumed transmitted to the world market and vice-versa. In **Figure 1.2**, prior to implementation of the PSP, a market equilibrium is represented by the intersection of total demand (D_T) and total supply (S) at point E, for which corresponding equilibrium quantity and price are (Q^*, P^*). The total demand (D_T) is an aggregate sum of domestic demand (represented by D_D) and foreign demand (not shown in the figure). Domestic consumption is Q_1^D. The amount exported is the difference between total supply and the amount consumed domestically (Q^*-Q_1^D). Total consumer surplus, which combines the consumer surpluses from both domestic and foreign consumers, is represented by the area AEP^*; the consumer surplus of domestic consumers is represented by the area HJP^* while that of foreign consumers is represented by the area $AEJH$. Producer surplus is represented by the area P^*EO.

When the Government implements the PSP and sets a support price (P^S) at a level that is higher than the equlibirum market price (P^*), the support price will effectively become the market price. In other words, not only the Government but also other buyers in the market will have to buy from farmers at a price equal to the support price. As a result, the market equlibirum will shift from point E to D.The corresponding quantity and price at the new equilibrium are (Q^S, P^S). In case of Thai rice market, however,farmers incur additional costs when participating in the

PSP. These costs include transportation costs for delivering rice to Government depots and transaction costs associated with delayed payment of loans. Assuming that these costs are such that farmers are indifferent between participating and not participatingin the program, this causes the observed market price to be below the support price. In **Figure 1.2**, the effective price for non-participants is simply the market price observed, which is equal to P^M. The effective price for the program participants is the support price less the additional costs, which is also equal to the market price P^M. It is important to note that this effective market price is observed after the Government has released some rice stock into the world market. This means the effective market price would have been higher than P^M (but smaller than P^S) had the Government stored all of the pledged rice. Thus, an impact of the PSP on economic welfare is a net impact of both Government purchase sand sales.

Figure 1.2: Impacts of the price support program (PSP)



At the market price P^M, total output increases to Q^M. Total consumption is Q^Cwhile the Government has net purchases of $(Q^M\text{-}Q^C)$. Domestic consumption is then Q_0^D.Private exports are $(Q^C\text{-}Q_0^D)$ denoted as $Q_0^{Ex,Prv}$ (not shown in the figure) while the Government exports $Q_0^{Ex,Gov}$(not shown). Thus, total exports are $Q_0^{Ex,Prv}$+$Q_0^{Ex,Gov}$ denoted by Q_0^{Ex}(not shown). Total amount of program loans *(LOAN)* are represented by the area BCQ^MQ^C. These loans are issued to farmers by BAAC when the farmers sell rice to the Government. Producer surplus has increased from P^*EO to P^MFO after the implementation of the PSP. Thus, the change in total producer surplus (ΔPS) is equal to the areaP^MFEP^*. Total consumer surplus has decreased from $AEP^*$to AGP^M. Hence, the change in total consumer surplus (ΔCS_T) is equal to the areaP^MGEP^*, which can be further decomposed into the change in domestic consumer surplus (ΔCS_D) represented by the area P^MIJP^* and the change in foreign consumer surplus represented by the area *IGEJ*.

The additional costs of program participation *(AC)* are represented by the area *BCFG*. While some part of the additional cost can be considered a transfer to other sectors, such as transportation and banking services, a portion could also be considered deadweight loss. However, it is not possible to determine these portions so the conservative assumption is made that there is no deadweight loss (all of the costs involve transfer only). Deadweight loss (*DWL*) from the PSP is therefore calculated by subtracting total program loans by the sum of the additional cost of program participation, the Government revenues from the redemption of pledged paddy rice (*RD*), the Government revenue from sales of non-redeemed paddy rice ($SALE_P$), and the net change in producer and consumer surplus (ΔPS+ΔCS_T). *RD* includes loan principal and interest charged. $SALE_P$ includes sales of milled rice ($SALE_M$) and its byproducts ($SALE_B$) less operating expenses (*EXP*). Formulas for calculating the economic welfare impacts under PSP are summarized in **Table 1.1.**

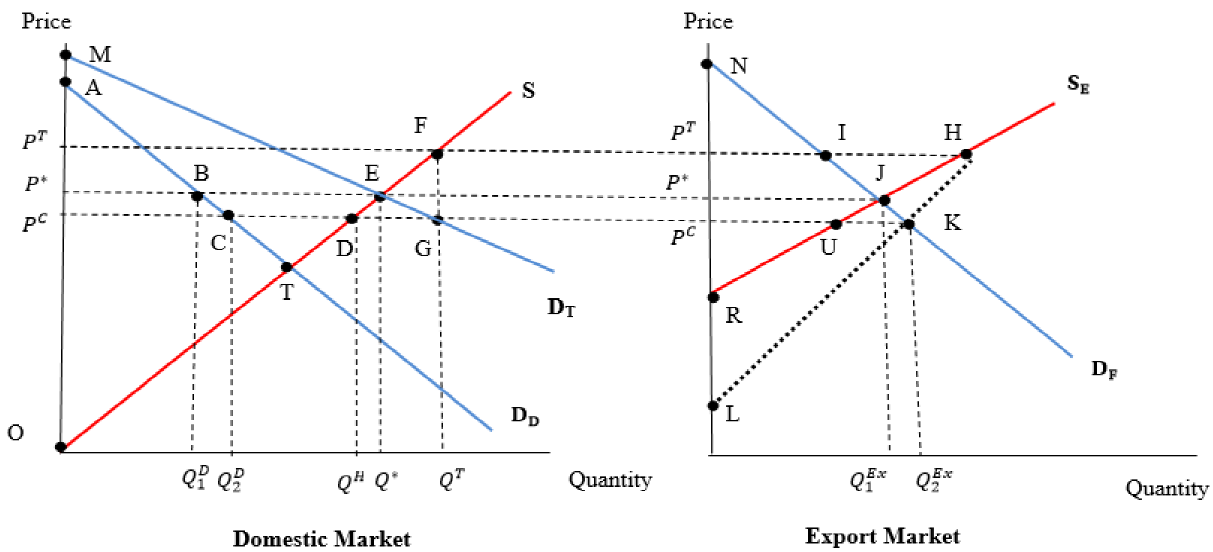
Table 1.1: Calculation of PSP impacts

Welfare Impact	Notation	Formula	Representation in Figure 1.3
BAAC loans issued to farmers	LOAN	$P^S(Q^M - Q^C)$	BCQ^MQ^C
Change in producer surplus	ΔPS	$0.5(P^M - P^*)(Q^M + Q^*)$	P^MFEP^*
Change in total consumer surplus	ΔCS_T	$0.5(P^* - P^M)(Q^C + Q^*)$	P^MGEP^*
Change in domestic consumer surplus	ΔCS_D	$0.5(P^* - P^M)(Q_1^D + Q_2^D)$	P^MIJP^*
Change in foreign consumer surplus	ΔCS_F	$\Delta CS_T - \Delta CS_D$	IGEJ
Costs of program participation	AC	$(P^S - P^M)(Q^M - Q^C)$	BCFG
Deadweight loss	DWL	$LOAN - (AC + RD + SALE_P)$ $-(\Delta PS + \Delta CS_T)$	Not shown

1.3.2 Welfare impact under a deficiency payment program (DPP)

This study uses a modified version of the analytical framework proposed by Schmitz and Chambers (1986) to analyze the welfare implications resulting from a deficiency payment program (DPP). The impacts of the DPP on aggregate welfare in the domestic and export markets are illustrated in the left and right panel of **Figure 1.3,** respectively.

Figure 1.3: Impacts of the deficiency payment program (DPP)



Prior to an implementation of the DPP, an equilibrium in the world market is at point *J* defined by the intersection of excess demand (D_F) and excess supply(S_E) curves as shown on the right panel. The corresponding price is P^*, which in turn constitutes an equilibrium in the domestic market at which quantity $Q^*$is produced, quantity $Q_1^D$is consumed domestically, and quantity $Q_1^{EX}$is exported (Q_1^{Ex} = Q^* -Q_1^D). Total consumer surplus, which combines the consumer surpluses of both domestic and foreign consumers, is represented by the area MEP^*. The consumer surplus of domestic consumers is represented by the area ABP^* while that of foreign consumers is represented by the area *MEBA* in the left panel or the area NJP^* in the right panel.

Producer surplus is represented by the area P^*EO. The area *BET* represents the trade surplus, or net gain from trade.

Now consider the imposition of a DPP such that the target price, P^T, is above the free market equilibrium price, P^*. For any observed market price P^C below P^T, producers will supply quantity Q^T and receive payments from the Government equal to *estimated* output and the difference between the target and market prices. The domestic supply curve now becomes $Q^T FS$ in the left panel. Corresponding to this new domestic supply is a new excess supply curve LHS_E in the right panel, with the segment below *H* corresponding to the perfectly inelastic portion ($Q^T F$) of the new supply curve in the domestic market. The introduction of the DPP leads to higher quantity produced, quantity traded, and lower world price (P^C). Specifically, the quantity produced increases from Q^* to Q^T, causing the market-clearing price to drop to P^C. Domestic consumption increases from Q_1^D to Q_2^D and the quantity exported increases from Q_1^{Ex} to Q_2^{Ex}.

Total deficiency payments (*PMT*) are represented by the area $P^T FGP^C$. It is important to note that deficiency payments are paid to farmers based on *estimated* output calculated as a product of program yield, which is fixed and varies across provinces, and the amount of rice land registered to the program. By assuming all rice land is registered and using an average national yield as program yield, deficiency payments can be calculated based on aggregate output instead of the *estimated* output by multiplying total output by the difference between the target price and the market price. This amounts to assuming that farmers respond to the incentive to increase production by increasing land size while keeping yield unchanged. Both producers and consumers gain as a result of the DPP. The producer surplus increases from P^*EO to $P^T FO$ which means the gain of producer surplus (ΔPS) is equal to $P^T FEP^*$. Domestic consumers gain as their consumer surplus increases from ABP^* to ACP^C, a gain (ΔCS_D) of P^*BCP^C. Similarly, consumer surplus of foreign consumers increases from *MEBA* to *MGCA*, a gain (ΔCS_F) of *BEGC*. Hence, total change in consumer surplus (ΔCS_T) is equal to P^*EGP^C.

Producers sell more at a higher price while consumers buy more at a lower price. According to Coffin and Henning (1989), the increase in foreign consumers' surplus is composed of a loss in trade surplus (ΔTS) and a loss in production efficiency (*PE*), represented by the areas *BEDC* and *EGD* in the left panel, respectively. Note that these areas correspond to the areas P^*JUP^C and *JKU* in right panel, respectively. The former is related to the loss that results from the target price inducing higher output and hence lowering the world price without reducing the true cost of production. The latter is the loss that arises from producing beyond the optimal level of output at which marginal cost equals marginal revenue. Since the deficiency payments are greater than the net gain from both consumer and producer surpluses combined, there is a deadweight loss (*DWL*) of *FEG*. The formulas to calculate the welfare impacts under DPP are summarized in **Table 1.2.**

Table 1.2: Calculation of DPP impacts

Welfare Impact	**Notati on**	**Formula**	**Representation in Figure 1.3**
Total deficiency payments	PMT	$(P^T - P^C)Q^T$	P^TFGP^C
Change in producer surplus	ΔPS	$0.5(P^M - P^*)(Q^T + Q^*)$	P^TFEP^*
Change in total consumer surplus	ΔCS_T	$0.5(P^* - P^C)(Q^T + Q^*)$	P^*EGP^C
Change in domestic consumer surplus	ΔCS_D	$0.5(P^* - P^C)(Q_1^D + Q_2^D)$	P^*BCP^C
Change in foreign consumer surplus	ΔCS_F	$\Delta CS_T - \Delta CS_D$	*BEGC or* P^*JKP^C
Loss in production efficiency	PE	$0.5(P^* - P^C)(Q^T - Q^H)$	*EDG or JKU*
Loss in trade surplus	ΔTS	$\Delta CS_F - PE$	*BEDC or* P^*JUP^C
Deadweight loss	*DWL*	$0.5(P^T - P^C)(Q^T - Q^*)$	*FEG*

Unlike in the case of PSP, farmers are assumed to incur no additional cost when participating in DPP. Recall that the additional cost under PSP includes transportation cost accrued when delivering harvests to the Government's designated depots and delayed payments due to lack of Government funds. Since farmers must sell rice on the open market, there is no additional transportation cost to the Government depots. Because there is no evidence of delayed payments reported during the course of DPP implementation, the cost of delayed payment is assumed negligible. This assumption is supported by the facts that the payment made to each household is much smaller under DPP, and that the Government has knowledge regarding the amount of funds needed to be allocated to each branch of the BAAC on a daily basis, which reduces the chances of having insufficient funds for making deficiency payments to farmers. Recall that the Government only has to pay the difference between the target and market prices to compensate farmers instead of buying rice from them. The target price is known to farmers prior to a start of each cropping season but the market price is unknown. The Government announces the *estimated* market price on every Monday during harvesting season. When signing the program contract, farmers are required to specify the date at which they want to exercise the right to receive deficiency payments. Farmers then receive deficiency payments only when the *estimated* market price announced on Monday of the same week as the chosen date is below the target price.

1.4 Methods and data

In order to compare the impact of the Thai rice PSP and DPP on economic welfare (i.e. producer surplus, consumer surplus, trade loss, and deadweight loss), one needs to find counterfactual values of prices and quantities that would have been observed had the policy regime implemented in any given period been different. In this study, the 2005/06 cropping season, in which the PSP was operational, is used to evaluate how alternative policies would have performed. This period was chosen mainly because it has the most detailed information on revenue and cost of the PSP which typically are not released by the Government. Fortunately, Poapongsakorn (Poapongsakorn and Charupong, 2010), a former member of Thailand National Rice Committee, was able to compile this information of the opertion of PSP in 2005/06 cropping season. Two counterfactual scenario, namely no Government intervention (NG) and the DPP, are investigated under the following circumstances:(i) when the target price is set equal to the support price observed in the 2005/06 cropping season; and (ii) when total deficiency payments are set equal to the same Government expenditures as observed under PSP during the 2005/06 cropping season. The comparison when target price and support price are set equal is designed to give insight into the relative effects when farmers face the same "minimum price" under each program, while the comparison when Government expenditures are set equal is designed to give insight into the "cost neutral" performance of the programs when Government costs are the same under each program. In each case, the changes in economic welfare can be calculated geometrically from relevant values of price and quantity observed in the selected period, assuming knowledge of key elasticities of supply and demand.

1.4.1 Calculating welfare impacts under the PSP using price elasticities

Referring to **Figure 1.2**, the effective market price (P^M) and observed production and consumption levels observed in the 2005/06 cropping season are substituted into equations representing demand and supply to compute for the relevant values of unknown variables including equilibrium price and output (Q^*, P^*) and the corresponding domestic and foreign consumptions ($Q_1^D$and Q^*- Q_1^D)when there is no Government intervention. The unknown variables that must be calculated in order to compute the changes in economic welfare under the PSP include the equilibrium market price (P^*), total output (Q^*), and domestic consumption (Q_1^D) under no Government intervention. Here, P^* and Q^* (located at point *E* in **Figure 1.2**) can be found by solving the following equations that represent price-elasticity of total demand (ε^a) and price-elasticity of supply (ε^s), respectively.[1]

$$\varepsilon^a = [(Q^C - Q^*)/Q^*]/[(P^M - P^*)/P^*] \tag{1.1}$$

$$\varepsilon^s = [(Q^M - Q^*)/Q^*]/[(P^M - P^*)/P^*] \tag{1.2}$$

P^M and Q^M, which respectively represent the equilibrium price and quantity under the PSP, are observed. So, P^* and Q^* are the only unknown variables and can be found directly by solving the system of two equations with two unknowns. In order to solve for Q_1^D, which represents domestic consumption at point *J* on the domestic demand curve D_D in **Figure 1.2**, the elasticity of domestic demand expressed in the following equation must be solved.

$$\varepsilon^d = [(Q_0^D - Q_1^D)/Q_1^D]/[(P^M - P^*)/P^*] \tag{1.3}$$

[1] ε^a is a weighted average of price elasticity of domestic and export demand (ε^d and ε^x, respectively)

Again, all variables except Q_1^D are known.Note that Q_0^D is known and equals total production(Q^M) less the sum of Government purchases (Q^G) and total exports (Q_0^{Ex}); Q_0^{Ex} is equal to a sum of private exports ($Q_0^{Ex,Prv}$) and Government exports ($Q_0^{Ex,Gov}$). Once all these unknown variables are determined, the impact of price support program on economic welfare can be computed directly.

1.4.2 Calculating welfare impacts under the DPP using price elasticities

For the first DPP evaluation the target price (P^T) is set equal to 8,465 baht/ton which is the support price (P^S) observed in the 2005/06 season. To evaluate DPP effects three variables need to be computed–total supply (Q^T), equilibrium market price (P^C), and domestic consumption (Q_2^D). A system of three equations, which represent price-elasticity of total supply (ε^s), price-elasticity of total demand (ε^a), and price-elasticity of domestic demand (ε^d), can be used to compute these unknowns. First, Q^T can be calculated by substituting the target price (P^T) and the set of information ($Q^*, P^*, Q_1^D, Q_1^{Ex}$), which are known from previous calculation in the case of PSP, into the equation representing the price-elasticity of supply (ε^s) evaluated at point E in **Figure 1.3.**The target price (P^T) is set equal to the support price (P^S).[2] This means Q^T is the only unknown in the equation and hence it can be solved directly for a given value of ε^s.

$$\varepsilon^s = [(Q^T - Q^*)/Q^*]/[(P^T - P^*)/P^*] \tag{1.4}$$

[2]Generally, the price that farmers receive when selling to the government is lower than the support price, because the price is discounted depending on moisture content and product-byproduct ratio. Thus, P^S is set equal to the effective support price defined as total BAAC loans issued to farmers under price support program divided by total quantity of pledged rice.

