As of 11/25/2005 11:07 AM

CONTRACT FARMING AND POVERTY REDUCTION: A CASE OF ORGANIC RICE CONTRACT FARMING IN THAILAND

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INTRODUCTION

Globally, of the 1.3 billion people living in extreme poverty (less than 1 US$ per day) 75% are living in Asia. Among the poor in Asia, up to 90 per cent are subsistence farmers living on low-value traditional crops. Traditionally, development in the agricultural sector put emphasis on increasing productivity using external inputs with insufficient attention other aspects, in particular to market linkages. This strategy has resulted in mixed poverty outcomes. In countries such as Lao PDR and Cambodia where poverty is a pervasive problem with approximately 35-40% of the population living below the poverty line, governments and donors are in search for an alternative strategy to develop the rural sector.

With globalization, market liberalization, and the development of rural infrastructure, new market opportunities for high-value crops and livestock production are opening up. However, for the rural poor to take advantage of new market opportunities, backward and forward market linkages must be put in place. These linkages include provision of information on what to grow, rural credit, farming inputs, agricultural extension advice, product accreditation and markets for the produce. Putting in place the necessary agri-services for a massive number of small farms and un-organized farmers will require tremendous resources from the governments. Successes in the provision of public sector agri-services are rare and failures have been numerous. In recent years, a strategy involving private sector has been looked upon as an alternative.

In the provinces of Cambodia and Lao PDR, bordering Thailand and the People's Republic of China, contract farming has emerged in response to lack of markets in an environment of high risk and high costs. Under contract farming, the purchaser (agri-business firm or trader) provides farmers with inputs, credit, technical advice and market services. In return, farmers produce a certain quantity and quality of crop or livestock, and sell them exclusively to the purchaser. Such arrangements allow farmers to have access to an array of agricultural services, which they would otherwise not have access to.

The emergence of contract farming as an institution for facilitating market exchange is not a recent phenomenon. For decades, contract farming has been used as a supply chain governance strategy in response to market and institutional failures that characterize the agricultural sector in different stages of development. While contract farming itself has been around for a long time, its importance as a tool for rural development and poverty reduction has only been reviewed in recent years.

Internationally, in response to changes in consumer preference within developed countries, multinational food corporations are engaging in contract farming in developing countries, mainly to ensure year-round supply of particular product ranges to specific markets (Humphrey, 2004; de Moura, Mollenkopf and Martin, 2003) and to take advantage of lower production costs It appears that through globalization, this type of contract farming could possibly transfer a production base to developing countries such as Lao PDR and Cambodia where conditions are conducive for growing non-traditional export crops, and where labor costs are lower. If managed well, this trend offers promising opportunities for the rural poor in these countries to gain from globalization. Contract farming would provide the rural poor in these areas with access to a vastly growing export market and hence opportunities to improve their income.

Scope and Delimitation of the Study

While tracing the benefits of contract farming is conceptually sound, empirical evidence on its impact on poverty eradication is limited. In particular, development of contract farming in the context of transition economy has not been looked into. (Setboonsarng and Penkett, 2005). While the benefits of implementing contract farming may be diverse, promoting contract farming for poor farmers with smallholdings remains a big challenge. To better understand the poverty and efficiency outcomes of such development strategy, addressing this gap in empirical evidence is critical.

Towards this end, the ADBI has committed to carry out two empirical studies in Lao PDR and in Cambodia on the profitability rice contract farming for export. These studies aim to assess differences in profitability and efficiency between contract and non-contract farmers using a common analytical framework: to conduct a farm household survey with a goal of estimating a profit frontier function of rice production as well as performing other statistical analysis.

In the neighboring country of Thailand where the stage of agriculture development is more advanced and where contract farming has been widely adopted, there are important lessons to be learnt for Lao PDR and Cambodia. Due to the growing demand of organic rice in developed countries, in 2003, the Ministry of Agriculture and Agriculture Cooperatives of Thailand commissioned a study to investigate the potential of developing organic rice in Thailand for export. The study included a farm household survey covering 445 contract and non-contract rice farming in five provinces in the North and Northeastern regions of Thailand. The farms covered in the dataset share many characteristics with the rural sector in Lao PDR and Cambodia, where the vast majority are smallholder farms in marginal areas, with excess labor and little or almost no access to markets and agricultural extension services.

The dataset has been made available to ADBI for further analysis and in particular to assess efficiency and poverty implications to extract lessons for Lao PDR and Cambodia.

The purpose of this report is to document the results of the econometric analysis in evaluating the profitability and profit efficiency of organic rice contract farming using the Thai dataset as a comparative case.

Methodology and Working Hypotheses

The present study employs the profit frontier methodology to assess the profitability and profit efficiency of the sampled Thai rice farmers and to discern the key factors contributing to the differences in estimated efficiency. Profit efficiency is defined here as the ratio of the observed profit to the potential maximum attainable profit. While profit provides a direct measure of relative competitiveness of one type of farm (*e.g.* contract farm) in relation to others (*e.g.* non-contract farm), the concept of efficiency can also be useful as another more refined indicator of relative competitiveness. Farms that use their resources more efficiently will in the long run out-compete their less efficient counterparts by capturing an increasing share of the market.

This study also attempts to account for selection bias using a two-stage switching regression model. The estimated models are used for subsequent “counterfactual” simulations of profit and profit efficiency. In particular, this study is set out to test the following two hypotheses:

1. Contract rice farmers are more profitable than non-contract rice farmers for comparable scales of operation; and

2. Contract rice farmers are more (profit) efficient than non-contract rice farmers for comparable scales of operation.

Since all contract rice farmers in the sample are organic or low-chemical farmers and all the non-contract farmers are conventional rice farmers, the above hypotheses can essentially be extended to make inferences on organic farmers versus conventional farmers. However, we also investigate the profitability and efficiency differences among the various stages of organic farming within the group of contract farmers.

Following this introduction, we examine the benefits of contract farming, particularly when it is promoted for organic agriculture. We briefly discuss the concept of efficiency and the use of stochastic frontier methodology in measuring efficiency (further details are given in the Appendix), and also review relevant profit frontier studies on rice farming. We then provide a brief background on contract farming in Thailand and describe the survey data used in this study. We summarize of the characteristics of the sampled farms, and present our results from the profitability and efficiency analysis. Specifically we test the two hypotheses set out above in comparing profitability and profit efficiency between contract and non-contract farmers. A concluding section summarizes the paper's main findings.

THE BENEFITS OF CONTRACT FARMING, AND CONTRACT FARMING FOR ORGANIC AGRICULTURE

The existing literature on contract farming identifies several major areas where contract farming can provide benefits. From the point of view of farmers, contract farming can provide access to markets, credit, technology and inputs that they would otherwise be excluded from. Moreover, contract farming can lead to improvements in income while reducing some of the risks they face from production and price fluctuations. From the point of view of purchasers, contract farming provides greater control over volume and quality consistency; to a certain extent, it can also lower certain transaction and production costs that purchasers face. Table 1 summarizes the main benefits identified in Setboonsarng and Penkett's (2005) comprehensive discussion of the advantages of contract farming for farmers and purchasers.