Similarly, P^C is the only unknown in the equation below that represents elasticity of total demand (ε^A) at point *E* in **Figure 1.3**, so it can be solved directly for a given value of ε^a.

$$\varepsilon^a = [(Q^T - Q^*)/Q^*]/[(P^C - P^*)/P^*] \tag{1.5}$$

The last unknown variable to solve for is the domestic consumption under deficiency payment program (Q_2^D). It can be found by solving the equation of price-elasticity of domestic demand (ε^d) at point *B* in **Figure 1.3** in which Q_2^D is the only unknown variable. In addition, subtracting domestic consumption from total supply yields a value of total export (Q_2^{Ex}) under the DPP.

$$\varepsilon^d = [(Q_2^D - Q_1^D)/Q_1^D]/[(P^C - P^*)/P^*] \tag{1.6}$$

For the case where DPP Government expenditures are set equal to those under the PSP, total deficiency payments (PMT) are set equal to 51,758 million baht which is the sum of total loans paid to farmers and the Government's operating expenses of the PSP in the 2005/06 season. The calculation of the unknown variables (Q^T, P^C, Q_2^D) are similar to that discussed previously except that the target price (P^T) is now another unknown to solve for. A system of four equations consisting of the equations from (1.4)-(1.6) and the equation representing total deficiency payments can be used to solve for these four unknowns. The latter equation expresses total deficiency payments as a product of total supply and the difference between the target price and market price.

$$PMT = Q^T(P^T - P^C) \tag{1.7}$$

1.4.3 Data

This study uses secondary data obtained from various agencies. The quantity and price data that covers the period from November 2005 to February 2006 is used to estimate an impact of the PSP on economic welfare during the first-cropping season of 2005/06 production year. This particular period was chosen mainly because it is the only period that the data on revenue and cost of the PSP are available. The production environment in this selected period is described as a typical cropping season in which average annual temperature and rainfall were 26.64 degree Celsius and 101.17 millimeter.[3] Similarly, the market condition was stable as described by a comparable ratio of total world supply and exports relative to that of the previous year. Specifically, total world supply of paddy rice was 621.40 million tons compared to 596.60 million tons in previous year while total world exports of milled rice were 29.10 million tons compared to 29.00 million tons in previous year.[4]

The market price (P^M), support price (P^S), and target price (P^T) are the weighted average of prices calculated from three types of rice, including white rice, jasmine rice, and glutinous rice. Total supply (Q^M) and private export quantity ($Q_0^{Ex,Prv}$) are the sum of monthly quantities of all rice types. The support and target prices are obtained from Thailand Department of Internal Trade Office (DIT). Total production, total private exports, and market prices are obtained from Thailand Office Agricultural Economics (OAE). According to Poapongsakorn and Charupong (2010), the sales of Government rice stock from the 2005/06 first-cropping season did not happen until one year later and it took the Government as long as three years to sell all of the rice. Thus, exports of the Government rice stock ($Q_0^{Ex,Gov}$) in 2005/06 are calculated as an

[3] Source: World Bank. Available at http://data.worldbank.org/indicator/ [accessed September 1, 2014]
[4] Source; Rice Outlook, USDA Economic Research Service. Available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1285 [accessed September 1, 2014]

aggregate sum of monthly exports from November 2004 to February 2005 of non-redeemed rice from the operation of the PSP in previous cropping season (2004/05).[5]

No attempt has been made to estimate the relevant price elasticities since implementation of the PSP. One reason is lack of sufficient data and another is because it is difficult in practice to capture the dynamics of demand and supply through interactions of a support price, market price, quantity of pledged rice, and the Government's rice exports. The present study does not attempt to estimate price elasticities directly either but uses estimates from existing literatures instead. Two sets of estimates of price elasticity of total supply, domestic demand, and export demand are drawn from the same sources as referenced in the study by Poapongsakorn and Charupong (2010). The combination of these estimates is used to create eight scenarios for sensitivity analysis.

Estimates of price-elasticity of total supply ($\varepsilon^S = 0.086$) and domestic demand ($\varepsilon^D = -0.392$) are obtained from the study by Isvilanonda and Kongrith (2008). This study provides the most recent estimates of these elasticities in case of the Thai rice market. In their study, price-elasticity of demand was estimated using an Almost Ideal Demand System (AIDS) model while price-elasticity of supply was estimated by seemingly unrelated regression estimation (SURE) in which the dependent variables are production share of major crops. The models were estimated using price and quantity data from 1970-2000. The other set of estimates of price-elasticity of total supply and domestic demand come from the studies by Konjing (1980) ($\varepsilon^S =$

[5] Unfortunately, the information on the government exports of non-redeemed rice retained from the operation of PSP in 2004/05 is not available. Instead, the government exports of non-redeemed rice retained from the operation of PSP in 2005/06, made available by Poapongsakorn and Charupong (2010), are used to derive the amount of government exports in 2005/06. Specifically, we assume that it also takes the Government three years to sell the rice stock retained from the 2004/05 PSP as did in 2005/06. Furthermore, the monthly exports by the government throughout the course of the three-year span are assumed equal. For a given rate of export, the amount of government exports in 2005/06 can be calculated accordingly.

0.0453) and Siamwala and Pattamasiriwat (1989) ($\varepsilon^D = -0.12$). Estimates of price-elasticity of export demand are obtained from two sources-- Siamwala and Pattamasiriwat (1989) ($\varepsilon^X = -4$) and Suntayoom (1981) ($\varepsilon^X = -7.04$). These ranges of price elasticity are quite reasonable for several reasons. The estimates of price-elasticity of supply indicate an inelastic supply of Thai rice, which is consistent with the fact that land is limited in Thailand so that an increase in production by land expansion is difficult. Because rice is the only staple food in the Thai diet, domestic demand for rice consumption is more inelastic than export demand and hence the price-elasticity of domestic demand is smaller than that of the export demand.

1.5 Results

1.5.1 Estimates of the impact of PSP on economic welfare

Table 1.3 shows the summary of market data under the PSP including prices and quantities, and the program expenditure/revenue observed during the 2005/06 cropping season. The calculated variables include prices and quantities under no Government intervention, which are the counterfactual values of price and quantity that would have been observed in this period had there been no PSP (nor DPP). The support price was set at 8,465 baht/ton, a weighted average of the actual support price of jasmine rice, white rice, and glutinous rice during the season. Total supply (Q^M) was 23.34 million tons while market price (P^M) was 6,614 baht/ton, a weighted average from all three types of rice. Recall that, in order to account for additional costs associated with program participation, both program participants and non-participants are assumed to receive the same realized/effective price when selling their rice. Thus, the effective price for PSP participants equals the observed market price (P^M). The Government purchased a total of 5.29 million tons of paddy rice from farmers and exported a total 1.29 million tons of non-redeemed rice withheld from previous seasons.[6] Total private exports were 4.54 million tons. Thus, total export (Q_0^{Ex}) and domestic consumption (Q_0^D) were 5.83 and 12.21 million tons, respectively.[7]

[6] Government exports are calculated by multiplying total non-redeemed rice in the previous season by the Government rate of export. Since neither the redemption rate nor the export rate of the non-redeemed rice from the operation of PSP in 2004/05 is known, they are assumed equal to their 2005/06 counterparts found in Poapongsakorn & Charupong (2010). Specifically, the redemption rate is 21.93% of total pledged rice while the export rate is 6.50% of total non-redeemed rice. Given the total amount of pledged rice of 5.10 million tons, Government exports in 2005/06 are estimated at 1.29 million tons of paddy rice.

[7] Q_0^D is calculated from the identity equation that expresses total supply as the sum of domestic consumption, government purchase, and exports.

Total loans made to farmers by the Government through the BAAC (*LOAN*) were 44,797.02 million baht. Total operating costs (*EXPS*) were 6,961.24 million baht. Hence, total cost of the PSP is 51,758 million baht. The Government has two sources of revenue including the loan repayment/redemption (*RD*) of pledged rice worth 10,706 million baht and the sales of non-redeemed rice ($SALE_M$) and its byproduct ($SALE_B$) worth 24,760 million baht. Note that the Government purchases paddy rice from farmers, processes the rice, and sells it as milled rice. In order to calculate loss/gain of rice sales measured in paddy-rice-equivalent value, operating expenses (*EXPS*) are subtracted from the value of milled rice and its byproduct ($SALE_M$+$SALE_B$) sold by the Government. This gives the sales value of pledged rice ($SALE_P$) of 17,799 million baht.

Table 1.3: Summary of the data observed during the implementation of PSP in 2005/06

Variables	**Value**
Price & Quantity under PSP (Unit: baht/ton & million tons)	
Support price (P^S)	8,465
Quantity of pledged rice (Q^G)	5.29
Total supply (Q^M)	23.34
Effective market price (P^M)	6,614
Total consumption (Q^C)	18.05
Domestic consumption (Q_0^D)	12.21
Private exports ($Q_0^{Ex,Prv}$)	4.54
Government exports ($Q_0^{Ex,Gov}$)	1.29
Total export s(Q_0^{Ex})	5.83
Program Cost & Revenue (Unit: million baht)	
BAAC loans (*LOAN*)	44,797
Value of redeemed rice (*RD*)	10,706
Sales of non-redeemed rice and its byproduct ($SALE_M$+$SALE_B$)	24,760
Operating expenses (*EXPS*)	6,961
Value of the sales of non-redeemed paddy rice ($SALE_P$)	17,799

Table 1.4 reports the estimated effects of the PSP and DPP under eight combinations of supply and demand elasticities used in evaluate sensitivity of results to the elasticity assumptions. Specifically, the combinations of price-elasticity of domestic demand (-0.392 and-0.120) and export demand (-4.00 and -7.08) constitute four different values of price-elasticity of total demand. Putting these cases together constitutes total of eight cases that are investigated in this study. The last two columns of the table report the upper and lower bound of computed values of welfare change. These values are the minimum and maximum corresponding to the welfare changes reported in the table.

The counterfactual values of total supply and market price under no Government intervention (Q^* *and* P^*) range between 22.99-23.23 million tons and 5,485-5,991 baht/ton, respectively. These values are lower than those observed under the PSP, as expected. In other words, the PSP has raised total supply by between 0.45-1.54% and the market price by between 10.40-20.58% compared to the no intervention case. Because all outputs must be consumed domestically or exported, total exports (Q_1^{Ex}) and domestic consumption (Q_1^D) under no intervention are larger than those under the PSP. Specifically, exports and domestic consumption are estimated between 10.00-10.85 million tons and between 12.37-13.04 million tons, respectively. Given total exports by private exporters of 5.83 million tons in 2005/06, this means implementation of PSP caused private exports to fall by 41.70- 50.20%.

An increase in market price under the PSP results in an increase in producer surplus (ΔPS) ranging between 14,487-26,237 million baht and a decrease in total consumer surpluses (ΔCS_T) ranging from -23,250 to -12,838 million baht. Consumer surplus of domestic consumers (ΔCS_D) falls by -13,944 to -7,764 million baht while that of foreign consumers (ΔCS_F) falls by -9,306 to -5,073 million baht. Despite receiving the support price on rice sales, participants of the

PSP incur these additional costs of participation which are then transferred to other sectors such as banking services in the form of interests paid on loans borrows for rice production and transportation services in the form of extra transportation cost for delivering rice to the designated Government depots. The additional costs of program participation (*AC*), calculated as a product of the difference between the support price (P^S) and market price (P^M) times the quantity of non-redeemed paddy rice, is estimated at 7,639 million baht. Lastly, the deadweight loss (*DWL*) associated with the program is estimated to range from 5,665-7,002million baht. The amount of additional costs and deadweight loss together represent the total amount from the total cost of PSP that are wasted as neither of them contributes to an increase the welfare surpluses nor Government revenue. This means as much as 10.94-13.53% of total Government spending on the operation of PSP are wasted as deadweight loss while 14.76% accounts for the additional cost of the program accrued in order to keep the program running.

Table 1.4: Estimates of the impacts of the price support program (PSP)

Cases by Elasticities	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Min	Max
ε^d	-0.39	-0.39	-0.12	-0.12	-0.39	-0.39	-0.12	-0.12		
ε^x	-4.00	-7.08	-4.00	-7.08	-4.00	-7.08	-4.00	-7.08		
ε^a	-1.31	-2.09	-1.10	-1.88	-1.31	-2.09	-1.10	-1.88		
ε^s	0.09	0.09	0.09	0.09	0.05	0.05	0.05	0.05		
Price & quantity under NG	**(Unit: baht/ton & mil. ton)**									
Total supply (Q^*)	23.02	23.14	22.99	23.13	23.17	23.23	23.15	23.23	22.99	23.23
Market price (P^*)	5,629	5,991	5,510	5,946	5,610	5,984	5,486	5,937	5,486	5,991
Domestic consumption (Q_1^D)	13.02	12.70	12.49	12.37	13.04	12.70	12.49	12.37	12.37	13.04
Export (Q_1^{EX})	10.00	10.44	10.50	10.76	10.13	10.53	10.65	10.85	10.00	10.85
Welfare Impacts of PSP	**(Unit: mil. baht)**									
Change in PS (ΔPS)	22,853	14,487	25,586	15,539	23,368	14,688	26,237	15,770	14,487	26,237
Change in total CS (ΔCS_T)	-20,245	-12,838	-22,663	-13,769	-20,709	-13,019	-23,250	-13,978	-23,250	-12,838
Change in domestic CS (ΔCS_D)	-12,438	-7,764	-13,642	-8,221	-12,687	-7,858	-13,944	-8,327	-13,944	-7,764
Change in foreign CS (ΔCS_F)	-7,807	-5,073	-9,021	-5,548	-8,022	-5,161	-9,306	-5,651	-9,306	-5,073
Additional cost of participation (AC)	7,639	7,639	7,639	7,639	7,639	7,639	7,639	7,639	7,639	7,639
Deadweight loss (DWL)	6,043	7,002	5,729	6,882	5,993	6,983	5,665	6,859	5,665	7,002

1.5.2 Estimates of the impact of DPP on economic welfare when the target price is equal to the support price

The counterfactual quantities and prices under no Government intervention are used in conjunction with the assumed values of price elasticity of demand and supply to find the counterfactual values of quantities and prices under the DPP assuming that the target price (P^T) is set equal to the support price (P^S). This means that total supply (Q*), market price (P*), domestic consumption (Q_1^D), and export quantity (Q_1^{Ex}) under no Government intervention (NG) are as previously calculated. The target price is set equal to 8,465 baht/ton. These values of price and quantity, and estimates of the DPP impact are presented in the top part of **Table 1.5.** The bottom part of the table contains estimates of prices and quantities under the DPP. Like the case of the PSP, a sensitivity analysis on the calculation of welfare impacts is conducted using the combination of price elasticities of total demand and supply that constitutes eight different cases. The last two columns of the table report maximum and minimum of the welfare changes drawn from all eight cases.

Supply is estimated to have increased under DPP while market price has fallen compared to no intervention. The counterfactual values of total supply and market price under DPP (Q^T *and* P^C*)* range between 23.61-23.87 million tons and 5,358-5,946baht/ton, respectively. Equivalently, the DPP is estimate to have caused total supply to increase by 1.61-3.85% and the market price to fall by 0.62-2.75%. Because all outputs must be consumed domestically or exported, total exports (Q_2^{Ex}) and domestic consumption (Q_2^D) increase; exports rise to between 10.52-11.46 million tons while the increase in domestic consumption ranges between 12.38-13.13 million tons. Since the target price is higher than the market price under no intervention (P^T>P^*), there is a gain in producer surplus; ΔPS ranges between 58,121-69,673 million baht. Similarly, there is a gain to consumers in term of an increase in consumer surplus as the market price under the DPP is lower than that under no intervention (P^C<P^*). Specifically, total consumer surplus (ΔCS_T) increases by 872-3,547 million baht. The surplus of domestic consumers (ΔCS_D) increases by 474-1,893 million baht while that of foreign consumers (ΔCS_F) increases by 399-1,656 million baht. Parts of the gain by foreign consumers are generated from loss in production efficiency (PE) and loss in trade surplus (ΔTS), which range between 7-70 million baht and between 392-1,587 million baht, respectively. Lastly, the deadweight loss (DWL) associated with the program is estimated to range between 469 and 1,376 million baht.

1.5.3 Estimates of the impact of DPP on economic welfare when total deficiency payments are equal to total Government expenditures under the PSP

In this section, the impact of DPP on economic welfare is investigated assuming identical Government expenditures as under PSP. By setting total deficiency payments to 51,758 million, which is also total cost of the PSP in the 2005/06 season, the corresponding target price is estimated to be between 7,563 and 8,138 baht/ton, depending on elasticity assumptions (**Table 1.6**). Producer surplus under DPP then increases by between 47,954 and 50,457 million baht. Domestic and foreign consumers gain as total consumer surplus increases by between 889 and 3,001 million baht. The deadweight loss (DWL) is estimated between 413 and 804 million baht. These results indicate that the target price can be set much lower than the support price for the same level of Government expenditure, and yet increase producer surplus under the DPP can still be twice as large of that under the PSP, while the deadweight loss is much smaller. Thus, the transfer of Government expenditures to farmers in the form of an increase in producer surplus is more efficient under the DPP than the PSP.