Table 1. The Benefits of Contract Farming

Parameter	Potential Benefits
Farmers	
Access to markets	Contract farming arrangements serve to link farmers to distant markets where the demand and price of crops are more favorable.
Access to credit	Purchasers extend credit to farmers either in cash or in kind by providing inputs such as seeds. In cases where purchasers do not extend loans to farmers, banks often accept the contracts as collateral.
Access to technology/ skills development	Contract farming arrangements often facilitate the introduction of new production techniques, and further measures that serve to upgrade agricultural commodities. These include training and assistance in crop production, soil and water management, book keeping of inputs and outputs, and at times even gender awareness training. Aside from straightforward technology transfer, farmers can become astute in learning how markets work, how to manage accounts, and run their farm as business.
Access to inputs	Purchasers frequently undertake measures to ensure that contracted producers have timely access to inputs including seeds and fertilizers, in addition to training support and monitoring proper crop husbandry practices.
Increased income	Contract farming can lead to improved income, especially in cases where contract farming is adopted for non-traditional crops that are sold at a premium.
Reduced price risk	In contract farming a predetermined price for the crop is generally established during contract negotiations at the onset of the growing season. This protects farmers from incurring losses in sales due to price fluctuations.
Reduced production risk	Contract farming arrangements facilitate risk sharing from production failures due to uncontrollable circumstances including poor weather or disease. Purchasers frequently absorb losses associated with reduced or non-existent throughput for the processing facility. Where production problems are widespread as a result of uncontrollable events, purchasers will often defer the repayment of production advances until the following season. Subsidies may also be provided to diminish risk during the startup period.
Purchasers	
Control over volume and consistency	Contract farming assures suppliers that the required crops can be consistently produced. Contract farming can also result in increased yields and improved quality with regard to certain types of crops.
Improved cost efficiency	Contract farming allows firms to minimize costs by not purchasing land or directly hiring labor. Smallholders have lower wage costs mainly due to the ability to use family labor. Contract farming can help firms minimize supervision costs, usually incurred due to classic principal-agent problems.

Source: Setboonsarng and Penkett (2005)

Contract farming likewise affords benefits to the government. While the development of market linkages for farmers is traditionally viewed as a public sector responsibility, the establishment of the necessary agro-services for a large number of small, unorganized farmers requires a tremendous amount of public sector resources. On the other hand, contract farming provides market linkages in ways, which do not burden the public sector.

Contract Farming and Organic Agriculture: Opportunities for Export Growth

In recent years, consumer concerns surrounding food safety have led to an increase in demand for organic products. The global market for organic products has been growing steadily not only in Europe and North America but in Asian countries such as Japan. Between 1998 and 2002, the compound annual growth rate of the organic food market was 17.7 percent. In 2002, the market for organic products was valued at US$23 billion, and it is estimated that it will continue to be the fastest growing sector in agriculture. Not surprisingly, organic food production has increased all over the globe, with much of the increase occurring in developing countries where farmers are being attracted by export benefits and substantial price premiums. Different studies estimate that farmers receive between 44 – 50 percent of the premium for organic products (Setboonsarng and Penkett 2005) .

But this increase in demand has come with a greater insistence on verifiable evidence of food product quality. This in turn has led to more stringent certification requirements and an influx of food traceability systems. Since chemical residues on food are not generally visible and conducting bio-chemical tests are costly and impractical, in order to guarantee the quality of products while minimizing transaction costs, certification systems and traceability systems have developed to provide information on products for consumers, notably in developed countries.

For export agents in developing countries, the ability to fulfill the traceability or certification requirements will determine their success in the export market for agricultural products, in particular, high value products such as organic products. Since such products have to meet strict quality requirements that are typically difficult to meet in spot markets, firms are utilizing contract farming to gain better control of inputs, achieve more uniform product attributes, and to reduce the cost of measuring quality, grading, and sorting of products.

Due to higher management costs of a food traceability system and the requirement for organic farming to be grown in areas free from chemicals, export firms are likely to engage farmers in marginal areas, where cost of labor is lower and where use of agrochemicals is minimal. For farmers, contract farming provides them the access to information and markets. For purchasers, contract farming provides control over inputs throughout all stages of production and processing, making it easier to implement traceability systems. For the government, contract farming facilitates the development of local standards that are consistent with international standards for food safety and traceability.

The Broader Benefits of Contract Farming for Organic Agriculture

Beyond issues of establishing the requisite certification standards and traceability systems to promote exports, there are broader benefits from promoting contract farming for organic agriculture for poverty reduction. Over the years, it has become increasingly clear to farmers, non-governmental organizations (NGOs), governments and international development agencies alike that the conventional practice of farming under the banner of the 'Green Revolution' has by-passed the poor in marginal areas while benefited the richer farmers in fertile areas. There is also increasing evidence that high-external-input agriculture is unsustainable. The unsustainable nature of conventional agriculture is manifesting itself in terms of stagnant or declining yields, increasing ecological degradation, and worsening rural socio-economic conditions. Increasingly, countries have started to look at organic agriculture as a means of reversing these negative effects.

For countries such as Lao PDR and Cambodia, where current practices are largely organic by default, it therefore makes little sense to promote large-scale commercial agriculture through conventional approaches, when the experience of neighboring developing countries clearly indicates that promoting high external input, export-orientated conventional agricultural systems has come at such a huge cost. In this context, promoting contract farming for organic agriculture would generate benefits that have a wider impact on poverty reduction and go beyond improving market access to export markets and increasing incomes alone (Table 2).

Table 2. Additional Benefits of Contract Farming for Organic Agriculture

Parameter	Potential Benefits
Agriculture	Increased diversity, long term soil fertility, high food quality, reduced pest/disease, self-reliant production system, stable production
Environment	Reduced pollution, reduced dependence on non-renewable resources, negligible soil erosion, wildlife protection, resilient agroecosystem, compatibility of production with environment
Social conditions	Improved health, better education, stronger community, reduced rural migration, gender equality, increased employment, good quality work
Economic conditions	Stronger local economy, self-reliant economy, income security, increased returns, reduced cash investment, low risk
Organizational/institutional	Cohesiveness, stability, democratic organizations, enhanced capacity

Source: Setboonsarng and Penkett (2005)

Getting the Incentives Right: Is Contract Farming Profitable?

The foregoing discussion clearly illustrates the potential for contract farming to provide benefits that meet multiple policy objectives. But while the benefits of implementing contract farming may be diverse, and while different stakeholders stand to gain from these benefits, persuading farmers to take part in such an arrangement is still largely a matter of financial incentives. In contract farming, one of the principal motives for smallholders consent is the promise of a steady and increased income incurred from the sale of their crops (Baumann, 2000). To convince farmers that contract farming is a profitable venture, providing empirical evidence is crucial. The following sections of the paper will attempt to address this fundamental requirement.

EFFICIENCY AND PROFIT FRONTIERS

Efficiency and inefficiency can generally be measured by its components - technical, cost, revenue and profit. *Technical efficiency* refers to a farm's ability to produce the maximum outputs for a given set of inputs and technology. Or conversely, it can be measured as the farm's ability to utilize the minimum amount of inputs to produce a desirable set of outputs for a given technology. *Cost efficiency* refers to the ability of the farm to minimize the expenditures required to produce a desirable set of outputs, given their respective input prices and production technology. Misallocation of inputs contributes to cost inefficiency and is sometimes refers to as input *allocative* inefficiency. *Revenue efficiency* refers to the farm's ability in allocating their outputs in a revenue-maximizing manner for a given set of output prices. Finally, *profit efficiency* refers to a farm's ability to obtain maximal profit for a given set of input prices, output prices, and technology.

While technical, cost, and revenue efficiency are necessary for the achievement of profit efficiency, they are collectively not sufficient for profit efficiency. Profit efficiency further requires that technical, cost and revenue efficiency be achieved at the proper scale, *i.e.*, it requires some kind of scale efficiency. (Kumbhakar and Lovell, 2000)

In this study, we utilize a dual variable profit frontier which portrays the maximum variable profit (defined as gross revenue less variable cost) obtainable by a farm given the prices of inputs and outputs, the production technology, and the presence of fixed inputs such as land and capital. The variable profit frontier is more appropriate when farms do not have the flexibility to adjust all inputs. Farms operating on the profit frontier are profit efficient while farms operating under the profit frontier are profit inefficient. Naturally, we are interested in measuring the level of inefficiency of each farm as well as the major determinants of inefficiency. Our approach is set out in the Appendix.