Table 1.5: **Estimates of the impacts of DPP when the target price is equal to the support price under PSP**

Cases by Elasticities	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Min**	**Max**
ε^d	-0.392	-0.392	-0.120	-0.120	-0.392	-0.392	-0.120	-0.120		
ε^x	-4.000	-7.080	-4.000	-7.080	-4.000	-7.080	-4.000	-7.080		
ε^a	-1.306	-2.086	-1.103	-1.883	-1.306	-2.086	-1.103	-1.883		
ε^s	0.086	0.086	0.086	0.086	0.045	0.045	0.045	0.045		
Given price & quantity under NG	**(Unit: baht/ton & million ton)**									
Total supply (Q^*)	23.02	23.14	22.99	23.13	23.17	23.23	23.15	23.23	22.99	23.23
Market price (P^*)	5,629	5,991	5,510	5,946	5,610	5,984	5,486	5,937	5,486	5,991
Domestic consumption (Q_1^D)	13.02	12.70	12.49	12.37	13.04	12.70	12.49	12.37	12.37	13.04
Export (Q_1^{Ex})	10.00	10.44	10.50	10.76	10.13	10.53	10.65	10.85	10.00	10.85
Price and Quantity under DPP	**(Unit: baht/ton & million ton)**									
Total supply (Q^T)	23.86	23.85	23.87	23.85	23.61	23.61	23.62	23.61	23.61	23.87
Market price (P^c)	5,499	5,920	5,358	5,868	5,541	5,946	5,406	5,896	5,358	5,946
Domestic consumption (Q_2^D)	13.13	12.75	12.52	12.39	13.09	12.73	12.51	12.38	12.38	13.13
Export (Q_2^{EX})	10.74	11.10	11.35	11.46	10.52	10.87	11.10	11.22	10.52	11.46
Total supply at Q^H	22.99	23.13	22.95	23.11	23.16	23.23	23.14	23.22	22.95	23.23
Welfare Impacts of DPP	**(Unit: million baht)**									
Deficiency payment (PMT)	70,787	60,706	74,166	61,951	69,048	59,462	72,262	60,647	59,462	74,166
Change in PS (ΔPS)	66,507	58,138	69,243	59,189	66,802	58,121	69,673	59,204	58,121	69,673
Change in total CS (ΔCS_T)	3,033	1,665	3,547	1,820	1,597	872	1,871	954	872	3,547
Change in domestic CS (ΔCS_D)	1,691	902	1,893	959	892	474	1,001	504	474	1,893
Change in foreign CS (ΔCS_F)	1,344	764	1,656	862	705	399	871	450	399	1,656
Loss in production efficiency (PE)	56	26	70	29	15	7	19	8	7	70
Loss in trade surplus (ΔTS)	1,287	738	1,587	833	690	392	852	442	392	1,587
Deadweight loss (DWL)	1,247	903	1,376	942	649	469	718	489	469	1,376

Table 1.6: **Estimates of the impacts of DPP when total deficiency payments are equal to total Government expenditures under PSP**

Cases by Elasticities	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Min**	**Max**
ε^d	-0.392	-0.392	-0.120	-0.120	-0.392	-0.392	-0.120	-0.120		
ε^x	-4.000	-7.080	-4.000	-7.080	-4.000	-7.080	-4.000	-7.080		
ε^a	-1.306	-2.086	-1.103	-1.883	-1.306	-2.086	-1.103	-1.883		
ε^s	0.086	0.086	0.086	0.086	0.045	0.045	0.045	0.045		
Given price & quantity under NG	**(Unit: baht/ton & million ton)**									
Total supply (Q^*)	23.02	23.14	22.99	23.13	23.17	23.23	23.15	23.23	22.99	23.23
Market price (P^*)	5,629	5,991	5,510	5,946	5,610	5,984	5,486	5,937	5,486	5,991
Domestic consumption (Q_1^D)	13.02	12.70	12.49	12.37	13.04	12.70	12.49	12.37	12.37	13.04
Export (Q_1^{Ex})	10.00	10.44	10.50	10.76	10.13	10.53	10.65	10.85	10.00	10.85
Price and quantity under DPP	**(Unit: baht/ton & million ton)**									
Target Price (P^T)	7,694	8,091	7,563	8,042	7,744	8,138	7,614	8,089	7,563	8,138
Total supply (Q^T)	23.75	23.84	23.72	23.83	23.57	23.61	23.55	23.61	23.55	23.84
Market price (P^c)	5,515	5,920	5,381	5,870	5,548	5,946	5,416	5,896	5,381	5,946
Domestic consumption (Q_2^D)	13.12	12.76	12.52	12.39	13.09	12.74	12.51	12.38	12.38	13.12
Export (Q_2^{EX})	10.63	11.08	11.20	11.44	10.47	10.87	11.04	11.22	11.17	10.72
Total supply at Q^H	22.98	23.12	22.94	23.10	23.16	23.23	23.13	23.22	22.94	23.23
Welfare impacts of DPP	**(Unit: million baht)**									
Change in PS (ΔPS)	48,301	49,339	47,954	49,211	49,882	50,457	49,687	50,386	47,954	50,457
Change in total CS (ΔCS_T)	2,666	1,661	3,001	1,786	1,440	889	1,627	957	889	3,001
Change in domestic CS (ΔCS_D)	1,490	900	1,607	942	805	483	871	506	483	1,607
Change in foreign CS (ΔCS_F)	1,176	761	1,394	844	635	406	756	451	406	1,394
Loss in production efficiency (PE)	44	26	50	28	13	7	15	8	7	50
Loss in trade surplus (ΔTS)	1,132	736	1,344	816	622	399	741	443	399	1,344
Deadweight loss (DWL)	792	757	804	762	436	413	444	415	413	804

1.5.4 A comparison of the effects of PSP and DPP on economic welfare

An identical value of the support/target price (8,465 baht/ton) does not translate into an identical value of price received/effective market price to producers. Due to the additional cost associated with program participation, an effective market price under PSP falls below the support price to 6,614 baht/ton. In contrast, the target price becomes an effective market price under DPP as there is no additional cost of program participation. As a result, total supply only increases by 0.45-1.54% under PSP while it increases by as much as 1.61-3.85% under DPP. Although PSP and DPP both increase total supply, their impacts on market price are opposite. PSP raises the market price by 10.40-20.58% while the market price falls by 0.62-2.75% under DPP.

Because the size of producer surplus depends on total supply and the difference between the support/target price and market price, there is a greater increase in producer surplus under DPP. The operation of PSP in 2005/06 attracted only 624,428 rice farm households while costing the Government as much as 44,797 million baht worth of loans plus operating expense of 6,614 million baht. By setting the target price identical to the support price, however, total deficiency payments are estimated between 59,462-74,166 million baht which are paid to almost all rice farm households (approximately 4 million households). For every dollar the Government spends on the PSP, only 0.28-0.51 dollars are transferred to farmers in the form of an increase in producer surplus while the transfer is as high as 0.93-0.97 dollars under the DPP. Consumers, especially domestic consumers, are much worse off under PSP as their surplus shrinks considerably as a result of a sharp increase in market price. In contrast, both domestic and foreign consumers are better off under DPP as the program results in a reduction of market price. Although, one may argue that the Government subsidizes foreign consumers at the expense of domestic consumers under DPP, the subsidy is relatively small compared to the gain in producer surplus. In contrast, domestic consumers suffer great losses in consumer surplus while an increase in producer surplus is limited under PSP. Lastly, the deadweight loss under the PSP is approximately 10.94-13.52% of the total costs while it accounts for less than 1% of total deficiency payments under DPP.

Because a higher proportion of Government expenditures is transferred to farmers in the form of an increase in producer surplus, while a smaller proportion is wasted in the form of deadweight loss, the DPP is considered more efficient than the PSP. Yet for identical support price and target price DPP is estimated to be more expensive in terms of Government outlays than PSP because it generates no revenue to the Government. Nevertheless, an identical amount of government expenditure when used to finance the DPP instead of the PSP would increase producer surplus more substantially while the deadweight loss is much smaller.

1.6 Conclusions and policy implications

Recent debate among Thai policymakers focuses on trade-offs between two rice farm policies, the price support program (PSP) and deficiency payment program (DPP). The PSP has been used for many years and is currently operating. In contrast, the DPP was first introduced in 2009 by the current opposition party, who was in power during that period, but the program was terminated once the current Government took over the office in late 2011. These programs are politically and economically important as they directly affect millions of rice farm households in the country and require enormous budget outlays from the Government. Despite high public attention, only a few studies have investigated the tradeoffs between these programs. So the objective of this study is to compare welfare impacts of PSP and DPP measured in terms of changes in producer surplus, consumer surplus, and deadweight loss by applying a computational model to calculate counterfactual values of quantity and price that would have been observed had the former been replaced by the latter. The 2005/06 cropping season is used as a base for the calculation as the information on revenue and cost of the PSP is readily available for this period.

Results indicate that replacing the PSP with DPP, while keeping the target price at the same level as the support price, results in an increase in total supply and a decrease in market price. Specifically, total supply would increase from 23.34 to between 23.61 and 23.87 tons while the market price would decrease from 6,614 to between 5,358-5,946 baht/ton. The surplus of producers and consumers both increase while deadweight loss would shrink considerably. However, Government costs under the DPP are higher than under the PSP. A comparison relative to the case of no Government intervention reveals that PSP results in an increase of both the market price and total supply while DPP results in a decrease of the market price while total supply increases. The farmer's incentive to increase production under PSP is impeded by the additional costs associated with delayed payments and transportation to Government depots. These costs, however, are not present when farmers participate in DPP because the Government knows the amount of funds needed to be allocated to each branch of the BAAC on a daily basis, which reduces the chances of having insufficient funds for making deficiency payments to farmers. In addition, there is no extra cost of transportation for delivering rice to the designated Government depots as rice are now sold on the open market. For these reasons, there is a greater increase in total supply under DPP despite identical support/target prices. The market price moves in an opposite direction due to the difference in the availability of supply in the open market. Because a significant portion of total supply is sold to the Government under PSP, less production is available for sale in the open market causing the market price to increase. In contrast, all production is either consumed domestically or exported under DPP. Hence, the increase in total supply leads to a fall in the market price. Specifically, PSP raises the market price by as much as 10.40-20.58% whereas DPP reduces the market price by 0.62-2.75% relative to the case of no Government intervention. Total supply only increases by 0.45-1.54% under PSP while it increases by as much as 1.61-3.85% under DPP.

The Government spent as much as 44,797 million baht on loans made to farmers plus the operating expense of 6,614 million baht while the same level of target price would have cost the Government between 59,462 and 74,166 million baht under DPP. Producer surplus increases by 14,487-26,237 million baht under PSP and by 58,121-69,673 million baht under DPP. The transfer of Government spending to farmers in the form of an increase in producer surplus is more efficient under DPP; as much as 93-97% of deficiency payments under DPP compared to only 28-51% of total loans plus operating expenses under PSP. Consumers, especially domestic consumers, are much worse off under PSP as their surplus shrinks considerably; domestic consumer surplus falls between 13,944-7,764million baht and that of foreign consumer between 9,306-5,073million baht. In contrast, consumers are better off under DPP; domestic consumer surplus increases by 474-1,893 million baht while that of foreign consumers increases by 399-1,656 million baht. Although, one may argue that foreign consumers are subsidized at the expense of domestic consumers under DPP, the subsidy is relatively small compared to the gain in producer surplus. Lastly, the deadweight loss under PSP ranges from 5,665 and 7,002million baht while it only ranges from 469 and 1,376 million baht under DPP. Equivalently, as much as 10.94-13.52% of Government spending under PSP are wasted in term of deadweight loss in order to keep the program operating. The amount of deadweight loss as a percentage of deficiency payments under DPP, however, is less than 1%.

For every dollar of Government spending, the DPP generates a larger percentage increase in producer surplus and smaller deadweight loss than PSP does. In this sense the DPP is more efficient. This claim is also supported by a cost-neutral analysis in which the DPP is found more efficient given an identical amount of Government expenditures under both programs. In addition, program benefits under DPP are more accessible as all farmers are guaranteed a minimum income so long as their lands are registered. The drawbacks of DPP include costly implementation because deficiency payments are made to almost all farmers, while no revenue is generated back to the Government. Arguably, the program tends to not only keep unproductive farmers from exiting the sector, but also encourage use of marginal lands or lands that would have been used for other purposes had there been no intervention. On the other hand, the inefficiencies or the barriers to program benefits have to be reduced if the Government chooses to continue with the PSP. Clearly, many farmers are discouraged from participating in PSP due to the additional costs of program participation. As these costs decrease, the market price should rise much closer to the support price. Consequently, the transfer from the program loans to farmers in the form of an increase in producer surplus would be more efficient. Yet, the Government could face a dilemma as these additional costs shrink because more rice will be sold to the Government while an increase in the market price will cause the sales of pledged rice in the world market to become more difficult. Thus, the support price would have to be carefully set at levels that are economically feasible given the current market environment.

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CHAPTER 2: THE RANKING OF FARMER PREFERENCE TOWARDS ALTERNATIVE FARM POLICIES IN THAILAND

2.1 Introduction

Two main types of government policies have been used to support Thai rice farmers and stabilize farm incomes--the price support program (PSP) and the deficiency payment program (DPP). Policymakers have been debating which of these programs should be preferred for many years. However, there has been no agreement even among rice farmers themselves regarding which policy is preferred. It has been argued that most of the benefits from PSP accrue to large-scale farms whereas program benefits are more evenly distributed under DPP. However, there is little empirical analysis to support even this contention.

Under PSP, farmers can sell/pledge their rice production to the Government at a support price which is announced before the start of each cropping season. Farmers are then allowed to redeem the pledged rice within a given period, in which case they then sell their rice on the open market. If they do not redeem the pledge they deliver to the Government and get the support price. Payment for sales to the Government will be transferred to the farmer's account at the Bank of Agriculture and Agricultural Cooperatives (BAAC), which can take from a few days to several months depending on the availability of Government funds. Under DPP, the Government sets a target price (again announced at the start of each cropping season) and guarantees deficiency payments to farmers when the market price falls below the target price. The deficiency payment is equal to the product of estimated farmer production and the price differential between the target price and the market price, as calculated by the Government. This means the deficiency payment depends on *estimated* production and price received by the farmer instead of *actual* production and price received.

Under DPP the Government has to make deficiency payments to all registered farmers regardless of their actual production or price. This subsidy goes to all registered farmers, including subsistence or small-scale farmers whose production is used mainly for own consumption. Given that this group of farmers represents the majority of Thai rice farmers, DPP payments are considered more evenly distributed, but it is also very costly. Under PSP the Government has to purchase and manage a rice stock. So after granting the loans to farmers, the Government also incurs additional costs, which include storage cost, milling cost, and marketing cost, and there is no guarantee that the Government will be able to sell rice at a higher price than they bought it. Ideally, the government would want to be able to sell the pledged rice at high prices and use the sale proceeds to repay the loans borrowed from the BAAC, as well as additional costs. However, it has turned out that the Government has experienced several difficulties when trying to sell the pledged rice in the world market, resulting in trading losses and a high level of stock accumulation. As funding the program has proved to be a difficult task, the Government inevitably has to delay the transfer of loans made to farmers. The delay can range from few weeks up to several months. Less than 25% of farmers have participated in the PSP, apparently due mainly to high additional costs of participation. Furthermore, most farmers who do participate tend to be large-scale farmers. As a result, many critics argue that the program benefits are not evenly distributed across different group of farmers.

Given the tradeoffs between PSP and DPP it would be useful to better understand farmer preferences for the alternative programs. Knowledge of these farmer preferences would help the Government select the program that yields the highest satisfaction to the farmers given identical Government administrative prices. One way to measure farmer preferences would be to evaluate farmer risk attitudes towards the distribution of farm profits under the alternative programs. But this approach is extremely difficult (if not implausible) to do for every farmer because the preference or utility function can take infinitely many forms. Alternatively, one can choose a risk-ranking criterion that relies on weaker assumptions regarding utility, such as stochastic efficiency with respect to a function (SERF) (Hardaker et al., 2004). SERF ranks farmer preferences towards policy alternatives based on the certainty equivalents (CE) derived from the stream of farm profits for a given range of risk aversion.[8] This amounts to comparing the distribution of incomes under alternative policy alternatives over a specified range of risk aversion instead of a particular utility function.

The objective of this study is to rank the preferences of a representative farmer in Thailand towards PSP and DPP under a range of risk aversion using SERF. The representative farmer is defined as a rice farmer who grows rice on a 25-rai rice farm.[9,10] The farmer is assumed to face two types of risk, namely production risk and market risk. The former involves yield risk while the latter involves price risk and the risk of delayed payments under PSP.

[8]The CE of a risky prospect is the sure sum with the same utility as the expected utility of the prospect.
[9] 2.5 rai = 1 acre
[10] The average land size in the Central region, a major region of white rice production, from 2006-2009 (the most recent available data) is 25 per rice farm household.

2.2 Literature review

2.2.1 Stochastic dominance criterion

Ideally, one would want to be able to identify each farmer's utility function and then calculate his expected utility for a given distribution of profit. Then, preferences for alternative programs can be ranked based on the values of expected utility. For instance, suppose that agents choose between cumulative distribution $F(x)$ and $G(x)$ where x represents profit. According to the expected utility model, $F(x)$ is preferred or indifferent to $G(x)$ if the expected utility derived from F is greater than or equal to that of G. However, identifying an individual's utility function is very difficult. Therefore, it would be useful to have other methods that require weaker assumptions about decision makers' preferences and probability distributions in order to determine a preference ranking. The mean-variance criterion, a risk-ranking criterion commonly used in the past, adopts a weaker assumption that all we know about utility is that it can be represented by a quadratic function. This method selects into efficient set only the risk prospects whose probability distributions have the highest expected value for given levels of variance. However, this criterion is limited because it implicitly assumes decision maker's risk preference is described by increasing absolute risk aversion, an unrealistic assumption in most cases. A more appropriate method is stochastic dominance which provides a partial ordering of risky alternatives for decision makers whose preferences are not completely known. This method relies on weaker assumptions about decision makers' preferences and probability distributions.

Hadar and Russell (1969) and Hanoch and Levy (1969) proposed two simple stochastic dominance criteria known as first-degree stochastic dominance (FSD) and second-degree stochastic dominance (SSD). Under FSD, all decision makers prefer $F(x)$ to $G(x)$ if $G(x) - F(x)$ is always greater or equal to zero. Under SSD, all risk-averse individuals prefer $F(x)$ to

*G(x)*if$\int_a^b [G(x) - F(x)]dx > 0$for $\forall x \in$[a,b]. Major problems of applying FSD include low discriminating power and the left-hand tail problem, resulting in a very large efficient set. The former refers to a situation in which it is unlikely to reject distributions that most risk-averse agents would eliminate from the efficient set. The later refers to a situation in which the distribution which first accumulates probability can never dominate other distributions that accumulate probability later by all decision makers who prefer more to less, no matter what happens later on. Despite higher discriminating power, SSD still faces the left-hand tail problem. As a result, the efficient set still remains very large under SSD (Robison and Myers, 2001)

2.2.2 Stochastic dominance with respect to a function (SDRF)

Generalized stochastic dominance, more generally referred to as stochastic dominance with respect to a function (SDRF) (Meyer, 1977a, 1977b) is capable of eliminating the left-hand tail problem. SDRF orders risky alternatives for a class of decision makers whose utility function is defined by lower bound risk aversion coefficients denoted by $r_L(x)$ and upper bound risk aversion coefficients denoted by $r_U(x)$. SDRF eliminates inefficient alternatives by determining the utility function$u(x)$ which satisfies (2.2) and minimizes (2.1), and checking whether the minimum is non-negative or not.

$$\int_0^1 [\mathrm{G(x) - F(x)}]\mathrm{u}'(\mathrm{x})\mathrm{dx}\,, \qquad \forall \mathrm{x} \in [1,0] \tag{2.1}$$

$$r_L(x) \le -u''(x)/u'(x) \le r_U(x) \tag{2.2}$$

Since (2.1) equals the expected utility from *F(x)* minus the expected utility from *G(x)*, we know that if we minimize it over a set of agents and the minimum is greater than or equal to zero then the set of agents unanimously prefer or are indifferent between *F(x)* and *G(x)*. If the minimum is less than zero then the set of agents is not unanimous in choosing *F(x)* over *G(x)*. Thus, the set of agents with risk aversion measures between $r_L(x)$ and $r_U(x)$unanimously prefer or are indifferent between *F(x)* and *G(x)* if and only if the minimum of (2.1) subject to (2.2) is greater than or equal to zero.

2.2.3 Stochastic efficiency with respect to a function (SERF)

The practical application of SDRF is limited because the method usually results in a large efficient set of risky alternatives. The reason is that SDRF requires unanimous agreement from all decision makers with all possible utility functions. The ranking by SDRF is also sensitive to marginal changes in the upper and lower bounds of risk aversion. Hardaker et al. (2004) proposed stochastic efficiency with respect to a function (SERF) as an alternative procedure to SDRF. Unlike SDRF, SERF requires that all risk aversion measures are of the same functional form as the lower and upper bound function. For instance, assuming constant bounds requires considering only decision makers with constant risk aversion coefficients (e.g. constant absolute risk aversion (CARA) or constant relative risk aversion (CRRA). Instead of eliminating an inefficient alternative by determining whether the minimum of (2.1) subject to (2.2) is greater than or equal to zero as SDRF does, SERF converts expected utility derived under each alternative into certainty equivalent values (CE) over a specified range of risk aversion as specified in (2.2). Because SERF makes a simultaneous rather than a pairwise comparison of risky alternatives, the efficient set obtained from SERF is smaller than that of SDRF. It is important to note that SDRF and SERF do not necessarily deliver the same efficient set (Meyer et al., 2009).

For the set of agents defined by the upper and lower bounds of risk aversion in (2.2), and for a chosen form of the utility function, the function for utility in terms of the stochastic outcome *x* and risk aversion *r(x)* is denoted as *U(x, r(x)).* The corresponding expected utility *EU(x, r(x))* is defined as:

$$EU\big(x, r(x)\big) = \int U\big(x, r(x)\big) dF(x) \approx \sum_i^I U\big(x_i, r(x)\big) P(x_i) \tag{2.3}$$

The first term on the right-hand side of (2.3) represents expected utility in a case when *x* is continuous while the second term represents its approximation evaluated over several discrete values of *x. F(x)* is the probability density of the stochastic outcome when *x* is continuous. In the discrete case, $P(x_i)$ is the probability for states *i* and there are *I* states for each risky alternative. According to Hardaker et al. (2004), starting with CDF data for a set of risky alternatives, equation (2.3) implies the following computational steps for evaluating SERF:

- Select points on each CDF for a finite set of values of *x.*
- Convert each of these *x* vales to its corresponding utility using the selected form of the utility function and the selected values of the risk version coefficient.
- Multiply each finite utility by its associated probability to calculate a weighted average of the utilities of outcomes or expected utility (*EU*).
- Converting each calculated value of expected utility into CE values which can be done by taking the inverse of the utility function evaluated at the expected utility:

$$CE(x, r(x)) = U^{-1}[EU\big(x, r(x)\big)] \tag{2.4}$$

The discrete function is then evaluated for a sufficient number of discrete points of *r(x)* to describe the relationship between *CE* and *r(x)* for each alternative. Partial ordering of alternatives by CE is the same as partially ordering them by utility values. Using this approach we end up with a vector of CE values for each of the *n* alternatives calculated for several values of *r(x)* within the bound as specified in (2.2). Only those alternatives which have the highest CE values for some value in the range of *r(x)* are considered efficient. All other alternatives are dominated in the SERF sense. The method also provides a cardinal ranking at each level of risk aversion by interpreting differences in CE values as risk premiums.

It is argued that the additional assumptions made in SERF are often reasonable because relative risk aversion is more or less constant for moderate variations in wealth (Hardaker and Lien, 2010). In other words, it is not likely that there will be large *kinks* in utility functions for wealth, causing sudden, large changes in relative risk aversion as wealth varies. Furthermore, when there is a change in the efficient set with a change in the form of the utility function, the cost of being wrong, measured by the difference in CEs, is almost always trivially small. For these reasons, SERF is used in this present study to rank farmer preferences. SIMETAR is a user-friendly program capable of performing the SERF ranking of risky alternatives.[11] The program allows users to choose either CARA or CRRA as decision makers' risk aversion function, which respectively entails to assuming a negative-exponential or power utility function.

[11]Simulation and Econometrics to Analyze Risks; www.simetar.com

2.3 Methods and data

In this study constant relative risk aversion (CRRA) coefficients of 0.5 to 4 are used as the lower and upper bounds of risk aversion to define a class of risk-averse farmers. A representative farmer is assumed to grow rice on a 25-rai rice land farm (the national average of land used for rice production per household) and to face stochastic profits caused by random yield and random market prices. Random yields are simulated from the estimated mean and variance obtained from the first-order autoregressive model (AR (1)) of yield with a time trend included. This choice of specification was chosen based on test statistics which reject the null hypothesis of unit root and support the null hypothesis of first-order autocorrelation of yield. The price distribution under each policy regime is simulated from the mean and variance obtained from a vector autoregressive (VAR) model which captures the relationship between the farm-gate price of Thai rice and the rice prices from other exporting countries as well as the effect of policy intervention (PSP and DPP). The VAR model was chosen over other alternative models, such as a structural model of demand and supply, mainly due to data limitations.

Because the preference ranking depends on the relative differences between the support/target price and market price, which varies across years, one could make a ranking of the alternative policies for all the years that these policies were implemented in order to draw an overall conclusion. However, a reasonable alternative is to investigate only the year in which the maximum and minimum of the price differential were observed. By evaluating these two extremes we can determine the sensitivity of the preference ranking to the gap between the support/target price and the market price. To achieve this goal, preference rankings in the two first-cropping seasons, 2006/07 and 2012/13, are investigated. These periods represent the period in which the price differential is smallest and largest, respectively. SERF is employed to investigate the ranking of farmer preferences under the following five scenarios; (1) no government intervention denoted as *NG*, (2) participating in PSP denoted as *PSP*, (3) declining PSP when the program is available denoted as *NPSP*, (4) participating in DPP denoted as *DPP*, and (5) declining DPP when the program is available denoted as *NDPP*.

2.3.1 Estimating the impacts of PSP and DPP on market price

Given that only small portions of total world rice supply are traded in the world market, and that Thailand is the major exporter of rice, any change in the Thai rice price is likely to have significant impacts on the world rice prices and vice-versa. A VAR model can account for these interactions. In this study, the VAR model is specified as

$$log\boldsymbol{P}_t = \sum_{i=1}^{K} \boldsymbol{A}_i log\boldsymbol{P}_{t-i} + \sum_{j=0}^{J} \boldsymbol{B}_i \boldsymbol{X}_{t-j} + \sum_{j=0}^{J} \boldsymbol{C}_i \boldsymbol{Z}_{t-j} + \boldsymbol{U}_t \tag{2.5}$$

where $\boldsymbol{P}_t$ is a vector of rice prices in period t

$\boldsymbol{X}_t$ is a vector of exogenous variables

$\boldsymbol{Z}_t$ is a vector of dummy variables representing different policy regimes

$\boldsymbol{U}_t$ is a vector of error terms assumed distributed as $N(\boldsymbol{0},\boldsymbol{\Omega})$; variance of the error term in each equation is represented by a symmetric matrix[12]

A, ***B***, ***C*** denote matrices of coefficients

[12] To investigate potential heteroskedasticity in variance of the error terms, $log\widehat{U}_t^2$ was regressed on the same set of explanatory variables that appear on the right-hand side of (2.5). LR-test indicates that these variables are not jointly significant at 5% significant level. The slope coefficients of the policy dummies are also individually insignificant at 5% level of significance. Thus, the null hypothesis of homoscedastic variance cannot be rejected.

P includes the farm-gate price of Thai white rice, the export price of Vietnam 5% white rice, and the export price of Pakistan 25% white rice. Several statistical tests are employed to justify the number of lagged prices included in the model.[13] The optimal number of lagged prices suggested by each test varies and ranges from two to four. Due to small sample size, two lags of each price variables are chosen for analysis here.

X includes a set of dummy variables representing the seasonal difference in production environment and marketing (*Season)*, the impacts of the food price crisis which took place in 2008 (*Crisis2008*and *Post-Crisis*), and the difference in political incentives held by the elected Government and military Government regarding the implementation of PSP (*Coup2006*). The variable *Season* is equal to 1if it is the first-cropping season and zero for the second-cropping season.[14] Because production of the first crop is typically twice as large that of the second crop, the market price tends to be lower during the first season. The variable *Crisis2008* is included to control for the unprecedented increase of rice prices in 2008; it is equal to 1 for both seasons in 2008 and zero elsewhere. Rice prices have not fully returned to normal levels observed prior to the crisis, so the variable *Post-Crisis* included to account for this recovery process; it is equal to 1 for all seasons after 2008 and zero elsewhere. Although the interim government selected by the military leaders did not discontinue PSP following the military coup that took place in September 2006, the support price was substantially cut to a level close to the market price. This probably reflects a contrasting view held by the elected Government and military government. Hence, the variable *Coup2006* is included to control for this change; it is equal to 1 for both seasons in 2007 and zero elsewhere.

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[13] These tests include log-likelihood-ratio test, final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and Hannan and Quinn Bayesian' information criterion (HQIC).
[14] First-cropping season starts in June and harvests between October and December. Although, planting and harvesting time for second crop vary by regions, most crops are delivered to the market around March and April.

Z contains a set of policy variables representing periods in which PSP and DPP were implemented.[15] These dummy variables are denoted by *PSP* and *DPP*, respectively. Note that, by setting both *PSP* and *DPP* to zero, the resulting regime represents no government intervention (NG). Ideally, we would want to measure the marginal impact of the changes in actual values of the support/target price on market price. To do that, we need to have a sufficient number of observations from the periods during which the programs were operating as well as enough variation in the support/target prices over time. Unfortunately, PSP has been implemented only for ten years while DPP was terminated after two years of operation. Furthermore, the variation in the support/target price over those years is small. For these reasons, the dummy variables representing each policy regime are used instead of the actual values of the support/target prices. Similarly, a small number of observations limits the adoption of a more flexible model in which policy choices appear as endogenous variables. However, the issue of endogeneity may be less of a concern in this application because the policy choice is arguably less dependent on economic factors but heavily driven by the face of the political party in power. There are two major political parties in Thailand who strongly disagree on the choice of policies for the rice market. One party has always supported the implementation of PSP while the other has a strong stand against the program in favor of DPP. When elected, each of these parties have a history of repealing a program previously implemented by its opposition in order to implement one of its own.

[15] PSP started in the second-cropping season of 2001/02 production year and has continued until now with two years of interruption by DPP from the first-cropping season of 2009/10 production year until 2010/11.

2.3.2 Simulating counterfactual market prices

The distribution of counterfactual market prices under alternative policies can be simulated by changing the policy variables (***Z***) to appropriate values. The market price (p_t) is assumed to be conditionally lognormally distributed:

$$p_t|(x_t, z_t) \sim Lognormal\ (\mu_t\ , \sigma^2) \tag{2.6}$$

where μ_t and σ^2 are the conditional mean and variance of $log(p_t)$. The conditional mean and variance of the market price are then:

$$E(p_t) = exp(\mu_t + \sigma^2/2) \tag{2.7}$$

$$Var(p_t) = (exp(\sigma^2)\text{-}1)(exp(2\mu_t + \sigma^2)) \tag{2.8}$$

Because the price variables in the VAR are in logarithmic form, simulating the VAR provides estimates of $\mu_t$and σ^2. Then (2.7) is used to generate conditional means of price levels and (2.8) to generate conditional variances. The estimator of $\mu_t$conditional on exogenous variables (x_t) and policy variable (z_t) can be expressed as:

$$\widehat{\mu_t}\ |\ (x_t, z_t) = \widehat{log(p_t)}\ |(x_t, z_t) \tag{2.9}$$

Because the error variance, σ^2, is homoscedastic, its estimator can be obtained directly from the VAR as residuals squared

$$\widehat{\sigma^2}\ |\ (x_t, z_t) = \widehat{\sigma^2} = \hat{u}^2 \tag{2.10}$$

where $\hat{u}$ is residual from the equation of Thai rice in the VAR model.

2.3.3 Simulating random yields

Rice yield (Y_t) is assumed to be conditionally lognormally distributed with constant variance[16]:

$$Y_t|(t, Y_{t-1}) \sim Lognormal\ (\theta_t\ , \sigma_y^2) \tag{2.11}$$

A representative farmer is assumed to grow only one type of rice, white rice. White rice was chosen over other major rice types, including jasmine rice and glutinous rice, because it has the largest share in term of annual production. The simulation of rice yield is based on a series of annual average white rice yield in the Central Plain region, a major hub of white rice production, from 1981-2012. After testing for first-order autocorrelation and a unit root, one lag of yield and a time trend are included in the yield equation.[17,18]

$$logY_t = \alpha + \beta t + \delta logY_{t-1} + v_t \tag{2.12}$$

where v_t are assumed to be normally-distributed random errors.

2.3.4 Generating simulated profits under the five selected scenarios

The simulated yields and counterfactual market prices are used to generate a stochastic profits stream under the five scenarios of interest. The profit function (NR) under each scenario can be described as follows.

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[16] White test statistic for heteroskedastic variance (F-test) including fitted value in (2.12) as independent variable is 0.33 and p-value is 0.57. Thus, the null hypothesis of rice yield has a homoscedastic variance cannot be rejected at 5% level

[17] Augmented Dickey-Fuller test statistic for a unit root including a time trend and one yield lag is -3.768and MacKinnon approximate p-value is 0.0183. Thus, the null hypothesis of rice yield has a unit root is rejected at the 5% level

[18]Durbin's alternative test statistic for first-order autocorrelation of the error v_t in (2.12) is 0.155 and p-value is 0.6939. Thus, we cannot reject the null of no first-order autocorrelation

Scenario 1: No government intervention (NG)

$$NR_{PSP} = (AY)P^m_{NG} - AC$$

Because there is no financial support from the Government, profit only depends on market price (P^m_{NG}) and total production (*AY*) where *A* and *Y* denote land size and yield, respectively. Given a constant production cost per area (*C*), total production cost (AC) increases in proportion with lands size.

Scenario 2: Participating in PSP (PSP)

$$NR = (AY)P^S - AC - ((1+r)^t - 1))(AY)P^S \quad if\ P^S > P^m_{PSP}$$

$$= (AY)P^m_{PSP} - AC \qquad if\ P^S < P^m_{PSP}$$

The Government offers to buy unlimited amount of rice from farmer at the support price (P^S). By participating in the program, the farmer's profit is equal to a product of total production (*AY*) and either the support price (P^S) or the market price (P^m_{PSP}), whichever is higher, less the sum of production cost and participation cost (the last two terms on the right-hand side of the above profit equation). Note that simulated values of the counterfactual market price P^m_{PSP} are obtained from the VAR model. When P^S>P^m_{PSP}, the farmer will choose to sell to the Government at the support price and incur the additional cost of program participation expressed by the last term on the right-hand side of the above equation. This term represents an opportunity cost of the delayed loans assumed equal to forgone interests that could have been earned elsewhere if the loans were paid on time. Here, the interest rate (*r*) is equal to the average of maximum lending rates by major commercial banks. The length of time during which the interest is compounded is equal to number of days before farmers receive the sale proceeds from the government (*t*), which is randomly drawn (without replacement) from survey data using bootstrapping techniques. The household survey data contains 187 participants of PSP, 98 of which have reported delays of loans which ranges from 7 to 95 days.

Scenario 3: Declining PSP when available (NPSP)

$$NR = (AY)P_{PSP}^{m} - AC$$

This scenario reflects what is commonly observed in the Thai rice market that some farmers choose not to participate in PSP and instead sell their harvest on the open market. In this case, the profit depends on market price (P_{PSP}^{m}) and total production (AY).

Scenario 4: Participating in DPP (DPP)

$$NR = (AY)P_{DPP}^{M} + AY^{T}(Max\{P^{T} - P_{DPP}^{M}, 0\}) - AC$$

Deficiency payments are calculated based on the difference between the target price (P^{T}) and the estimated market prices (P_{DPP}^{m}), times the estimated yields (Y^{T}). The farmer sells rice to buyers in the market and receives the total revenue of (AY)P_{DPP}^{m}. The Government only makes deficiency payments to the farmer when the market price falls below the target price. Again, the distribution of counter factual market prices P_{DPP}^{m} is obtained from the VAR model.

Scenario 5: Declining DPP when available (NDPP)

$$NR = (AY)P_{DPP}^{m} - AC$$

If the farmer fails to participate in the program, he receives no deficiency payment and receives only the sale proceeds from selling in the open market at the market price (P_{DPP}^{m}).