In terms of the wider literature, while rice is perhaps the most studied agricultural commodity by frontier researchers, very few have used profit frontiers, which could be due to lack of appropriate data. In a review article by Bravo-Ureta and Pinheiro (1993) on efficiency analysis of developing country agriculture, 13 out of 20 studies were on rice farming. However, only two studies used the dual profit frontier approach and only one was on rice farming. Ali and Flinn (1989) used a single equation dual profit frontier to examine the efficiency of 120 rice producers from the Pakistani Punjab. They found that the average inefficiency was 31%. Education was found to have a significant role in reducing profit inefficiency, while off-farm employment and difficulties in securing credit to purchase fertilizer would tend to increase profit inefficiency. The other study by Bailey et al. (1989) is on dairy farms.

Since 1993, there are a few more studies that employed profit frontiers. Abdulai and Huffman (2000) used a stochastic translog profit frontier to examine the efficiency of 256 farmers in the Northern region of Ghana. They found that the average inefficiency was 27.4%. Their inefficiency analysis suggested that education of household head, access to credit, greater specialization, and location in districts with better access to extension services and better infrastructure were significant variables for increasing profit efficiency. On the other hand, increasing participation in nonfarm activities by farmers and being older would tend to lower profit efficiency. Rahman (2003) also used a dual profit translog frontier to investigate the efficiency of 380 farms, which produced a modern variety of rice in three agro-ecological regions of Bangladesh. He found that the average inefficiency was about 23%. Farmers with more experience in growing modern varieties of rice, better access to input markets and extension services, located in fertile regions, as well as those with less off-farm work and owned their land were found to be more efficient.

To our knowledge, there are no other efficiency studies on rice farming which employ the stochastic profit frontier approach. However, there are several efficiency studies of other agricultural products using the stochastic frontier approach since the 1993 review article by Bravo-Ureta and Pinheiro. Arajuo and Bonjean (1999) used a stochastic profit frontier to study the efficiency of different land tenure patterns in Brazilian farms. Bhattacharyya and Glover (1993) also employed a stochastic profit frontier to examine the efficiency of small versus large farms in India. Wang, Cramer and Wailes (1996) and Wang, Wailes and Cramer (1996) developed a shadow-price profit frontier model to examine the efficiency of Chinese rural households in farming operations. Delgado, Narrod and Tiongco (2003) have employed the profit frontier approach to investigate the efficiency of large versus small and contract versus independent livestock farms in the Philippines, India, Thailand, and Brazil.

DATA SET

In 2003, the Ministry of Agriculture and Agriculture Cooperatives of Thailand commissioned a survey to investigate the potential of developing organic rice in Thailand for export. The survey covers 5 provinces, 2 of which are in the Northern region namely Phayao and Chiang rai, while the other 3 are in the Northeastern region including Ubon Ratchathani, Surin, and Yasothon.

Farms in Northeast Thailand are ones, which practiced conventional agriculture using high level of agro-chemicals until the early 1980s. In the mid-1980s, in Surin and Yasothon Provinces, the movement of natural agriculture practice and environmental conservation promoted by religious groups and several Non-Government Organizations (NGOs) initiated contract farming of organic rice as a solution to the problems faced by farmers. This development was then supported by European NGOs, who wished to produce organic rice for export to their Fair Trade Networks. In Ubon Ratchathani, contract farming of organic rice was supported by an international NGO as one of the strategy for community development. It was also an income earning strategy for the NGO.

In contrast to the Northeast Region, organic rice farming in the Northern region was a private sector-led initiative, prompted by demand growth in European countries. In search for land where chemicals has not been applied for organic rice, the firms searched for marginal forest areas and introduced rice contract farming to farmers.

The data used to estimate the profitability and profit function parameters are assembled from the farm survey conducted during 2002 and 2003 with an updated interview with key informants during early part of 2005. Within each province approximately the same number of contract and non-contract farmers were surveyed in the same locality. All of the contract rice farmers are organic or low-chemical farmers while all the non-contract farmers are conventional rice farmers. This resulted in 83 contract-organic and 85 conventional farmers surveyed in the Northern region, and 140 contract-organic and 137 conventional farmers in the Northeastern region. Thus, there are a total of 445 farms surveyed, 168 in the Northern region and 277 in the Northeast (Table 3).

The contract-organic farms in the survey can be categorized into three groups according to the length of their organic farming history and restrictions on their farming practices. Farmers in the "permanent organic" group include those certified to completely avoid using chemical fertilizer and pesticides or herbicides, while those in the "transitional organic" or "initial organic" groups may still use chemical fertilizers or even pesticides and herbicides. As the names suggest, "transitional" organic farms generally have longer history and more experience in organic rice farming than the "initial" organic group. It should be noted that in this sample all organic farmers are contract farmers, while all conventional farmers are non-contract farmers.

Table 3 gives the division between different categories of farmers within regions and provinces.

Table 3. Distribution of the sampled rice farms by region, province and special groups

Region	Province	Group	Type of rice produced by group	No. of sample
North	Phayao	Permanent organic	Certified organic rice	20
		Conventional	Conventional (using chemical inputs)	23
	ChiangRai	Permanent organic	Permanent organic rice	21
		Transitional organic	Transitional organic rice	21
		Initial organic	Initial organic rice	21
		Conventional	Conventional (using chemical inputs)	62
		Total sample of contract-organic rice farmers		83
		Total sample of conventional rice farmers		85
Northeast	Ubon Ratchathani	Transitional organic	Certified organic rice	52
		Conventional	Conventional (using chemical inputs)	47
	Surin	Permanent	Certified organic rice	14
		Transitional	Transitional organic rice	17
		Initial	Chemical safe (no chemical fertilizer)	11
		Conventional	Conventional (using chemical inputs)	45
	Yasothon	Permanent/transitional organic	Growing organic rice more than 5 yrs.	15
		Permanent/transitional organic	Growing organic for rice 2-4 yrs.	15
		Transitional organic	First year transitional organic rice	16
		Conventional	Conventional (using chemical inputs)	45

Region	Province	Group	Type of rice produced by group	No. of sample
		Total sample of contract-organic rice farmers		140
		Total sample of conventional rice farmers		137
Entire country		Total sample of contract-organic rice farmers		223
		Total sample of conventional rice farmers		222

Source: Survey conducted during January-February 2003, B. Titapiwatanakun (2005)

Information on quantity and value of rice output and major inputs were gathered in the farm survey. The major inputs include seed, hired and family labor, chemical fertilizer, organic fertilizer, pesticides and herbicides, fuel, machinery rental, land, and capital assets. In addition, date were collected on the characteristics of farmers and farms.

Table 4 provides a summary of the characteristics of the sampled farms by contract and non-contract farmers and by region. Overall, household heads for contract farms were significantly[1] younger (age of 49 vs. 51 years) and better educated (2.86 vs. 2.36 years of formal education) than non-contract farms. These differences were also true for the two regions except that there was no significant difference between the age of the household heads between contract and non-contract farms in the Northern region. While there were no significant differences of experience in rice farming for the contract and non-contract farmers in both regions, contract farmers in the North exhibited a significantly higher level of experience in fragrant rice farming than non-contract farmers, but this relationship was reversed for the Northeastern region. With respect to experience in organic rice farming, contract farmers in the North had a significantly higher level than the Northeast (5.83 vs. 3.23 years).

Table 4. Characteristics of sampled farms

	Total Sample Means	Non-Contract Farmers Means	Contract Farmers Means	p-value*
NORTH (No. of farms)	**168**	**85**	**83**	
Age of household head (years)	47.90	47.56	48.24	0.6660
Education of household head (years)	2.52	2.32	2.72	0.0229
Number of household members engaged in rice farming	2.14	2.15	2.13	0.8625
Female members engaged in rice farming (%)	0.48	0.50	0.46	0.5890
Land allocated to rice (rai/farm)	11.98	10.23	13.77	0.0044
Land ownership (%)	85%	76%	94%	0.0013
Years in rice farming	35.47	32.21	38.81	0.0858
Years in fragrant (Hom Mali) rice farming	10.45	8.65	12.29	0.0164
Years in organic rice farming	2.88	0.00	5.83	0.0000
% of saline soil	5%	6%	4%	0.4931
% of income from non-agricultural activities	8%	7%	9%	0.7390
% of agricultural income from rice faming	58%	56%	60%	0.5650

[1] Significance herein refers to statistical significance.

	Total Sample Means	Non-Contract Farmers Means	Contract Farmers Means	p-value*
% of labor from family	66%	67%	65%	0.6900
% of seed from own supply	42%	38%	47%	0.2229
% of organic fertilizer from own supply	15%	4%	26%	0.0000
NORTHEAST (No. of farms)	**277**	**137**	**140**	
Age of household head (years)	50.72	52.81	48.68	0.0019
Education of household head (years)	2.67	2.39	2.94	0.0004
Number of household members engaged in rice farming	2.53	2.54	2.51	0.8482
Female members engaged in rice farming (%)	0.54	0.54	0.53	0.9690
Land allocated to rice (rai/farm)	12.17	11.01	13.31	0.0169
Land ownership (%)	93%	92%	94%	0.4478
Years in rice farming	43.00	42.45	43.54	0.6747
Years in fragrant (Hom Mali) rice farming	13.97	16.50	11.49	0.0001
Years in organic rice farming	1.63	0.00	3.23	0.0000
% of saline soil	8%	9%	7%	0.6204
% of income from non-agricultural activities	14%	16%	12%	0.2790
% of agricultural income from rice faming	62%	61%	64%	0.5320
% of labor from family	76%	76%	76%	0.8783
% of seed from own supply	65%	70%	59%	0.0588
% of organic fertilizer from own supply	56%	53%	60%	0.1223
TOTAL (No. of farms)	**445**	**222**	**223**	
Age of household head (years)	49.66	50.80	48.52	0.0261
Education of household head (years)	2.61	2.36	2.86	0.0000
Number of household members engaged in rice farming	2.38	2.39	2.37	0.8384
Female members engaged in rice farming (%)	0.51	0.52	0.51	0.7310
Land allocated to rice (rai/farm)	12.10	10.71	13.48	0.0003
Land ownership (%)	90%	86%	94%	0.0040
Years in rice farming	40.16	38.53	41.78	0.1378
Years in fragrant (Hom Mali) rice farming	12.64	13.50	11.79	0.0093
Years in organic rice farming	2.10	0.00	4.20	0.0000
% of saline soil	7%	8%	6%	0.4430
% of income from non-agricultural activities	12%	13%	11%	0.4650
% of agricultural income from rice faming	61%	59%	63%	0.3920
% of labor from family	72%	73%	72%	0.7475
% of seed from own supply	56%	58%	55%	0.5299
% of organic fertilizer from own supply	41%	34%	48%	0.0005

* p-value is the smallest level of significance for which we can reject the respective hypothesis test of difference in means between contract and non-contract farmers using the appropriate t-test.

The average number of household members engaged in rice farming was very similar for contract and non-contract farmers (2.37 vs. 2.39) overall and in both regions. The percentage of female members engaged in rice farming was also very similar for contract and non-contract farmers (51% vs. 52%) overall and in both regions. Overall, contract farmers allocated an average of 13.48 rai of land to rice farming which was significantly higher than the non-contract farmers who had allocated only 10.71 rai. Similar patterns were also exhibited in both regions. With respect to land ownership, while there was no significant difference between contract and non-contract farmers in the Northeast, contract farmers in the North had a higher percentage of ownership than the non-contract farmers (94% vs. 76%). While the percentage of income derived from non-agricultural activities was significantly lower for the farms in the North (8%) than the Northeast (14%), there were no significant differences between the two contracting groups within each region. As to the percentage of agricultural income derived from rice farming, there were no significant differences between regions and within the two contracting groups.

While farms in the Northeastern region used a significantly higher percentage of family labor (76%) when compared to the North (66%), there were no significant differences between contract and non-contract farmers within each region. While the contract and non-contract farmers in the North region on the average showed no significant differences in using their own seeds, non-contract farmers in the Northeastern region used significantly more seeds from their own supply than contract farmers (70% vs. 59%). In terms of utilization of organic fertilizers, contract and non-contract farmers in the North region were similar in the percentage from own production (slightly more than half). However, contract farmers in the Northeast used significantly more organic fertilizers derived from own supply than non-contract farmers (26% vs. 4%).[2] Finally, both regions had a similar endowment of saline soil and there were no significant differences in soil distribution between contract and non-contract farmers.

THE PROFIT FRONTIER ESTIMATES

Since contract and non-contract farming tend to have different production processes, we estimate their profit efficiency separately.[3] (see Appendix)

Tables 5a and 5b provide the summary statistics of variables used in estimating the profit frontiers for contract and non-contract farms respectively.

[2] It should be noted that there is a high cash cost associated with organic fertilizers, which is interesting as we would normally assume that organic fertilizers are derived from farm wastes (e.g. compost) and therefore is appropriate for farmers who do not have access to credit. In the case of Thailand, it appears from the survey that there are all sorts of commercial forms of organic fertilizers (e.g. EM-effective microorganism) and farmers in the North do have available cash to purchase it.

[3] An alternative is to include contract and non-contract farms in a single estimation and use a dummy variable to distinguish them. However, as pointed out by Delgado et al. (2003), Warning and Key (2002), and Larsen and Foster (2005), such specifications may lead to self-selection or simultaneity bias since the decision to be a contract or organic farmer may not be independent from other production decisions.

Table 5a. Summary statistics of variables used in frontier estimation (contract farms)[1]

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Output, profit, prices and fixed inputs:					
Rice output	Kg	5,134	3,444	400	22,500
Variable profit (Gross revenue less total cash cost)	baht/farm	26,692	18,207	2,495	90,881
Rice price	baht/kg	7.37	1.39	5	10
Seed price	baht/kg	9.88	1.48	6	15
Hired labor wage	baht/person/day	195	365	21	4,600
Chemical fertilizer price	baht/kg	7.04	0.18	6	8
Organic fertilizer price	baht/kg	2.08	3.17	0.15	28
Machinery power	baht/rai	213	211	5	1,010
Fuel price	baht/rai	5.76	5.09	0.10	33
Land	Rai	14	8.58	1	60
Capital	Bath	53,265	67,557	204	543,717
Farm-specific variables:					
Farm characteristics and endowments					
Regional dummy (North=1; Northeast=0)	0/1	0.37	0.48	0	1
Farm size	Rai	14	8.58	1	60
Land ownership (own=1; rent=0)[2]	0/1	0.94	0.24	0	1
Rice income in total agricultural income	%	63%	25%	8%	100%
Demographic and other characteristics of household head					
Experience in fragrant rice farming	Years	12	9.82	1	50
Level of formal education	Years	2.86	1.38	1	8
Age	Years	49	11	30	76
Non-agricultural income in total household income	%	11%	20%	0%	92%
General production practices					
Amount of own labor	%	72%	26%	9%	100%
Amount of own organic fertilizer	%	47%	39%	0%	100%
Amount of own seed	%	55%	50%	0%	100%

1 Among the 223 contract farms in the sample, only 222 used in the regression; one outlier excluded.
2 Farms with more than 50% of lands owned considered owners farm; those with less than 50% of lands owned considered rented farms.