2.3.5 Ranking the representative farmer preferences using SERF

The CRRA coefficients (RRAC) are assumed to range from 0.5 to 4 as suggested by Anderson and Dillon (1992); 0.5 is hardly risk averse, 1.0 is normal or somewhat risk averse, 2.0-is rather risk averse, 3.0 is very risk averse, and 4.0 is extremely risk averse. The initial wealth (W) of the representative farmer is assumed to equal twice the average of simulated total revenue obtained under no intervention. The power utility expressed as a function of the stochastic profit stream *X* under policy alternative *j* evaluated at the *ith* iteration can be written as

$$U_j\left(X_{ij}\right) = (X_{ij} + W)^{(1-RRAC)}$$

Given the probability (*p*) of observing each stochastic profit, the expected utility is

$$E\left(U_j\right) = \sum_i p_{ij}(X_{ij} + W)^{(1-RRAC)}$$

The formula for calculating certainty equivalence (CE) under power utility function is

$$CE = E(U_j)^{(\frac{1}{1-RRAC})} - W$$

SIMETAR converts the expected utility under each policy alternative into CE values for a set of selected values of RRAC which are bounded between 0.5 and 4. Using this approach we end up with a vector of CE values for each of the *n* alternatives calculated for several values of *RRAC* within the bound. Only those alternatives which have the highest CE values for some value in the range of *RRAC* are considered efficient. All other alternatives are dominated in the SERF sense. The method also provides a cardinal ranking at each level of risk aversion by interpreting differences in CE values as risk premiums.

2.3.6 Data

The rice prices in the VAR model include the farm-gate price of Thai white rice, the F.O.B. price of 5% broken white rice from Vietnam, and the F.O.B. price of 25% broken white rice from Pakistan. The prices observed in November and April from 1997 to 2012 are used as representative of prices observed during the first- and second-cropping season, because most rice production in each season are sold in these respective months. PSP was first implemented at a national level in the second season of the 2001/02 production year and lasted until the second season of the 2008/09 production year. DPP was first implemented in the first season of the 2009/10 production year and lasted until the second season of the 2010/11 production year after which the program was replaced by the PSP. This gives four observations of the period in which DPP was implemented and 15 observations in the case of PSP. The rest of the observations represent market data under no intervention (NG).

A series of farm-gate price of Thai rice is obtained from Thailand's Office of Agricultural Economics (OAE).A series of the export prices (F.O.B.) are obtained from United States Department of Agriculture (USDA) and the Food and Agriculture Organization (FAO). A series of support prices under PSP from 2001 to 2012 and the target price under DPP from 2009 to 2011 are obtained from Thailand Department of Internal Trade (DIT). Production costs including both fixed and variable costs are obtained from OAE. The length of delayed payments, defined as the number of days until farmers received the loan payments after pledging their rice with the Government, is obtained from the Author's 2012/13 rice farm survey in Buriram province. The sample contains 387 farm households of which 130 households participated in PSP during the 2012/13 first season. The cost of delayed payments is calculated by averaging the maximum lending rates by major commercial banks. The rice yields obtained from OAE are the average yields observed in the Central Plain region from 1981 to 2012.

2.4 Results

The preference rankings in 2006/07 and 2012/13 are reported separately. This cross comparison examines whether the ranking would change as the difference between the support and market prices increases from its historical minimum to maximum. This section is organized into five parts. The first part presents the estimation of conditional mean and variance of market price under three policy regimes (i.e. PSP, DPP, and NG) by the VAR model. The second part presents the estimation of conditional mean and variance of rice yield by the AR (1) model. Upon obtaining the estimates of conditional market prices and yields, SIMETAR uses these means and variances to simulate stochastic farm profits which are then converted to CE values for preference ranking by SERF. The third and fourth parts discuss the preference rankings by SERF in 2006/07 and 2012/13, respectively. The last part provides a sensitivity analysis of the preference ranking with respect to yield variability and levels of initial wealth.

2.4.1 Simulation of market prices

The VAR model consists of three rice-price equations including farm-gate price of Thai rice and export prices of rice from Vietnam and Pakistan. For the purpose of this study, we are only interested in the parameter estimates from the equation of the Thai rice price in log form, (*log (Thai farm-gate price*)). Hence, only the regression results from this equation are discussed (see **Table 2.1)**.[19] All explanatory variables are jointly significant at the 1% significant level. All prices lagged by two seasons are statistically significant at 5%. This means the response of current price to changes of past prices is more pronounced within the same cropping season.

[19]The results from the other two equations are reported in **Table A2.1a-A2.1b** in appendix A.

Despite their statistical insignificance, *Season* and *Coup2006* are included in the model as their slope coefficients display signs that are consistent with our prior expectation. Dropping these variables causes the slope coefficients of other variables to display signs that are counterintuitive. The negative sign on the dummy variable *Season* indicates that the first crop receives lower market price than the second crop does, which is reasonable as we would expect lower market price during the first season due to higher production. The slope coefficient on the dummy*Coup2006* is positive which indicates that only weak evidence was found to support that the continuation of PSP by the military-elected Government had boosted the market price. The dummy variable *Crisis2008* has a positive slope coefficient and is statistically significant at 1%.As we would expect, the crisis drove the farm-gate price and export prices to unprecedented levels. Furthermore, the crisis also caused some spillover effect which persistently continues into subsequent years as indicated by a positive sign on the slope coefficient of the dummy variable *Post-Crisis*.

Table 2.1: Regression result from the equation of Thai rice price in the VAR model

Dep. Variable: log(Thai farm-gate price)$_t$	Coeff.	Std. Err.	z	P>z
log(Thai farm-gate price)$_{t-1}$	-0.116	0.207	-0.560	0.574
log(Thai farm-gate price)$_{t-2}$	0.378	0.224	1.690	0.041
log(Vietnam export price)$_{t-1}$	-0.426	0.265	-1.610	0.108
log(Vietnam export price)$_{t-2}$	-0.603	0.280	-2.160	0.031
log(Pakistan export price)$_{t-1}$	0.614	0.254	2.410	0.016
log(Pakistan export price)$_{t-2}$	0.663	0.312	2.120	0.034
PSP dummy	0.143	0.049	2.930	0.003
DPP dummy	-0.020	0.096	-0.210	0.832
Season dummy	-0.024	0.043	0.550	0.585
Coup2006 dummy	0.090	0.076	1.190	0.233
Crisis2008 dummy	0.534	0.112	4.750	0.000
Post-Crisis dummy	0.301	0.113	2.670	0.008
Constant	5.069	1.164	4.360	0.000

Despite an increase in rice supply following the implementation of PSP and DPP, both programs have different effects on market price as evidenced by the differences in the direction of the price change and its magnitude. The dummy variable *PSP* is statistically significant at 1% which implies that PSP increases market price by 14.3% on average. In contrast, the dummy variable *DPP* has negative coefficient. This result suggests that market price decreases by 2% on average throughout the course of DPP implementation. However, the impact of DPP is not statistically significant which is probably due to insufficient number of observations as the program was implemented for only two years (four cropping seasons). Of course, these estimates may be fragile given the small number of total observations, especially those under DPP. However, it is interesting to note that these results are quite consistent with the price effects of DPP and PSP estimated by the partial equilibrium model reported in Chapter 1. For the partial equilibrium results the market price is estimated to increase by between 10.40 and 20.58% on average under PSP in the 2005/06 season while it is estimated to fall by between 0.62 and 2.75% on average under DPP. Because the estimates of policy impact on market price estimated by the VAR model fall within these ranges estimated by the partial equilibrium model, we argue that they are quite reasonable and use of these values to compute the market price distribution is appropriate.

The slope coefficients of PSP and DPP have opposite sign as expected. As all rice production must be sold to private buyers in the open market under DPP, the increase in total rice supply tends to cause the market price to fall. In contrast, the competition between the Government and other buyers in the market drives up the market price under PSP.[20] The

[20]It is important to note that the market price can fall below the support price under PSP because some farmers decline to sell to the Government, even when the support price is higher than the market price, because the decision to participate in the program is governed not only by size of the support price relative to the market prices but also

magnitude of price change is much larger under PSP because the Government purchases large amounts of stock that are not released back onto the domestic market. The amount of rice production withdrawn from the market by the Government purchase under PSP offsets the increase in total rice supply induced by the program; the average quantity of pledged rice in the first-season from 2005/06 to 2008/09 is 4.24 million tons while total supply only increased by 1.14 million tons per year on average.

The fitted values of the conditional log price and its standard errors are used to simulate the counterfactual market prices under PSP, DPP, and NG scenarios by assuming the log price is normally distributed. Summary statistics of the simulated prices in 2006/07 and 2012/13 are presented in **Table 2.2**. Recall that only the PSP was implemented in these selected years. The support prices in 2006/07 and 2012/13 were 15,000 and 6,500 baht/ton as shown in column 4.[21] Mean and standard deviation of the simulated counterfactual prices are reported in column 5 and 6.Given the support price of 15,000 baht/ton, the corresponding market price is estimated at 10,112 baht/ton. Replacing PSP by DPP would cause the market price to fall to 8,598 baht/ton while removing all intervention programs would change market price to 8,775 baht/ton. When the support/target price is set at 6,500 baht/ton the estimated market price under PSP is approximately 6,281 baht/ton and the counterfactual market prices under DPP and NG are 5,445 and 5,336 baht/ton, respectively.

Notice that the probability that the market price exceeds the support price under PSP is very small in 2012/13 because the price differential is as high as 4,888 while standard deviation is only 965. In contrast, the probability of the market price exceeding the support price is much

by individual farm characteristics such as land size and financial position that may influence the costs of participation in the PSP.

[21]The averages of actual market price corresponding to these support prices were 9,753 and 6,380 baht/ton, respectively (not shown in the table).

higher in 2006/07 as the price differential is only 219 while the standard deviation is 599.Thus, in 2012/13 the support/target price will almost always trigger and the representative farmer would base his or her decision on the high probability of receiving these prices when choosing between PSP and DPP.

Table 2.2: Mean and standard deviation of counterfactual farm prices

Type	Year	Regime	Support/Target Price	Market Price	
				Mean	Std.
White	2012/13	PSP	15,000	10,112	965
White	2012/13	NG	NA	8,775	837
White	2012/13	DPP	15,000	8,598	820
White	2006/07	PSP	6,500	6,281	599
White	2006/07	NG	NA	5,445	519
White	2006/07	DPP	6,500	5,336	508

2.4.2 Simulation of rice yields

The result from the AR (1) of log yields is reported in **Table 2.3**. The adjusted R-squared is 0.75. All explanatory variables are jointly significant at 1%. Random yields are simulated from the fitted values of log yield in year 2006 by assuming that the log yield is normally distributed. Upon obtaining these fitted values rice yields are converted from log to level. Summary statistics of the simulated conditional yields in 2006/07 and 2012/13 are presented in **Table 2.4**.

Table 2.3: OLS regression of Thai rice yield

log(Yield)	Coefficient	Std.	t	P>t
Constant	4.849	1.1	4.41	0
Year	0.019	0.005	3.79	0.17
L1.log(Yield)	0.183	0.186	0.99	0.333

Table 2.4: Summary statistics of simulated rice yields

	Mean	Std.	Min	Max
Yield 2006/07	536.50	61.12	377.61	739.75
Yield 2012/13	621.69	71.40	410.25	946.79

2.4.3 The preference ranking by SERF in the 2012/2013 season

Table 2.5 shows summary statistics of the simulated profits plus initial wealth under the five scenarios of interest in the 2012/13 production season.[22] The gap between the support/target price and the market price is largest in this period. The simulation of profit assumes that the support/target price is equal to 15,000 baht/ton, the actual observed value in this season. The result shows that PSP and DPP have raised mean farm profit by significant amount. The standard deviation of profit under PSP is much large than that under DPP, so PSP is found to be more risky than DPP. In fact, DPP yields the lowest standard deviation of profit in all cases. This is because the program guarantees to pay farmers a fixed payment for each unit of land registered regardless of actual outputs produced as long as the market price falls below the target price.

Table2.5: Summary statistics of simulated profit plus initial wealth in 2012/13

	NG	PSP	DPP	NPSP	NDPP
Mean	144,197	237,193	240,527	164,108	140,795
Std.	20,790	26,929	15,726	23,886	20,276
Min	88,797	162,656	197,239	104,432	91,780
Max	207,291	331,486	304,370	262,690	231,070

[22] Because profit streams need to be greater than zero in order to calculate certainty equivalent values under power utility function, initial wealth calculated as mean of revenues under no intervention was added to each value of the simulated profit. Initial wealth in the 2012/13 season was calculated at 135,000 baht. Nevertheless, the term "profit" will be used to refer to "profit plus initial wealth" throughout the remaining sections of this study for convenience purposes.

Figure 2.1: Profit CDFs of the representative rice farmers in 2012/13

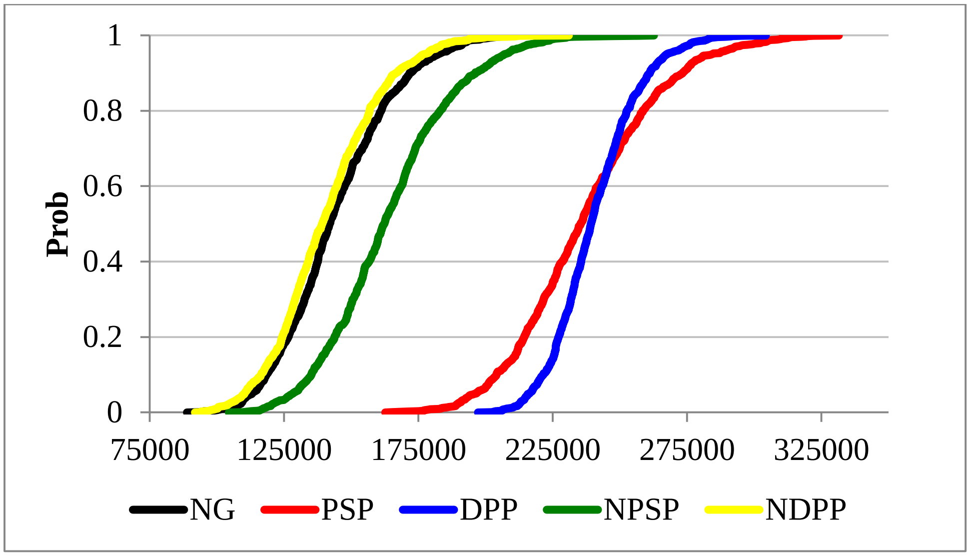


Figure 2.1 shows the CDF plots of farm profits under the five scenarios. According to first-degree stochastic dominance (FSD), the profit streams under PSP and DPP dominate those of NPSP, NDPP, and NG because CDFs of the former scenarios are always located to the left of the latter scenarios. This means the farmer is always better off when joining either PSP or DPP. However, the shape of these CDFs suggests that PSP is more risky than DPP; the probability of observing profits falling in the upper- and lower-tail of distribution is higher under PSP. In addition, one may ask whether the farmer is still better off under the implementation of PSP compared to the no intervention scenario if he is unable to participate in the program. This situation is particularly important because significant portions of rice farm households in Thailand do not participate in PSP. Although those who fail to participate in PSP are not guaranteed a sale price as high as the support price, they still benefit from an increase in the market price brought about by the program. The tradeoff, of course, is the higher dispersion of the market price and profit. The CDF graphs clearly show that the NPSP scenario dominates NG and NDPP by FSD. This means the gain from an increase in the mean market price under PSP is

so large that it outweighs the cost associated with the higher variance of profit. Unfortunately, the preference ranking between PSP and DPP cannot be determined by FSD as their CDFs cross. Thus, the ranking must be justified based on the CE values of profit stream and levels of risk-aversion which is done by SERF.

Figure 2.2: The SERF ranking of the five scenarios in 2012/13 based on CE values

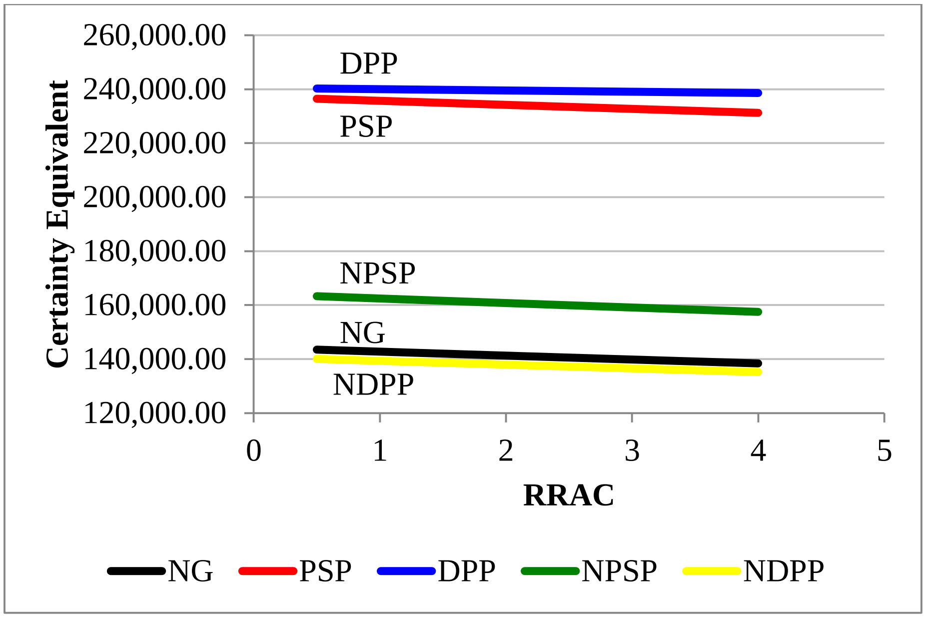


Figure 2.2 illustrates the preference ranking of the representative farmer towards the five scenarios of interest by SERF based on the CE values associated with profit streams calculated over a range of constant relative risk aversion (CRRA) from 0.5 to 4. These CE values jointly establish a CE line for each scenario. Notice that all CE lines have a downward slope which indicates that the sure sum that would make the farmer as well off as accepting a stream of stochastic profit gets smaller as the farmer becomes more risk-averse. Because the CE line under DPP always lies above that of PSP, the representative farmer would always prefer DPP to PSP.