Table 5b. Summary statistics of variables used in frontier estimation (non-contract farms)[1]

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Output, profit, prices and fixed inputs:					
Rice output	Kg	4,106	3,050	360	25,000
Variable profit (Gross revenue less total cash cost)	baht/farm	15,114	13,182	180	107,350
Rice price	baht/kg	5.94	0.72	4	12
Seed price	baht/kg	9.66	2.45	5	20
Hired labor wage	baht/person/day	144	87	36	952
Chemical fertilizer price	baht/kg	7.02	0.47	5	9
Organic fertilizer price	baht/kg	1.29	1.88	0.13	25
Machinery power	baht/rai	237	209	5	1,159
Fuel price	baht/rai	6.12	4.46	0.21	32
Land	Rai	11	7.36	1	50
Capital	Bath	34,115	44,882	235	366,981
Farm-specific variables:					
Farm characteristics and endowments					
Regional dummy (North=1; Northeast=0)	0/1	0.39	0.49	0	1
Farm size	Rai	11	7.36	1	50
Land ownership (own=1; rent=0)[2]	0/1	0.86	0.35	0	1
Rice income in total agricultural income	%	59%	27%	7%	100%
Demographic and other characteristics of household head					
Experience in fragrant rice farming	years	13	9.34	1	50
Level of formal education	years	2.38	1.06	1	8
Age	years	51	11	29	85
Non-agricultural income in total household income	%	12%	23%	0%	89%
General production practices					
Amount of own labor	%	74%	27%	8%	100%
Amount of own organic fertilizer	%	35%	44%	0%	100%
Amount of own seed	%	57%	49%	0%	100%

1 Only 212 among the 222 non-contract farms in the sample used in the regression; one outlier excluded; another 9 farms excluded for negative profits.
2 Farms with more than 50% of lands owned considered an owners farm; those with less than 50% of lands owned considered a rented farm.

Since our interest is in the estimation of profit inefficiency and its determinants, we do not focus on the estimates of the stochastic profit frontier except for the derived profit elasticities. Table 6 shows the profit elasticities with respect to the 6 variable input prices and the 2 fixed factors for both contract and non-contract farms. The profit elasticities of contract farms with respect to seed price, wage and energy are negative as expected yet not statistically significant, while the elasticities with respect to the prices of chemical fertilizer, organic fertilizer and machinery are positive yet insignificant.

As to the non-contract farms, the profit elasticities with respect to all the input prices are of the correct sign except for seed which is also not statistically significant. For both contract and non-contract farms, profit elasticities with respect to the two fixed factors (land and capital) are also of the right sign but capital is not statistically significant. The estimated profit elasticities with respect to land are 0.87 for contract farms and 0.98 for non-contract farms, indicating that profit tends to increase by less than 1% with a 1% increase in land allocated to contract or non-contract rice farming.

Table 6 Estimated profit elasticities for contract farms

Profit elasticity with respect to	Contract farms		Non-contract farms	
	Elasticity	p-value	Elasticity	p-value
Variable inputs				
Seed price	-0.242	0.151	0.100	0.414
Wage	-0.076	0.277	-0.017	0.884
Chemical fertilizer price	0.106	0.653	-0.012	0.962
Organic fertilizer price	0.021	0.547	-0.171	0.002
Machinery	0.018	0.447	-0.047	0.108
Energy	-0.052	0.119	-0.001	0.985
Fixed inputs				
Land	0.868	0.000	0.975	0.000
Capital	0.006	0.784	0.027	0.385

Given the data and model specification, the results indicate that the farm-specific variables included in the inefficiency effects model contribute significantly, both as a group and several individually, to the explanation of profit inefficiency among the sample rice farms in Thailand. It should be noted that a negative coefficient indicates that variable has a positive impact on profit efficiency and vice versa. The results show that non-contract farmers in the North region were more profit efficient than those in the Northeast region.[4] The size of farm was found to have a negative impact on the profit efficiency of both contract and non-contract farms, although it was not significant at the 10% level. As expected, landowners were more efficient than the tenants for contract farmers, although this was not statistically significant. In contrast, owner farms appear to be less efficient than tenant farms for non-contract farming, although the impact is also not statistically significant. As expected, the importance of rice to total agricultural income had a statistically significant positive impact on the profit efficiency of non-contract farming. In other words, non-contract farms devoted a larger effort to rice farming. However, this relationship does not apply to contract farming. Experience in

[4] Since the region dummy is not included in the estimation for contract farming, the regional impact on contract farmers' profit efficiency is not directly captured by the estimation. Yet further analysis later shows that contract farmers in the North also tend to have higher profit efficiency.

fragrant rice farming had a statistically significant and positive impact on the efficiency of contract farming yet this had no significant impact on that of non-contract farming. Education had a positive impact on the efficiency of non-contract farming, which is nevertheless not statistically significant. In contrast, education had a negative impact on contract farmers' efficiency, which is also not significant. Age appears to negatively affect the efficiency of both contract and non-contract farming; the impact is greater and more significant for contract than non-contract farming. Similarly, both contract and non-contract farmers who had a higher proportion of non-agricultural income were found to be less profit efficient, indicating that when farmers devoted more time on off-farm jobs, less time would be available for agricultural activities resulting in lower efficiency. With respect to farming practices, both contract and non-contract farms with proportionately more family labor were significantly more profit efficient, as expected. Similarly, non-contract farms that utilized more on-farm organic fertilizer were more profit efficient although not statistically significant, yet the impact was the opposite for contract farms. Finally, both contract and non-contract farms that utilized more of their own seeds were less profit efficient, although this was not significant at the 10% level. Although several of the variables were statistically insignificant, most of the variables exhibited the correct signs. It should be pointed out that the results are for the overall sample and more detailed profit efficiency by region as well as other farm characteristics will be presented later in the section on Comparative Profit Efficiency.

COMPARATIVE PROFITABILITY

In this section, we will test the first hypothesis that "contract rice farmers are more profitable than non-contract rice farmers for comparable scales of operation." Table 7 shows that contract or organic farmers made a significantly higher profit over total cash cost as well as profit over total variable cost in the overall sample and in each region. Contract farmers on the average generated a profit over total variable cost of 1,234 baht per rai in the North and 1,098 baht per rai in the Northeast. On the other hand, non-contract farmers produced a profit over total variable cost of only 731 baht per rai in the North and 273 baht per rai in the Northeast. Contract farmers clearly outperformed non-contract farmers in both regions and significantly more so in the Northeast. This can largely be explained by the significantly higher price of rice received by the contract farmers (6.5 vs. 6.0 baht/kg in the North and 7.9 vs. 5.9 baht/kg in the Northeast). On the other hand, it is interesting to note that production in kg per rai or yield was very similar for the contract and non-contract farmers in both regions.

Table 7. Cost and return of rice farming in Thailand

	Total sample	Contract/organic farms				Non-contract /conventional farms	p-value[1]
		Permanent	Transitory	Initial	Total		
NORTH (number of farms)	**168**	**41**	**21**	**21**	**83**	**85**	
Profit over total variable costs:							
Total profit (baht)	13,680	17,437 [a,b]	21,015[a]	15,754 [a,b]	17,916	9,543[b]	0.0009
Profit per unit of land	980	1,166[a]	1,309 [a]	1,291[a]	1,234	731 [b]	0.0000

	Total sample	Contract/organic farms				Non-contract /conventional farms	p-value[1]
		Permanent	Transitory	Initial	Total		
(baht/rai)							
Profit per unit of production (baht/kg)	1.98	2.34 [a]	2.68 [a]	2.61 [a]	2.50	1.48 [b]	0.0000
Profit over cash costs:							
Total profit (baht)	21,800	27,377 [a]	30,731 [a]	22,371 [a,b]	26,959	16,762 [b]	0.0001
Profit per unit of land (baht/rai)	1,847	2,018 [a]	2,042 [a]	1,927 [a]	2,001	1,697 [a]	0.0047
Profit per unit of production (baht/kg)	3.90	4.23 [a]	4.23 [a]	4.07 [a]	4.19	3.62 [a]	0.0018
Production/Yield (kg/rai)	464	472 [a]	477 [a]	461 [a]	470	458 [a]	0.3899
Price of rice (baht/kg)	6.26	6.59 [a]	6.45 [a]	6.38 [a]	6.50	6.02 [b]	0.0000
Cash costs (baht/rai):[2]	1,061	1,095 [a]	1,034 [a]	1,022 [a]	1,061	1,060 [a]	0.9867
Labor	406	440 [a]	368 [a]	349 [a]	399	414 [a]	0.7706
Seed	57	44 [a]	43 [a]	76 [a]	51	62 [a]	0.3598
Chemical fertilizer	136	0 [d]	85 [c]	138 [b]	56	214 [a]	0.0000
Organic fertilizer	95	217 [a]	161 [a]	96 [b]	172	19 [c]	0.0000
Pesticides and herbicides	5.61	0 [c]	3.51 [a,b]	2.38 [a,b]	1.49	9.63 [a]	0.0016
Fuel	93	98 [a]	79	115 [a]	98	88 [a]	0.4546
Machinery power	267	295 [a]	295 [a]	246 [a]	282	253 [a]	0.4328
Non-cash costs (baht/rai):	868	852 [a]	733 [a]	636 [a]	767	966 [a]	0.0375
Labor	774	645 [a,b]	620 [a,b]	574 [b]	621	923 [a]	0.0014
Seed	42	57 [a]	51 [a]	33 [a]	50	34 [a]	0.0972
Organic fertilizer	52	150 [a]	62 [b]	28 [b]	97	8.75 [b]	0.0011
Total variable costs (baht/rai)	1,928	1,946 [a,b]	1,768 [a,b]	1,658 [b]	1,828	2,026 [a]	0.0401
Farm capital assets (baht/farm)	57,322	75,494 [a]	79,081 [a]	63,113 [a]	73,269	41,751 [a]	0.0039
Farm capital assets (baht/rai)	16,378	18,853 [a,b]	17,956 [a,b]	25,956 [a]	20,423	12,427 [b]	0.0073
NORTHEAST	**275**	**40**	**88**	**11**	**139**	**136**	
Profit over variable costs:							
Total profit (baht)	9,983	22,606[a]	13,071[b]	5,531[c]	15,218	4,633[c]	0.0000
Profit per unit of land (baht/rai)	690	1,800[a]	833[a]	654[bc]	1,098	273[c]	0.0000
Profit per unit of production (baht/kg)	1.66	4.97[a]	2.21[b]	1.60[b]	2.96	0.34[c]	0.0000
Profit over cash costs:							
Total profit (baht)	19,726	35,203[a]	24,320[b]	12,693[c]	26,532	12,771[c]	0.0000
Profit per unit of land (baht/rai)	1,644	2,849[a]	1,867[b]	1,416[c]	2,114	1,163[c]	0.0000

	Total sample	Contract/organic farms				Non-contract /conventional farms	p-value[1]
		Permanent	Transitory	Initial	Total		
Profit per unit of production (baht/kg)	4.66	8.07[a]	5.34[b]	3.85[c]	6.01	3.29[c]	0.0000
Production/Yield (kg/rai)	346	353 [a]	347 [a]	350 [a]	349	342 [a]	0.5881
Price of rice (baht/kg)	6.89	10 [a]	7.14 [b]	6.29 [c]	7.89	5.87 [d]	0.0000
Cash costs (baht/rai):[2]	725	631 [a]	592 [a]	810 [a]	621	831 [a]	0.0006
Labor	281	239 [a]	274 [a]	369 [a]	272	290 [a]	0.6599
Seed	16	2.40 [a]	17 [a]	14 [a]	13	18 [a]	0.1388
Chemical fertilizer	95	0 [b]	0 [b]	0 [b]	0	192 [a]	0.0000
Organic fertilizer	101	174 [a]	114 [a,b]	191 [a]	137	65 [b]	0.0000
Pesticides and herbicides	1.33	0.00 [a]	0.00 [a]	0.00 [a]	0	2.69 [a]	0.0001
Fuel	37	49 [a,b]	33 [b]	69 [a]	40	34 [b]	0.2596
Machinery power	193	166 [a]	154 [a]	167 [a]	158	228[a]	0.0079
Non-cash costs (baht/rai):	954	1,049 [a]	1,033 [a]	761 [a]	1,016	890 [a]	0.0585
Labor	697	677 [a]	726 [a]	512 [a]	695	699 [a]	0.9387
Seed	58	69 [b]	39 [b]	107 [a]	53	63 [b]	0.1981
Organic fertilizer	199	303 [a]	269 [a]	142 [b]	269	127 [b]	0.0000
Total variable costs (baht/rai)	1,679	1,680 [a]	1,625 [a]	1,572 [a]	1,637	1,721 [a]	0.2746
Farm capital assets (baht/farm)	36,191	34,618 [a]	45,367 [a]	33,311 [a]	41,320	30,950 [a]	0.0628
Farm capital assets (baht/rai)	9,062	8,439 [a]	9,651 [a]	8,614 [a]	9,220	8,901 [a]	0.8257
TOTAL	**443**	**81**	**109**	**32**	**222**	**221**	
Profit over variable costs:							
Total profit (baht)	11,385	19,989[a]	14,601[b]	12,240[b]	16,227	6,522[c]	0.0000
Profit per unit of land (baht/rai)	800	1,479[a]	925[b]	1,072[b]	1,149	449[c]	0.0000
Profit per unit of production (baht/kg)	1.78	3.64[a]	2.30[b]	2.26[b]	2.78	0.78[c]	0.0000
Profit over cash costs:							
Total profit (baht)	20,513	31,242[a]	25,555[b]	19,044[c]	26,692	14,306[c]	0.0000
Profit per unit of land (baht/rai)	1,721	2,428[a]	1,901[b]	1,752[b]	2,072	1,369[c]	0.0000
Profit per unit of production (baht/kg)	4.37	6.13[a]	5.13[b]	4.00[c]	5.33	3.41[c]	0.0000
Production/Yield (kg/rai)	390	413 [a]	372 [a]	423 [a]	394	387 [a]	0.4828
Price of rice (baht/kg)	6.65	8.27 [a]	7.00 [b]	6.35 [c]	7.37	5.93 [d]	0.0000
Cash costs (baht/rai):[2]	852	866 [a]	677 [b]	949 [a]	785	919 [a]	0.0053
Labor	328	341 [a]	292 [a]	356 [a]	319	338 [a]	0.5746
Seed	31	24 [b]	22[b]	54 [a]	27	35 [b]	0.1303
Chemical fertilizer	111	0 [c]	16 [c]	91 [b]	21	201 [a]	0.0000

	Total sample	Contract/organic farms				Non-contract /conventional farms	p-value[1]
		Permanent	Transitory	Initial	Total		
Organic fertilizer	99	196 [a]	123 [b]	128 [b]	150	47 [c]	0.0000
Pesticides and herbicides	2.95	0 [b]	0.68 [b]	1.56 [b]	0.56	5.36 [a]	0.0000
Fuel	59	74 [a,b]	42 [c]	99 [a]	62	55 [b,c]	0.2916
Machinery power	221	231 [a]	181 [a]	219 [a]	205	238 [a]	0.1334
Non-cash costs (baht/rai):	921	949 [a]	975 [a]	679 [b]	923	919 [a]	0.9461
Labor	726	661 [a,b]	705 [a,b]	553 [c]	667	785 [a]	0.0199
Seed	52	63 [a]	41 [a]	59 [a]	52	52 [a]	0.9319
Organic fertilizer	143	225 [a]	229 [a]	68 [b]	204	82 [b]	0.0000
Total variable costs (baht/rai)	1,773	1,815 [a]	1,653 [a]	1,628 [a]	1,708	1,838 [a]	0.0336
Farm capital assets (baht/farm)	44,205	55,309 [a]	51,863 [a]	52,869 [a]	53,265	35,104 [a]	0.0009
Farm capital assets (baht/rai)	11,836	13,710 [b]	11,251 [b]	19,995 [a]	13,409	10,257 [b]	0.0338

1 p-values are for the respective tests of mean difference between contract farmers and non-contract farmers.
Similar superscript letters across organic groups denote homogeneous subsets using the Duncan's multiple range test at the 5 % level of significance.
2. Besides those listed in the table, cash costs also include certification fees for organic farms.