The ranking by SERF of the other scenarios is consistent with that by FSD. That is, NPSP is preferred to NG and NDPP. By the same token, NG is preferred to NDPP.

To supplement the ordinal ranking provided by SERF, the CE values computed at the five selected values of CRRA can be used to provide a cardinal ranking of these scenarios, as shown in **Table 2.6**. For a given value of CRRA, the difference in CE values between any pair of scenarios indicates the risk premium, or minimum amount of a sure sum that makes the farmer indifferent between alternatives. For example, a normal risk-averse farmer defined as having CRRA of 1 would prefer DPP to PSP and the risk premium is 4,344 baht. This means the farmer is willing to pay up to 4,344 baht in exchange for the profit stream under DPP instead of PSP. The risk premium increases as the CRRA coefficient increases from 1 to 4, in which case the risk premium is 7,272. Because the sizes of the premiums are not trivial, we conclude that the farmer clearly prefers DPP to PSP.

Table 2.6: The CE values at five given values of CRRA coefficient in 2012/13

RRAC	NG	PSP	DPP	NPSP	NDPP
0.5	143,458	236,438	240,273	163,254	140,078
1	142,708	235,671	240,015	162,390	139,352
2	141,223	234,151	239,505	160,682	137,915
3	139,759	232,647	239,000	159,003	136,500
4	138,419	231,265	238,537	157,470	135,204

2.4.4 The preference ranking by SERF in the 2006/2007 season

Table 2.7 shows summary statistics of simulated profits plus initial wealth under the five scenarios of interest in 2006/07.[23] The support/target price is set at 6,500 baht/ton which is the actual observed value in this season. The gap between the support/target price and the market

[23] The initial wealth in the 2006/07 was calculated at 75,000 baht

price is much smaller compared to the case of 2012/13. As a result, there is a much lower probability of realizing a market price that triggers Government purchases or deficiency payments. Because the mean and variance of the market price are higher under PSP, the farmer benefits in two ways when participating in the program. First, the farmer is guaranteed a minimum price equal to the support price. Second, his chances of receiving a market price that exceeds the support price is also higher. In other words, the program not only insures the farmer against low market prices but also increase the probability of receiving a higher market price. The latter benefit is smaller under DPP because mean and variance of the market price are lowest under this program.

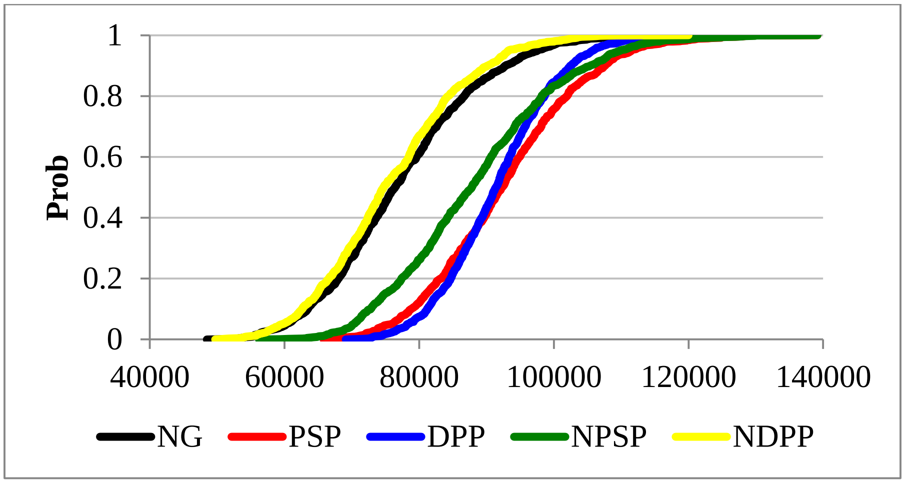
Table 2.7: Summary statistics of simulated profit plus initial wealth in 2006/07

	NG	PSP	DPP	NPSP	NDPP
Mean	77,390	92,754	91,678	88,402	75,826
Std.	11,442	11,146	8,460	12,402	10,599
Min	48,478	65,831	69,118	56,195	49,715
Max	131,318	139,164	130,141	139,164	120,016

Figure 2.3 shows the CDF plots of profit under the five scenarios in 2006/07. Like in the case of 2012/13, the profit streams obtained under NDPP and NG are FSD dominated by the other scenarios. This means the farmer is better off when the Government intervenes in the market, either in the form of PSP or DPP. Again, the no intervention scenario is less preferred to PSP, even when the farmer does not participate in the program. The shape of these CDFs suggests that PSP and NPSP are more risky than DPP; the probability of observing profits falling in the upper- and lower-tail of distribution is higher under PSP and NPSP. Unfortunately, the preference rankings of the pairs PSP&DPP and NPSP&DPP cannot be determined by FSD as

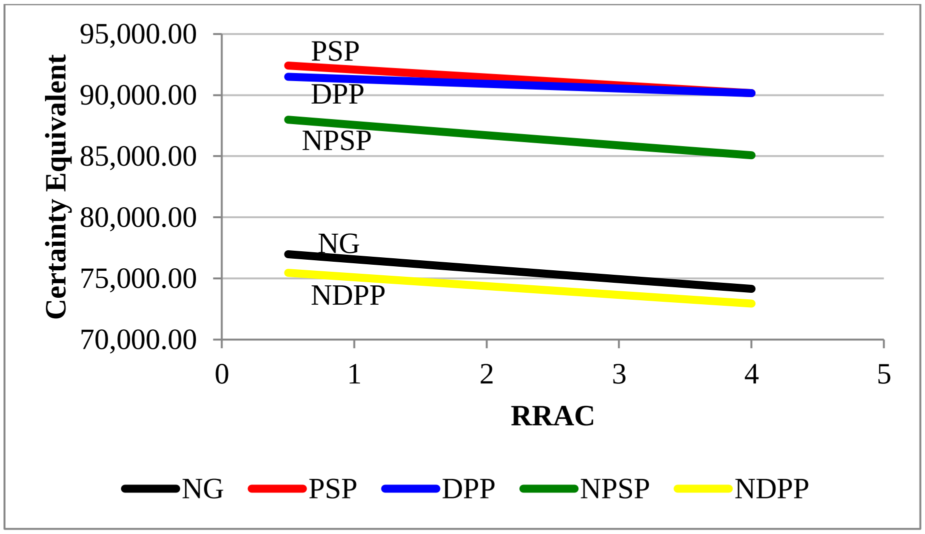
their CDFs cross. Thus, the ranking must be justified based on the CE values of profit stream and levels of risk-aversion which is done by SERF.

Figure 2.3: Profit CDFs of the representative rice farmers in 2006/07



The preference ranking by SERF in 2006/07 is shown in **Figure 2.4**. The result clearly indicates that DPP is preferred to PSP and NPSP as the CE lines of the former case are always above the latter cases. The fact that the CE lines under PSP and DPP are close to one another implies that the risk premium is small and hence the farmer prefers one to the other only by a small margin.

Figure 2.4: The SERF ranking of the five scenarios in 2006/07 based on CE values



The CE values computed at the five specific values of CRRA are reported in **Table 2.8.** Notice that the risk premium of the pair PSP&DPP for a normally risk-averse individual (CRRA coefficient of 1) is only 799 baht. This means a DPP participant requires only 799 baht of a sure sum in order to make him as well off as participating in PSP. Unlike in the case of 2012/13, the risk premium decreases as the CRRA coefficient increases from 1 to 4, in which case the risk premium is only 10 baht. This implies the gain from an increase in mean of the market price under PSP slightly outweighs its cost associated with delayed payments for a normally risk-averse individual while they equally offset each other for an extremely risk-averse individual. Because the sizes of the premiums are very small, we conclude that the farmer would be almost indifferent between the choice of DPP and PSP when the support/target price is close to the market price.

Table 2.8: The CE values at five given values of CRRA coefficient in 2006/07

RRAC	NG	PSP	DPP	NPSP	NDPP
0.5	76,974	92,423	91,484	87,974	75,459
1	76,553	92,087	91,288	87,541	75,086
2	75,721	91,421	90,896	86,686	74,346
3	74,903	90,763	90,508	85,846	73,613
4	74,155	90,160	90,150	85,083	72,942

2.4.5 Sensitivity analysis of the preference ranking

The results from the preference ranking by SERF discussed above were obtained under some specific assumptions on initial wealth, the yield distribution, the price distribution, and rate of interest charged on delayed loan payments. The order of the ranking, however, could change if these parameters take on different values. Thus, a sensitivity analysis was conducted by varying these parameters within a specific range. Specifically, the standard deviation of rice yield, the standard deviation of market price, level of initial wealth, and level of maximum lending rate were scaled up and down by a factor of two. The results from the sensitivity analysis in 20012/13 and 2006/07 are reported in **Table 2.9** and **Table 2.10**, respectively. In 2012/13, the ranking is not sensitive to changes in these parameters. So, DPP is still always preferred by a risk-averse farmer, whose CRRA coefficients are bounded between 0.5 and 4, independent of initial wealth, degree of yield and price variability, and lending rate.

In 2006/07, the ranking between PSP and DPP is sensitive to changes in all of the parameters while the rankings among NPSP, NG, and NDPP are not. Recall that PSP is preferred to DPP in the base case. However, the ranking switches and at least the extremely risk-averse farmer would switch his/her preference from PSP to DPP when initial wealth or price volatility is halved. This means the farmer is less willing to take on a more-risky asset (i.e. PSP) as wealth decreases. Similarly, the reduction in price volatility lowers the probability of receiving a high market price which decreases the benefit of PSP. In addition, the extremely risk-averse farmer would prefer DPP to PSP if yield variability or lending rate is doubled. This means PSP becomes too risky as yield variability and lending rate increase. Because the risk premiums associated with the pair DPP&PSP are quite small in all cases in 2006/07, we conclude that the farmer is largely in different between these programs.

Table 2.9: Sensitivity analysis of the SERF ranking in 2012/13

Parameter	Ranking	Scaled down by 1/2		Base		Scaled up by 2	
		LRAC	URAC	LRAC	URAC	LRAC	URAC
Initial wealth	1st	DPP	DPP	DPP	DPP	DPP	DPP
	2nd	PSP	PSP	PSP	PSP	PSP	PSP
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP
Yield Std.	1st	DPP	DPP	DPP	DPP	DPP	DPP
	2nd	PSP	PSP	PSP	PSP	PSP	PSP
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP
Price Std.	1st	DPP	DPP	DPP	DPP	DPP	DPP
	2nd	PSP	PSP	PSP	PSP	PSP	PSP
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP
Lending rate	1st	DPP	DPP	DPP	DPP	DPP	DPP
	2nd	PSP	PSP	PSP	PSP	PSP	PSP
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP

Table 2.10: Sensitivity analysis of the SERF ranking in 2006/07

Parameter	Ranking	Scaled down by 1/2		Base		Scaled up by 2	
		LRAC	URAC	LRAC	URAC	LRAC	URAC
Initial wealth	1st	**PSP**	**DPP**	PSP	PSP	PSP	PSP
	2nd	**DPP**	**PSP**	DPP	DPP	DPP	DPP
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP
Yield Std.	1st	PSP	PSP	PSP	PSP	**PSP**	**DPP**
	2nd	DPP	DPP	DPP	DPP	**DPP**	**PSP**
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP
Price Std.	1st	**DPP**	**DPP**	PSP	PSP	PSP	PSP
	2nd	**PSP**	**PSP**	DPP	DPP	DPP	DPP
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP
Lending rate	1st	PSP	PSP	PSP	PSP	**PSP**	**DPP**
	2nd	DPP	DPP	DPP	DPP	**DPP**	**PSP**
	3rd	NPSP	NPSP	NPSP	NPSP	NPSP	NPSP
	4th	NG	NG	NG	NG	NG	NG
	5th	NDPP	NDPP	NDPP	NDPP	NDPP	NDPP

2.5 Conclusion and discussion

The objective of this study is to compare the preference ranking of a representative rice farmer in Thailand towards two important government programs—the price support program (PSP) and the deficiency payment program (DPP). Under PSP the government buys rice from farmers at the support price by issuing loans based on actual production. In contrast, DPP requires farmers to sell rice on the open market. Only when the market price falls below the target price does the Government compensate farmers with deficiency payments, which depend on estimated production. It might initially seem that PSP and DPP should yield equal benefits to farmers when the support price and the target price are equal, which would lead to the conclusion that the farmers should be indifferent between these programs. However, the benefits realized under each program are distinct and can differ significantly for at least three reasons. First, the benefits of PSP are discounted due to the additional cost associated with the delayed payment of program loans. Second, the fact that deficiency payments are made based on a fixed yield implies that farmers are compensated more or less than they would be paid if the payments were based on actual yields. Third, distribution of profits could significantly differ if the impact of PSP and DPP on probability of the market price exceeding the support/target price differ.

Stochastic efficiency with respect to a function (SERF) is employed to rank farmer preferences by comparing the certainty equivalent (CE) values associated with the stochastic profit streams under each policy scenario. The representative farmer is assumed to grow rice on a 25-rai rice land and face stochastic profit because of random yield and market price uncertainty. Random yield is simulated from the estimated mean and variance of yield obtained from a first-order autoregression model with trend. The market prices under each policy regime are simulated from the conditional mean and variance of the farm-gate price of Thai white rice estimated from the vector autoregressive (VAR) model which captures the relationship between rice prices and the effect of changes in the policy regime on the price distributions. The VAR model consists of three equations of rice prices including the farm-gate price of Thai white rice and the export prices of white rice from Vietnam and Pakistan. After obtaining the simulated values of yield and market prices the simulated profit under the following five scenarios are generated: PSP participation & non-participation, DPP participation & non-participation, and no intervention. Lastly, SERF is employed to rank the farmer preferences in two selected seasons: the first-cropping seasons of 2006/07 and 2012/13. These seasons represent a period in which the difference between the support/target and market price is considerably small and large, respectively.

The results from the VAR model show that in 2012/13 PSP has increased the average farm-gate price of Thai rice by 14.3% while DPP would have depressed average price by 2%. The increase in the market price under PSP, however, comes at the cost of higher price variability. Price variance is largest under PSP and smallest under DPP. In both selected periods the profit streams under PSP and DPP dominate profits under NG by FSD. In addition, the farmer is better off under the PSP compared to the no intervention scenario, even if the choice is to not participate. This result is particularly important because more than half of rice farm households in the country do not participate in the PSP due to the additional costs associated with delayed payments. Although those who fail to participate in PSP are not guaranteed a sale price as high as the support price, they still benefit from an increase in the mean of market price brought by the program. The tradeoff, of course, is the higher variance of the market price and profit. The CDF graphs clearly indicate that the farmer is indeed better off under PSP even when failing to receive the support price as a nonparticipant of the program. This means the gain from an increase in the mean of market price under PSP is large enough that it outweighs the cost associated with the higher degree of profit variation.

The preference ranking between PSP and DPP cannot be determined by FSD because their CDFs cross. The preference ranking by SERF shows that all risk averse farmers would prefer DPP to PSP in 2012/13. This ranking is invariant to changes in initial wealth, yield variability, price volatility, and the lending rate viewed an opportunity cost of delayed payments under PSP. In 2006/07 the preference ranking switches and the farmer now prefers PSP to DPP by small margins. In addition, the results are sensitive to changes in all of the parameters. When the standard deviation of price or initial wealth is halved, an extremely risk-averse farmer would prefer DPP to PSP. Similarly, the farmer is willing to take less risks, and hence chooses DPP over PSP, as the lending rate or the standard deviation of yield is doubled. However, the difference in these rankings measured in term of risk premium is very small. Thus, one could argue that the farmer is largely indifferent between PSP and DPP in this case. Overall, DPP is ranked either higher than PSP by large premiums or lower by small premiums which allows us to conclude that the farmer would prefer DPP to PSP in most situations if both are simultaneously offered by the Government at identical support and target prices.

At least two policy implications can be drawn from this study. First, given the criticisms that PSP generates enormous government deficits, has been marred by alleged corruption, and provides an unequal distribution of program benefits, switching from PSP to DPP could alleviate these problems and still be preferred by most farmers in most situations. Second, because sensitivity analysis indicates that the preference ranking is sensitive to changes in yield variability, crop insurance programs could have a significant influence on farmer preferences for alternative farm programs.

APPENDIX

Table A2.1a: Regression result from the equation of Vietnam export price in the VAR model

Dep. Variable: log(Vietnam export price)$_t$	Coefficient	Std. Err.	z	P>z
log(Thai farm-gate price)$_{t-1}$	-0.506	0.374	-1.350	0.177
log(Thai farm-gate price)$_{t-2}$	0.420	0.406	1.040	0.300
log(Vietnam export price)$_{t-1}$	-0.788	0.481	-1.640	0.101
log(Vietnam export price)$_{t-2}$	-0.667	0.507	-1.320	0.188
log(Pakistan export price)$_{t-1}$	1.146	0.461	2.490	0.013
log(Pakistan export price)$_{t-2}$	0.794	0.566	1.400	0.160
PSP dummy	0.093	0.088	1.060	0.291
DPP dummy	0.053	0.174	0.310	0.759
Season dummy	0.012	0.079	0.150	0.880
Coup2006 dummy	0.399	0.137	2.900	0.004
Crisis2008 dummy	0.842	0.203	4.140	0.000
Post-Crisis dummy	0.502	0.205	2.450	0.014
Constant	3.707	2.109	1.760	0.079

Table A2.1b: Regression result from the equation of Pakistan export price in the VAR model

Dep. Variable: log(Pakistan export price)$_t$	Coefficient	Std. Err.	z	P>z
log(Thai farm-gate price)$_{t-1}$	-0.243	0.330	-0.740	0.462
log(Thai farm-gate price)$_{t-2}$	0.067	0.358	0.190	0.852
log(Vietnam export price)$_{t-1}$	-1.166	0.424	-2.750	0.006
log(Vietnam export price)$_{t-2}$	-0.160	0.446	-0.360	0.719
log(Pakistan export price)$_{t-1}$	1.705	0.406	4.200	0.000
log(Pakistan export price)$_{t-2}$	0.262	0.498	0.530	0.599
PSP dummy	0.102	0.078	1.310	0.191
DPP dummy	0.137	0.153	0.900	0.371
Season dummy	-0.148	0.069	-2.140	0.032
Coup2006 dummy	0.399	0.121	3.300	0.001
Crisis2008 dummy	0.542	0.179	3.020	0.002
Post-Crisis dummy	0.365	0.180	2.020	0.043
Constant	3.579	1.856	1.930	0.054

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CHAPTER 3: TECHNICAL EFFICIENCY OF THAI JASMINE RICE FARMERS: COMPARING SUPPORT PRICE PROGRAM PARTICIPANTS AND NON-PARTICIPANTS

3.1 Introduction

In Thailand, the rice price support program (PSP) continues to be used to support rice prices and raise farm incomes. Under the PSP, farmers are allowed to sell their paddy rice to the Government at the support price, which is administratively determined. Then farmers are given four months to redeem the pledged paddy (reject the Government offer and sell their rice on the open market), otherwise they have to deliver the paddy to the Government and receive the support price. The primary objective of the program has turned from an initial focus on stabilizing rice prices to raising farm incomes as, over time, the support price has been raised more and more relative to the market price. As a result, Thailand has witnessed an enormous increase in rice production from 27.16 million tons in 2001 to 37.43 million tons in 2012.