Table 7 also provides a comparison of the detailed cost structure of the contract vs. non-contract farmers. While there were no significant differences in the cash cost per rai of labor, seed, fuel and machinery power between contract and non-contract farmers in the North, contract/organic farmers spent significantly more on organic fertilizers, but less on chemical fertilizers and pesticides and herbicides as expected. Contract farmers in the North on the average also utilized significantly less family labor (valued at the hired wage). As expected, contract farmers used significantly more of their own supply of organic fertilizers than non-contract farmers in the North. However, it was surprising that contract farmers in the North utilized more of their own seed than non-contract farmers. Similar to the North, contract farmers in the Northeast showed no significant difference in the cash cost per rai for seed, labor, and fuel but significantly more cash cost for organic fertilizer and less cash cost for chemical fertilizer and pesticides and herbicides. However, contract farmers in the Northeast had a significantly lower cash cost for machinery power contrary to expectation. Contract farmers in the Northeast showed no significant difference in non-cash cost of labor and seed but a significantly higher non-cash cost for organic fertilizer as expected. While the invested capital assets valued at baht/rai were significantly higher for contract farmers in the North, there was no significant difference between contract and non-contract farmers in the Northeast. It is interesting to note that farmers in the North were generally more capitalized than the Northeast (16,377 vs. 9,062 baht/rai of capital assets).

Table 7 also shows the differences in profit and cost structure among the three organic farmer groups – permanent, transitory and initial – indicating their levels of sophistication in organic farming. While organic farmers in the North regardless of their stage of transition achieved similar levels of profit (in terms of profit over cash cost per rai and per kg), the permanent organic farmers in the Northeast were more profitable than the transitory and initial organic farmers. In fact, profitability of the initial organic farmers was no different from that of the conventional farmers in the Northeast. This profitability pattern can again be largely explained by the price of rice received by the farmers. While the price of rice was not significantly different among the three organic groups in the North (6.6, 6.5 and 6.4 baht/kg respectively for permanent, transitional and initial organic farms), the price received by the permanent organic farmers (10 baht/kg) in the Northeast was higher than the transitory and initial organic farmers (7.1 and 6.3 baht/kg respectively). One can also discern the level of sophistication of organic farming between the North and Northeast through their inputs used. While only the permanent organic farmers among the three organic groups in the North did not use any chemical fertilizer, pesticide and herbicide in their operations, all three groups of organic farmers in the Northeast had refrained totally from using any chemicals in their operations. Furthermore, organic farmers in the Northeast used more on-farm organic fertilizer than the farmers in the North.

Table 8. Profitability by farm size, in profit after cash costs/rai

Land category	All farms	Non-contract farmers	Contract farmers	p-value*
0-5 rai	1,719[a]	1,374 [a]	2,432[a]	0.0000
6-10 rai	1,744[a]	1,413 [a]	2,076[ab]	0.0000
11-20 rai	1,723[a]	1,337 [a]	2,021[b]	0.0000
>20 rai	1,646[a]	1,276 [a]	1,866[b]	0.0057
Total	1,721	1,369	2,072	0.0000

* p-values are for the respective tests of mean difference between contract farmers and non-contract farmers.
Similar superscript letters across farm size denote homogeneous subsets using the Duncan's multiple range test at the 5 % level of significance.

As shown in Table 8, profit after cash costs for contract farmers decreases with the increase in farm size while for non-contract farmers profit after cash cost is relatively stable throughout. Contract and organic farming do not seem to be biased against smaller farms in terms of profitability as generally conceived. Furthermore, profits are significantly higher for contract farmers for all farm sizes when compared with non-contract farmers.

Selection bias and counterfactual simulation

The above profitability comparison reveals that contract farms in the sample generally have higher profits than non-contract farms. However, this profitability difference does not necessarily indicate that contracting has a positive impact on profits because it could be caused by selection bias. That is, the higher profitability in contract farming may merely reflect the fact that farms with the potential of securing higher profitability are more likely to become contract farms. Put plainly, those contract farms would tend to have relatively high profits whether engaging in contract or non-contract farming.

A "counterfactual" simulation can help sort out the impact of contracting on profitability. In brief, the key to this approach is to estimate farms' "counterfactual profits" and compare them to their actual profits. The counterfactual profit of a *contract* farm is defined as the hypothetical profit that it could have earned had it farmed like a (typical) *non-contract* farm. Similarly, the counterfactual profitability of a *non-contract* farm is defined as the hypothetical profit that it could have earned had it farmed like a (typical) *contract* farm. Non-contract farms in the sample generally sold their rice at lower prices than contract farms. We use the rice prices of contract (or non-contract) farms in the estimation of the counterfactual profits of non-contract (or contract) farms.

Higher actual than counterfactual profits for contract farms would indicate that contract farms would have been less profitable had they operated like a non-contract farm. Similarly, lower actual than counterfactual profits for non-contract farms would indicate that non-contract farms would have been more profitable had they operated like a contract farms (see Appendix for details of counterfactual analysis).

The counterfactual results are given in table 9. Had contract farms operated like a non-contract farm, their counterfactual profits would (on average) have been 31% lower than their actual profits; the differences are 49% and 21% respectively for contract farms in the North and Northeast. Conversely, had non-contract farms operated like a contract farm, their counterfactual profits would have been 47% higher than their actual profits; the differences are 9.4% (significant at 10% level) in the North and 72% in the Northeast. These results clarify that the observed higher profitability in contract farming is not simply because of contract farming attracting high profitable farms; rather, it is evidence supporting the hypothesis that contract farming tends to be more profitable than non-contract farming.

Table 9. Counterfactual vs. actual profits

Profit	**Entire**		**North**		**Northeast**	
	Profit differences	p value	Profit differences	p value	Profit differences	p value
Contract counterfactual vs. Contract actual	-31.4%	0.0000	-48.8%	0.0000	-21.1%	0.0059
Non-contract counterfactual vs. Non-contract actual	47.4%	0.0000	9.4%	0.0957	71.8%	0.0000

COMPARATIVE PROFIT EFFICIENCY

In this section, we will test the second hypothesis that “contract rice farmers are more profit efficient than non-contract rice farmers for comparable scales of operation.”

Table 10. Profit efficiency of contract vs. non-contract rice farmers

	N	Actual Profit (baht/rai)	Profit Loss (baht/rai)	Profit Efficiency index
All	443	1,721	842	0.68
Contract	222	2,072	906	0.72
Non-contract	221	1,369	778	0.64
p-value		0.0000	0.0388	0.0032

North	168	1,847	650	0.76
Contract	83	2,001	727	0.76
Non-contract	85	1,697	575	0.76
p-value		0.0047	0.0934	0.9916
Northeast	275	1,644	960	0.63
Contract	139	2,114	1,014	0.69
Non-contract	136	1,163	905	0.56
p-value		0.0000	0.1769	0.0002

Table 10 shows the profit efficiency, actual profit and profit loss per rai for contract and non-contract farms by region. Profit loss is defined here as the amount of unrealized profit due to inefficiency and can simply be calculated as the difference between maximum possible profit (that is, profit on the profit frontier) for each farm and its actual profit. Profit efficiency reported is an index adjusted by including the nine negative profit observations that were dropped from the estimation.[5]

The estimated mean profit efficiency score for the entire sample farms is 0.68. In other words, significant profit inefficiency occurred among the sample rice farms in Thailand and farms could increase their profit by ~32% or 842 baht/rai by improving their efficiency.