Some analysts have questioned the effectiveness of the PSP. In particular, it has been argued that large-scale commercialized farmers are the major recipients of the benefits while small-scale farm households tend to have been left out (Poapongsakorn and Charupong, 2010). This raises two important questions. First, what factors influence farmer decisions to participate in the PSP? Second, are there differences in the rice production technology being used and the level of technical efficiency among program participants and non-participants? The decision to participate will be governed by the size of the support price relative to the market price but other individual farm characteristics such as size and financial position may also influence the costs of participation for individual farms. For example, farmers who deliver rice to the Government typically have to wait extra time to receive payment and the size, scope, and financial position of the farm may influence their ability to accept delayed payment. The PSP may also attract new farmers and marginal farmers who otherwise would not have brought land into rice production, and these new entrants may use different technologies and have different levels of technical efficiency. The determinants of the participation decision and the distribution of technical efficiency among participants and non-participants is important information for evaluating the full economic effects of the PSP.

The stochastic frontier model (SFM) is a standard approach to evaluating the nature of production technologies and the distribution of technical efficiency among a sample of firms (Aigner, Lovell, and Schmidt, 1977). Several studies have applied the SFM to samples of Thai rice farmers (Chaovanapoonphol, Battese, and Chang, 2009; Rahman, Wiboonpongse, Sriboonchitta, and Chaovanapoonphol, 2009; Srisompun and Isvilanonda, 2012). Yet, the issue of whether PSP participants and nonparticipants use the same production technologies and have the same levels of technical efficiency has not been investigated to date. One approach would be to estimate different SFMs for each subsample of data (participants and nonparticipants) and compare results. However, the fact that farmers choose to participate or not in a way that is likely non-random may lead to sample selection bias in estimates from this naïve approach. Failure to account for such selectivity could bias the estimated parameters of both the stochastic frontier production technology and the distribution of technical efficiency.

In response, we augment the standard stochastic frontier model with a participation equation explaining the decision to participate in the PSP, and then use Heckman's two-step estimation and Greene's sample selection stochastic production frontier model to explore levels of technical efficiency among participants and non-participants. The resulting model is used to investigate two important issues: (a) what are the key determinants of farmers' decision to participate in the PSP?; and (b) do program participants and non-participants use different rice production technologies and have different levels of technical efficiency?

3.2 Theoretical model

In this section we first discuss the standard stochastic frontier model proposed by Aigner, Lovell, and Schmidt (1977) (here after the ALS model) that does not account for selection bias. Then we discuss the two approaches to accounting for selectivity bias in SFMs, namely Heckman's SFM two-step estimation (Heckman, 1979) and Greene's SFM with correction for sample selection bias (Greene, 2010).

3.2.1 Stochastic frontier model (SFM model)

The standard stochastic frontier model or the ALS model (Aigner, Lovell, and Schmidt, 1977) is specified as:

$$y_i = \boldsymbol{\beta}'\boldsymbol{x_i} + v_i - u_i\,, \qquad (3.1)$$

$$u_i = \sigma_u|U_i|,\ \ U_i \sim N[0,1]$$

$$v_i = \sigma_v V_i,\ \ V_i \sim N[0,1]$$

where y_i,$\boldsymbol{x_i}$,v_i, and u_i represent output, input vector, idiosyncratic error in the production frontier, and technical inefficiency, respectively, for a sample of firms indexed by *i*. Technical inefficiency $u_i$is assumed to be truncated normal and takes only non-negative values. The frontier is assumed linear in parameters but nonlinearity of the production frontier is allowed through transformations of the y_i, and $\boldsymbol{x_i}$values (e.g. log transformations and including higher order terms in $\boldsymbol{x_i}$). The standard model assumes that the mean level of technical inefficiency is invariant across observations. However, Kumbhakar et al. (1991) show how to relax this assumption by allowing the mean to be a function of exogenous variables (e.g. management skills). This specification allows a part of the technical inefficiency to be explained by farm-specific factors. Econometric estimation provides estimates of the frontier parameters together with an auxiliary model of technical inefficiency as a function of farm-specific factors.

One underlying assumption of SFMs is that all farmers in the sample have access to the same production technology. If some characteristics allow a sub-sample of farmers to have access to a different production technology, a separate estimation of the stochastic frontier production is needed. However, these subsample estimations may then provide biased estimation of population production functions if the farmers' decision on which technology to use is governed by farm and farmer characteristics. Treating the observed data as if they are randomly sampled from the population and estimating the SFM of each subsample separately potentially biases the estimated parameters.

There are two approaches to accounting for this selectivity bias in SFMs: (a) the Heckman's two-step procedure to correct for sample selection bias by appending the inverse Mill's ratio as a covariate in separate SFMs for each sub-sample (Heckman, 1979); (b) Greene's SFMs with correction for sample selection bias. Green's model jointly estimates the selection models and the SFMs allowing for correlated errors (Greene, 2010).

3.2.2 SFM estimation using Heckman's approach

Let d_i^*be a latent variable representing an unobservable selection criterion variable which is postulated to be a function of some exogenous variables ($\boldsymbol{z_i}$):

$$d_i^* = \boldsymbol{\alpha}'\boldsymbol{z_i} + w_i \tag{3.2}$$

where $\boldsymbol{\alpha}$ is a vector of parameters and w is the error term distributed as $N(0, \sigma_w^2)$.The selection criterion variable is unobserved. Instead, a dummy variable, d_i, is observed and takes a value of 1 when $\boldsymbol{\alpha}'\boldsymbol{z_i} + w_i > 0$ and the decision is made to participate and zero otherwise:

$$d_i = 1[\boldsymbol{\alpha}'\boldsymbol{z_i} + w_i > 0],\ w_i \sim N[0,1] \tag{3.3}$$

where the variance of w has been normalized to one.

SFM estimation by Heckman's (1979) two-step procedure to correct for sample selection bias involves the following steps: (1) fit a probit model for the sample selection equation; and (2) estimate a SFM for each subsample but including the inverse Mill ratio (IMR) from the first step as a covariate to correct for selectivity bias and test its significance using a t-test. If the slope coefficient of the IMR from at least one of the sub-samples is significantly different from zero, there is evidence to reject the null hypothesis of no selection bias. On the other hand, failure to reject the null hypothesis indicates that selection bias is not present. The model can be specified as (3.3) plus:

Regime 1: $$y_{i1} = \boldsymbol{\beta_1}'\boldsymbol{x_{1i}} + \rho_1 IMR_{1i} + v_{i1} - u_{i1} \qquad if \quad d_i = 0 \tag{3.4}$$

Regime 2: $$y_{i2} = \boldsymbol{\beta_2}'\boldsymbol{x_{2i}} + \rho_2 IMR_{2i} + v_{i2} - u_{i2} \qquad if \quad d_i = 1 \tag{3.5}$$

where $u_{ji} = \sigma_{ju}|U_{ji}|,\ \ U_{ji} \sim N[0,1] \quad ;\ j = 1,2$

$v_{ji} = \sigma_{jv}V_{ji},\ \ V_{ji} \sim N[0,1] \quad ;\ j = 1,2$

ρ_j is the parameter that detects the presence of selectivity bias

The estimation of (3.4) and (3.5) proceeds as follows. First, (3.3) is estimated using the full sample and the IMR is obtained and substituted into (3.4) and (3.5). Second, (3.4) and (3.5) are estimated by sub-sample OLS. Finally, the t-test on IMR will determine whether we can reject the null hypothesis of no selection bias.

3.2.3 SFM estimation using Greene's approach

Greene (2010) argues that the Heckman's switching regression is inappropriate in models that are nonlinear because: (1) in nonlinear models like the SFM the impact of selection on the conditional mean of the model of interest will not necessarily take the form of an inverse Mill ratio; (2) the bivariate normality assumption needed to justify the inclusion of the inverse Mills ratio in the second model does not generally appear anywhere in the SFM; and (3) the dependent variable, conditioned on the sample selection, is unlikely to have the distribution described by the model in the absence of selection.

Greene proposed an internally consistent method of incorporating the sample selection problem in a SFM. In his model the error term in the selection model (w_i) is assumed to be correlated with the noise in the SFM (v_i). This correlation between v_i and w_i is denoted by ρ. Greene's model is then written as:

$$d_i = 1[\boldsymbol{\alpha}'\boldsymbol{z_i} + w_i > 0], \; w_i \sim N[0,1] \tag{3.6}$$

$$y_i = \boldsymbol{\beta}'\boldsymbol{x_i} + \varepsilon_i \,, \;\; \varepsilon_i \sim N[0, \sigma_\varepsilon^2]$$

where $(y_i, \boldsymbol{x_i})$are observed only when $d_i = 1$,

$$\varepsilon_i = v_i - u_i, \quad u_i = \sigma_u |U_i|, \;\; U_i \sim N[0,1], \qquad v_i = \sigma_v V_i, \;\; V_i \sim N[0,1],$$

$$(w_i, v_i) \sim bivariate\ normal\ with\ correlation\ \rho$$

The conditional density for an observation in Green's model is

$f(y_i|x_i, |U_i|, \boldsymbol{z}_i, d_i) =$

$$\left[d_i \left\{ \begin{array}{l} \left(\dfrac{exp\left(\dfrac{\frac{1}{2}\left(y_i - \beta' x_i + \sigma_u |U_i|\right)^2}{\sigma_v^2} \right)}{\sigma_v \sqrt{2\Pi}} \right) \\ \times \Phi\left(\dfrac{\rho(y_i - \beta' x_i + \sigma_u |U_i| / \sigma_\varepsilon) + \boldsymbol{\alpha}' \boldsymbol{z}_i}{\sqrt{1-\rho^2}} \right) \end{array} \right\} + (1 - d_i)\Phi(-\boldsymbol{\alpha}' \boldsymbol{z}_i) \right] \qquad (3.7)$$

The unconditional log likelihood for the model in (3.6) is formed by integrating out the unobserved $|U_i|$ then maximizing with respect to the unknown parameters.

$$logL(\beta, \sigma_u, \sigma_{v,} \alpha, \rho) = \sum_{\mathrm{i=1}}^{\mathrm{N}} \log \int_{|U_i|} f(y_i|x_i, |U_i|, \boldsymbol{z}_i, d_i)\, p(|U_i|) d(|U_i|) \qquad (3.8)$$

where $p(|U_i|) = \frac{\phi(|U_i|)}{\Phi(0)} = exp\left(-\frac{1}{2}|U_i|^2\right)\sqrt{\frac{2}{\Pi}}$, $|U_i| \geq 0$

Since the integral of this function does not exist in a closed form, Greene (2010) proposes computation by simulation. The simulated log likelihood function is

$logL_s(\beta, \sigma_u, \sigma_{v,} \alpha, \rho) =$

$$\sum_{i=1}^{N} log \frac{1}{R} \sum_{r=1}^{R} \left[d_i \left\{ \begin{array}{l} \left(\dfrac{exp\left(\dfrac{\frac{1}{2}\left(y_i - \beta' x_i + \sigma_u |U_{ir}|\right)^2}{\sigma_v^2} \right)}{\sigma_v \sqrt{2\Pi}} \right) \\ \times \Phi\left(\dfrac{\rho(y_i - \beta' x_i + \sigma_u |U_{ir}| / \sigma_\varepsilon) + \boldsymbol{\alpha}' \boldsymbol{z}_i}{\sqrt{1-\rho^2}} \right) \end{array} \right\} + (1 - d_i)\Phi(-\boldsymbol{\alpha}' \boldsymbol{z}_i) \right] \qquad (3.9)$$

The single equation MLE of $\boldsymbol{\alpha}$ in the probit equation (3.6) is consistent, albeit inefficient. These estimates of $\boldsymbol{\alpha}$ are then taken as given to simulate the log likelihood using (3.9). Finally, use the Murphy and Topel (2002) correction to adjust the standard errors in the same fashion as Heckman's correction of the canonical selection model in (3.4) and (3.5).

3.3 Model specification and data

3.3.1 Model Specification

This study uses both the Heckman and Greene methods to estimate stochastic production frontier models of PSP participants and non-participants while controlling for selectivity bias. Both methods require two sets of variables; one for the production frontier and the other for the probit model which models a farmer's decision to participate in the PSP. The functional form used for the frontier is extended Cobb-Douglas so that for j=1, 2 sub-samples (participants and nonparticipants) the model is:

$$LNPROD_{ji} = \beta_{j0} + \beta_{j1}LNFERT_{ji} + \beta_{j2}LNSEED_{ji} + \beta_{j3}LNLAND_{ji} + \beta_{j4}LNLANDSQ_{ji} + \beta_{j5}IRR_{ji} + \beta_{j6}TECH_{ji} + v_{ji} - u_{ji}$$

where $u_i = \sigma_u|U_i|,\ \ U_i \sim N[0,1]$;

$$v_i = \sigma_v V_i,\ \ V_i \sim N[0,1]; \tag{3.10}$$

with i indexing farms. The dependent variable *LNPROD* is log of total production of jasmine rice per rai. The explanatory variables include a set of log inputs; land (*LNLAND*), land squared (*LNLDSQ*), total fertilizer used per rai (*LNFERT*), total seeds used per rai (*LNSEED*), a dummy variable indicating whether land is irrigated (IRR), and a dummy variable taking a value of one if a farmer uses transplanting and zero if they seed (*TECH*). Labor is not included because rice production is no longer labor-intensive and only a small variation in labor used per rai is typically observed. To evaluate sensitivity to exclusion of the labor variable we also estimated models with a labor variable (*LNLAB)*, measured as a sum of family and hired laborers used in rice production per rai.

The probit participation-decision equation is specified as

$$PSP_i = 1[\alpha_0 + \alpha_1 EDU_i + \alpha_2 EXP_i + \alpha_3 LAND_i + \alpha_4 TRANSPOR_i + \alpha_5 STORAGE_i + \alpha_6 BORROW_i + \alpha_7 BAAC_i + \alpha_8 DIST_i + \alpha_9 CROP2_i + \alpha_k \sum_k^5 REGION_{ik} + w_i > 0] \qquad where \quad w_i \sim N[0,1] \tag{3.11}$$

The dependent variable PSP_i is observed and takes a value of 1 when the decision is made to participate and zero otherwise. As the distance from plots to the nearest depot (*DIST*) increases, farmers may have less incentive to sell to the government because they have to bear higher costs of transporting rice, especially if several trips are needed. By the same token, lack of transportation (*TRANSPOR*) may cause farmers to sell their harvest to other buyers located nearby instead. Farmers are expected to be more likely to participate in the program if they own a storage facility (*STORAGE*) because it gives farmers more flexibility in when to sell. Also, the government pays farmers storage fees if rice is kept with farmers after pledging. The variables *EDU* and *EXP* respectively denote head of household's years of education and years of rice-farming experience. These variables are expected to positively affect farmers' management skills and therefore influence participation. The notion of large farms having lower fixed costs associated with transporting rice to PSP depots implies that the probability of participation would increase as land size (*LAND*) increases.

The variable *BORROW* indicates whether a farmer has borrowed money to finance his/her rice production. A high level of the support price relative to market price is likely to induce farmers to participate in the program especially those who are indebted. As the distance from home to the nearest Bank of Agriculture and Agricultural Cooperatives (*BAAC)* increases, the incentive to participate may decrease because information about the PSP is less frequently communicated to farmers. The variable *CROP2* indicates whether a farmer produces during a second-season rice. The dummy variable *REGION* representing six different districts in which the survey took place is included to account for other regional-specific factors that possibly influence the participation but are not observed. For instance, farmers in certain districts are discouraged from participating due to a lengthy processing-time for transferring money to farmers' bank accounts from the BAAC, which tends to vary by branches. Sometimes, farmers in certain regions have to sell to other buyers because a depot has exceeded its daily storage capacity.

Recall that Heckman's method requires inclusion of the inverse Mill's ratio (*IMR*). In the first step, the inverse Mill's ratio is obtained from a pooled-probit estimation as shown in (3.11). In the second step, separate production frontier models are estimated by appending the inverse Mill's ratio obtained from the first step as one of the covariates. The selectivity bias is present if the estimated coefficient of *IMR* (ρ) is statistically difference from zero at least in one of the subsamples under a t-test. In contrast, Greene's method estimates (3.10) and (3.11) in one step by NLOGIT (version 4) for which the distributional assumptions of the error terms are as stated in (3.6).

3.3.2 Data

The empirical analysis is based on a sample of 387 jasmine-rice farm households chosen from 21 villages located across Buriram province in Thailand. The province is one of the largest producers of jasmine rice in Thailand and represents approximately 15% of total area and production of jasmine rice in 2011.[24] Six out of 23 districts located across the province were randomly selected. Then, two villages located in irrigated areas and two villages located in areas

[24] Thailand Office of Agricultural Economics

with no irrigation system in place are randomly chosen from each selected district, constituting a total sample of 24 villages. Finally, 20 jasmine-rice farm households from each village were selected for interview.[25] The data include inputs used, geographical location of plots, and socio-economic characteristics of farm household members. The information collected covers the major (1st) rice season in 2012/13. The sample contains 130 farmers, who have participated in the PSP during the 2012/13 major cropping season, and 257 non-participants.

[25]Due to some technical problems, however, the survey only took place in 21 villages from which data from 387 rice farm households were collected.

3.4 Results

3.4.1 Differences in input allocation and farmers' characteristics

Table 3.1 presents summary statistics for output, inputs, and characteristics of farmers classified by their PSP participation status. Note that the log of total inputs (fertilizer, seed, and labor) and total output are used in the estimation. The mean differences of total output and total inputs used significantly differ between the two sub-samples at 1% level but they are not significant at 5% level when measured on a per-rai basis. Land size and is significantly different between PSP participants and non-participants despite similar average yields. The difference in land size is quite large which indicates that the scale of production is much larger for participants. However, non-participants apply more fertilizer per rai. On average, participants have more years of education but less farming experience. The proportion of farmers lacking transportation and storage infrastructure is higher among non-participants. The proportion of participants who borrow money is higher among participants. In fact, total household debts are statistically higher for those who participate in PSP (not shown). The distances to nearest PSP depot and BAAC are higher for non-participants. Yet, only the former is statistically significant. Lastly, a higher proportion of the participants reported that they also produce rice in the second season. This perhaps indicates that the participants are more commercialized.

Table 3.1: Average input used and farmers' characteristic variables

Variable	Non PSP (N=257)	PSP (N=130)	Mean Difference (Non PSP-PSP)	
Production				
Total production (kg)	4,327	10,117	-5,790	***
Total fertilizer (kg)	461	1,053	-591	***
Total seed (kg)	349	799	-450	***
Total labor (man-day)	93	231	-138	***
Land (rai)	13.42	30.29	-16.87	***
Irrigation (irrigated=1, zero otherwise)	0.33	0.39	-0.06	
Technique (transplanting=1,seeding=0)	0.13	0.15	-0.03	
Characteristics				
Education (years)	5.11	5.52	-0.41	*
Farming experience (years)	35.64	33.39	2.25	*
Land (rai)	13.42	30.29	-16.87	***
Transportation (own=1,none=0)	0.38	0.50	-0.12	***
Storage (own=1,none=0)	0.80	0.92	-0.12	***
Borrow (yes=1,no=0)	0.37	0.57	-0.20	***
Distance to nearest BAAC (km.)	8.31	7.75	0.56	
Distance to nearest PSP depot (km.)	17.06	14.64	2.85	***
2nd-season crop grower (yes=1,no=0)	0.17	0.23	-0.06	*
Production & input used per rai (supplemental information/not used in SFM)				
Yield (kg/rai)	348.80	345.15	3.65	
Fertilizer (kg/rai)	35.69	33.85	1.84	*
Seed (kg/rai)	26.42	25.93	0.49	
Labor (man-day/rai)	6.72	7.11	-0.39	

***, **, * denote 1%, 5%, and 10* significant levels, respectively

Source: author's survey

3.4.2 Determinants of PSP participation

Results from the probit model of PSP participation are shown in **Table 3.2**. Neither education nor farming experience has a statistically significant impact on the likelihood of program participation. Similarly, owning a vehicle that can be used for transporting rice increases the probability of program participation but its effect is statistically insignificant.

Owning a storage facility increases the probability of participation and this effect is statistically significant at the 10% level. The ability to store may facilitate program participation because the Government's PSP depots are often overwhelmed at the beginning of harvest season and participants have to delay delivery. Without storage farmers would have to sell immediately on the market. However, the distance to nearest PSP depot does not have a statistically significant impact on the likelihood of program participation, once regional differences are accounted for.

Distance to nearest BAAC has a statistically significant (10% level) negative effect on the probability of program participation. The BAAC is a source of PSP program information and close proximity may also increase the ability of farmers to borrow money from the bank to finance the delayed payment that usually accompanies program participation. Similarly, farm borrowing has a positive relationship with program participation. Finally, land area has a positive relationship with the probability of program participation, as does the farmer's cultivation of rice during the second growing season. These factors indicate that there is a positive relationship between the degree of commercialization of the farm and the likelihood of participating in the PSP. However, a direction of causality cannot be determined. On the one hand, large farms may tend to participate in the program. On the other hand, it is also possible that participating farms get larger overtime.

Table 3.2: The estimated parameters of the probit model for participation decision

Variable	Coefficient	
Constant	-1.66	***
Education	-0.02	
Farming experience	-0.01	
Land	0.05	***
Transportation	0.16	
Storage	0.34	*
Borrow	0.41	***
Distance to nearest BAAC	-0.03	*
Distance to nearest PSP depot	0.01	
2nd-season crop grower	0.41	*
Region 1	0.34	
Region 2	-0.53	*
Region 3	0.85	***
Region 4	0.18	
Region 6	-0.15	
Model diagnostics		
Log likelihood	-180.62	
Chi squared	130.61	
P-value	0.00	
McFadden pseudo R-squared	0.27	

***, **, * denote 1%, 5%, and 10% significant levels, respectively.

3.4.3 Frontier production technologies

Table 3.3 and **Table 3.4** report the parameter estimates of stochastic production frontiers of participants and non-participants, respectively. The results in column 2 are from Greene's method while those in column 3 and 4 are from Heckman's method. In the table GRN and HECK-N denote results from the functional form for production technology described in (3.10) and (3.11) with inclusion of the inverse Mill's ratio in the latter. The HECK-F results use alternative specification in which labor is added. We evaluate this alternative specification because labor is considered a typical input used in rice production despite its declining intensity.[26] Note that HECK-N is nested in HECK-F. Results show that estimates from the two Heckman specifications are very similar but results from Green's model are quite different. This divergence in parameter estimates using Greene's and Heckman's method has been noted in other studies as well (e.g., Wiboonpongse et al., 2012). Because the participation decision equation and the SFM are simultaneously estimated under Greene's model, over-parameterization could be the cause this divergence in parameter estimates.

Table 3.3: Estimated parameters of the SFM model for PSP participants

Variable	GRN coefficient		HECK-N coefficient		HECK-F coefficient	
Production function						
Constant	22.272		6.745	***	6.539	***
Fertilizer	0.1036		0.072		0.069	
Seed	0.0722		0.124	**	0.111	**
Labor					0.068	**
Land	1.4271	*	0.246		0.282	
Land squared	0.3576		0.062	*	0.050	
Irrigation	-0.0002		0.116	*	0.100	
Technique	0.1873		0.135	*	0.096	
Variance parameters						
Log likelihood	-1920.66		-42.47		-40.67	
σ_v	1.02		0.18		0.06	
σ_u	23.81		0.49		0.08	
$\rho_{(v,w),\text{Heckman}}$			-0.20	*	-0.17	
$\rho_{(v,w),\text{Greene}}$	0.33					

***, **, * denote 1%, 5%, and 10% significant levels, respectively.

[26] The alternative specification did not converge using Green's model and so results for that case are not shown. So, Greene's model can only be compared to Heckman's model using the nested specification (i.e. a specification in which labor is excluded)

Table 3.4: Estimated parameters of the SFM model for PSP non-participants

Variable	GRN coefficient		HECK-N coefficient		HECK-F coefficient	
Production function						
Constant	12.374		5.617	***	5.395	***
Fertilizer	0.005		0.185	***	0.175	**
Seed	0.191	***	0.159	***	0.158	***
Labor					0.115	***
Land	0.012	**	0.569		0.512	***
Land squared	1.256		-0.008		-0.017	
Irrigation	0.426	***	0.115	**	0.181	***
Technique	0.264		0.036		0.006	
Variance parameters						
Log likelihood	-2015.97		-196.87		-189.63	
σ_v	0.98		0.16		0.15	
σ_u	5.97		0.91		0.90	
$\rho_{(v,w),\text{Heckman}}$			-0.11		-0.11	
$\rho_{(v,w),\text{Greene}}$	-0.0018					

***, **, * denote 1%, 5%, and 10% significant levels, respectively.

For the participants (**Table 3.3**), only land size is statistically significant using Greene's method. Under the HECK-N specification, all inputs except fertilizer are statistically significant. The HECK-F specification indicates that only seed and labor are statistically significant. However, log-likelihood-ratio test (LR-test) strongly rejects joint exclusion restrictions for land and land squared (not shown). Hence, land is still a key factor of production. In case of the non-participants (**Table 3.4**), more parameters are statistically significance under Greene's model, seed, land, and irrigation. Yet, their estimates are very different from those estimated by the Heckman's method. Under the HECK-F specification, all variables except planting technique are statistically different from zero. Like the participants, the estimates of land and land squared are not individually significant but are jointly significant under HECK-N specification.

The estimates for the selectivity bias parameter (ρ) are reported at the bottom of Table 3 and 4. For the participants, we cannot reject the null hypothesis of no selectivity bias using Green's model of HECK-F. Selectivity bias is somewhat significant under the HECK-N specification as the null hypothesis is rejected but only at the 10% level (p-value = 0.095). For the non-participants, all three models reject the existence of selectivity bias. Therefore, the conclusion is that there is no strong evidence suggesting the presence of selectivity bias. This means the stochastic production frontier for the participants and non-participants can be estimated separately using the standard SFM if their production technologies indeed differ, or by pooling the data if their production frontiers are the same.

Table 3.5 and **Table 3.6** report the parameter estimates of stochastic production frontier estimated by the standard SFM (or ALS) model under several alternative specifications. ALS-N and ALS-F are the standard SFM specified in (3.1) and are respectively similar to that of HECK-N and HECK-F except that now the inverse Mill's ratio is excluded. The models specified under ALS-N and ALS-F are estimated using the pooled/full sample. The other results are from sample-separated models. ALS-N1&2 and ALS-F1&2 are constrained to have the same frontier coefficients but allow variance parameters to differ. That is, technical efficiency for each sub-sample is estimated separately by constraining frontier parameters to be the same for participants and non-participants but allowing standard deviations of the errors (σ_u and σ_v) to differ across the sub-samples. For ALS-N3&4 and ALS-F3&4, no constraint is imposed on production technology and variance parameters. A LR-test for different production frontiers in these two subsamples rejects the null hypothesis of homogenous production frontier; i.e. testing the full-sample model against (unconstrained) sample-separated models.[27] A LR-test for different

[27]A likelihood-ratio Chow test gives a test statistic (a Chi-squared statistic) of 33.94 with 9 degrees of freedom (seven coefficient parameters of production technology and two variance parameters) which is significant at 1%

production technology while allowing the variance parameters to differ strongly supports the null hypothesis of homogeneous production technology; testing the full-sample model which allows only differences in an intercept between participants and non-participants against the full model which allows differences in both an intercept and slope coefficients.[28] An LR-test for different variance parameters strongly reject the null hypothesis that technical inefficiency of these subsamples are drawn from the same distribution.[29] These test results imply that participants and non-participants share the same production technology but there technical efficiencies do differ.

Table 3.5: Estimated parameters of the nested-model stochastic production frontier

Variable	ALS-N (Pooled) coefficient		ALS-N1 (Non PSP) coefficient	ALS-N2 (PSP) coefficient	ALS-N3 (Non PSP) coefficient		ALS-N4 (PSP) coefficient	
Production function								
Constant	5.645	***	constrained	constrained	5.409	***	6.189	***
Fertilizer	0.145	***	constrained	constrained	0.190	***	0.103	*
Seed	0.157	***	constrained	constrained	0.150	***	0.117	*
Land	0.475	***	constrained	constrained	0.562	***	0.267	
Land squared	0.027		constrained	constrained	0.005		0.069	*
Irrigation	0.150	***	constrained	constrained	0.135	**	0.141	**
Technique	0.103	*	constrained	constrained	0.052		0.122	*
Variance parameters								
Log likelihood	-258.23		-223.02	-48.02	-197.55		-43.70	
σ_v	0.18		0.20	0.14	0.17		0.25	
σ_u	0.78		0.86	0.60	0.90		0.38	
σ_ε^2	0.64		0.78	0.39	0.84		0.21	

***, **, * denote 1%, 5%, and 10% significant levels, respectively.

level. Thus, we reject the null hypothesis of homogenous production frontiers between participants and non-participants.

[28] A likelihood-ratio test gives a test statistic (a Chi-squared statistic) of 3.11 with 6 degrees of freedom (six interaction-coefficient parameters of production technology) which is not significant at 5% level. Thus, we cannot reject the null hypothesis of homogenous production technology between participants and non-participants.

[29] A likelihood-ratio test gives a test statistic (a Chi-squared statistic) of 29.85 with 2 degrees of freedom (two variance parameters) which is significant at 1% level. Thus, we reject the null hypothesis technical inefficiency of these subsamples are drawn from the same distribution

Table 3.6: Estimated parameters of the full-model stochastic production frontier

Variable	ALS-F (Pooled) coefficient		ALS-F1 (Non PSP) coefficient	ALS-F2 (PSP) coefficient	ALS-F3 (Non PSP) coefficient		ALS-F4 (PSP) coefficient	
Production function								
Constant	5.414	***	constrained	constrained	5.178	***	6.064	***
Fertilizer	0.146	***	constrained	constrained	0.179	***	0.097	*
Seed	0.146	***	constrained	constrained	0.146	***	0.105	*
Labor	0.108	***	constrained	constrained	0.120	***	0.078	**
Land	0.443	***	constrained	constrained	0.504	***	0.299	
Land squared	0.015		constrained	constrained	-0.005		0.054	
Irrigation	0.180	***	constrained	constrained	0.203	***	0.113	*
Technique	0.044		constrained	constrained	0.022		0.092	
Variance parameters								
Log likelihood	-251.05		-191.83	-47.16	-193.50		-41.79	
σ_v	0.17		0.19	0.12	0.18		0.20	
σ_u	0.78		0.85	0.61	0.88		0.46	
σ_ε^2	0.64		0.75	0.38	0.80		0.25	

***, **, * denote 1%, 5%, and 10% significant levels, respectively.

3.4.4 Technical efficiency of PSP participants and non-participants

Summary statistics of the technical efficiency scores for PSP participants and non-participants under ALS-N and ALS-F are presented in **Table 3.7**. On average, the participants are more technically efficient than the non-participants as indicated by the fact that mean technical efficiency is higher while having lower standard deviation. The distribution of technical efficiency scores for the participants displays leftward skew while that of the non-participants displays rightward skew. Under the ALS-N specification 23.08% of participants have technical efficiency scores above 0.8 compared to 16.74% for non-participants. This means participants group has a higher proportion of farmers with high technical efficiency scores compared to that of non-participants. In contrast, a higher proportion of non-participants technical efficiency scores are located in the lower tail of the distribution; 35.41% of the sample are located below 0.5 compared to 26.15% of participants. On the one hand, one may argue that the program tends to attract efficient farmers. On the other hand, it is also possible that the program participants have become more efficient. Unfortunately, the direction of the effect cannot be determined. The ALS-F specification also produces similar conclusions. The distribution of technical efficiency scores are not much different from those reported in **Table 3.6** when estimated from the unconstrained model using the pooled sample (not shown).

Table 3.7: Distribution of technical efficiencies

Interval	**Nested Model**		**Full Model**	
	NON-PSP (ALS-N1)	**PSP (ALS-N2)**	**NON-PSP (ALS-F1)**	**PSP (ALS-F2)**
0.91-1.00	1.95%	3.85%	2.33%	6.15%
0.81-0.90	14.79%	19.23%	15.56%	18.46%
0.71-0.80	19.84%	13.85%	16.73%	13.85%
0.61-0.70	13.23%	18.46%	16.34%	16.15%
0.51-0.60	14.79%	18.46%	12.84%	16.15%
under 0.51	35.41%	26.15%	36.19%	29.23%
Mean TE	0.58	0.63	0.58	0.63
Standard Deviation	0.22	0.17	0.22	0.18
Minimum	0.02	0.20	0.02	0.18
Maximum	0.93	0.94	0.93	0.95

3.5 Conclusion and policy implications

The objective of this study was to identify the factors that determine Thai jasmine-rice farmers' decision to participate in the PSP and estimate the frontier production technology and technical efficiency of participants and non-participants. Two approaches to dealing with the selection bias problem were applied—Greene's model and Heckman's two-step adjustment approach. The result indicates that land size has a positive relationship with the likelihood to participate in the program. Households using loans are also more likely to participate in the program than those who do not. Barriers to program participation include distance to the nearest BAAC branch, which is a government-affiliated agency responsible for issuing loans to farmers.

The difference between parameter estimates obtained from the Heckman's and Greene's methods are large. Estimates from Greene's method indicate there is no statistical evidence of selection bias while only weak evidence was found under Heckman's method. Therefore, the conclusion is that there is no selectivity bias and the production model can be estimated using the standard frontier approach without accounting for selection bias. However, the results from a likelihood-ratio test indicate that both participants and non-participants share the same frontier production technology but have a different distribution of inefficiency. So, technical efficiency scores for each group are computed separately assuming a homogeneous frontier production function. The analysis of technical efficiency reveals that PSP participants are more efficient because the mean of technical efficiency scores are relatively higher while their variance is smaller. The distribution of technical efficiency scores for non-participants also displays leftward skew compared to the rightward skew for participants. In other words, a higher proportion the participants are located in the high-efficiency range and less in the low-efficiency range.

The findings from this study have some important policy implications. First, there is a strong relationship between land size and the probability of participating in the program. This is consistent with the observation that most PSP participants produce rice on a large scale. Therefore, a significant portion of program benefits are captured by large farms. However, the causality between farm size and participation can also go in the opposite direction in which case it implies that participating farms get larger. Since the participants are more technically efficient in production, one can also argue that the program tends to attract efficient farmers. On the other hand, it is also possible that participating farms become more efficient overtime. Lastly, policymakers may need to investigate factors that significantly deter the farmers' participation decision if they want to distribute program benefits more evenly to all farmers.

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