As shown in Table 10 farmers in the North region exhibited significantly higher profit efficiency than the Northeast region, with a mean efficiency of 0.76 vs. 0.63. Overall, contract farmers were significantly more profit efficient than non-contract farmers, with a mean profit efficiency of 0.72 vs. 0.64.

This is also true for farmers in the Northeast where contract farmers are found to be significantly more profit efficient than non-contract farmers (0.69 vs. 0.56). However, the efficiency scores of contract and non-contract farmers in the North were virtually the same on average, although the scores were more diverse among the non-contract farmers

[5] The profit efficiency measure PE_i given in equation (2) in the Appendix, which measures the ratio of a farm's actual profit to its maximum attainable profit, is not well defined when actual profits are negative. Since all the 9 cases of negative profits are non-contract/conventional farms, excluding them would lead to biased results. Therefore, we suggest the following measure of the profit efficiency of farms with negative actual profits. We first calculate the absolute value of profit loss of each of the 9 negative-profited farm compared to its estimated maximum attainable profit; let us denote such profit losses as $\Delta\pi_i$. Then, the profit efficiency of say farm *i* among these 9 negative-profited farms is measured by $-\Delta\pi_i / \max(\Delta\pi_j)$, where $\max(\Delta\pi_j)$ represents the greatest profit loss among these 9 farms. Under this profit efficiency measure, the profit efficiency score of a farm with negative profits would be negative and at the range of [-1, 0). The one with the largest profit loss would have profit efficiency score of -1; and the closer a farm's negative profit efficiency to zero, the greater its profit efficiency score would be compared to other farms with negative actual profits. That farms with positive (or negative) actual profits have positive (or negative) profit efficiency scores implies that farms with negative actual profits must be less efficient than those with positive profits. This makes sense because farms with negative profits have lost more than whatever attainable profits they may have. Considering that we have used the least efficient farm as a benchmark to index the profit efficiency of farms with negative profits, we adjust the efficiency measure for positive-profited farms accordingly by using $PE_i / \max(PE_j)$ to measure farm *i*'s efficiency. In sum, the adjusted profit efficiency scores are in the range of [-1, 1]. Farms with positive actual profits have positive profit efficiency scores, while farms with negative profits with negative scores. The greater a farm's score is, the more profit efficient it is.

It should be noted that since all the contract farmers were also organic farmers, we could reasonably infer that organic farmers were significantly more profit efficient than non-contract farmers using conventional method. Unfortunately, we would not be able to separate their individual effects, that is, how much of the profit efficiency was due to organic farming versus the contract arrangement.

Table 11 shows the profit efficiency across different farm sizes for contract and non-contract farmers. Similar to profitability, contract farmers had a higher profit efficiency for all farm sizes except those greater than 20 rai. Contract farmers appear to show a slight tendency to decreasing profit efficiency for larger farm size while non-contract farmers are rather homogeneous across all farm sizes. Furthermore, similar to profitability, with respect to profit efficiency contract and organic farming do not seem to be biased against smaller farms.

Table 11. Profit efficiency by farm size

Farm Size	**0-5 rai**	**6-10 rai**	**11-20 rai**	**>20 rai**
All Farms				
Actual profit (per rai)	1,719[a]	1,744[a]	1,723[a]	1,646[a]
Profit loss (per rai)	821[b]	774[b]	850[b]	1,067[a]
Profit Efficiency	0.69[a]	0.70[a]	0.67[a]	0.64[a]
Non-Contract/Conventional Farms				
Actual profit (per rai)	1,374 [a]	1,413 [a]	1,337 [a]	1,276 [a]
Profit loss (per rai)	801[a]	762[a]	764[a]	818[a]
Profit Efficiency	0.64[a]	0.65[a]	0.62[a]	0.64[a]
Contract/Organic Farms				
Actual profit (per rai)	2,432[a]	2,076[ab]	2,021[b]	1,866[b]
Profit loss (per rai)	862[b]	786[b]	916[b]	1,215[a]
Profit Efficiency	0.78[a]	0.75[a]	0.70[ab]	0.64[b]
p-value of profit efficiency between contract and non-contract farmers	0.0276	0.0325	0.1351	0.9902

Note: Similar superscript letters across farm size denote homogeneous subsets using the Duncan's multiple range test at the 5 % level of significance.

Table 12a shows the profit efficiency among the different groups of organic farms at different stages of development and sophistication. The permanent organic farming group consists of farms, which had fully converted to organic practice (mostly more than 4 years into organic farming). The transitional organic farming group represents farms, which were under transition (mostly 2-4 years into organic farming), while the initial organic farming group represents farms, which had just gone organic (mostly one to two and years in organic farming). Farmers with longer history and more experience in organic farming appear to be more profit efficient as well as more profitable. However, multiple range tests show that all three groups of organic farmers in the North exhibited similar profit efficiency as well as profitability. In fact, they were not different from the inorganic farmers. On the other hand, as indicated earlier, permanent organic farmers had a higher profitability than transitional and initial organic farmers in the Northeast and in that order. While profit efficiency was not statistically different between the permanent and transitory groups in the Northeast, it was higher for these than for the initial organic group, whose efficiency was statistically similar to the conventional farmers.

Table 12a. Profit efficiency by different stages of organic farming

	Permanent Organic	Transitory Organic	Initial Organic	All Organic	Conventional
All Farms					
Actual profit (per rai)	2,428[a]	1,901[b]	1,752[b]	2,072	1,369[c]
Profit loss (per rai)	956[a]	904[a]	790[a]	906	778[a]
Profit Efficiency	0.75[a]	0.71[b]	0.70[ab]	0.72	0.64[b]
North					
Actual profit (per rai)	2,018 [a]	2,042 [a]	1,927 [a]	2,001	1,697 [a]
Profit loss (per rai)	745[a]	691[a]	727[a]	727	575[a]
Profit Efficiency	0.77[a]	0.77[a]	0.75[a]	0.76	0.76[a]
Northeast					
Actual profit (per rai)	2,849[a]	1,867[b]	1,416[c]	2,114	1,163[c]
Profit loss (per rai)	1,172[a]	955[a]	909[a]	1,014	905[a]
Profit Efficiency	0.73[a]	0.69[ab]	0.60[ab]	0.69	0.56[b]

Note: Similar superscript letters across groups denote homogeneous subsets using the Duncan's multiple range test at the 5 % level of significance.

Table 12b shows profit efficiency by different types of institutional arrangements in organic farming. While the NGO groups (in Surin and Yasothon) exhibited a higher profit when compared to the semi-NGO group in Ubon, the private farmer groups in Phayao and ChiangRai revealed the highest profit efficiency, followed by the semi-NGO and NGO groups. The multiple-range test indicates that although these three institutional groups were all more profitable than the conventional farmers statistically, only the private farmer group was more profit efficient.

Table 12b. Profit efficiency by different types of institution in organic farming

	Organic				Conventional
	Private Farmer Group	Semi-NGO Group	NGO Group	Entire organic	Entire conventional
All Farms					
Actual profit (per rai)	2,001[ab]	1,908[b]	2,233[a]	2,072	1,369[c]
Profit loss (per rai)	727[b]	921[ab]	1,068[a]	906	778[b]
Profit Efficiency	0.76[a]	0.70[ab]	0.69[ab]	0.72	0.64[b]

Note: Similar superscript letters across groups denote homogeneous subsets using the Duncan's multiple range test at the 5 % level of significance.

Counterfactual simulation regarding profit efficiency

Similar to the case of the actual-counterfactual profitability comparison, the difference in profit efficiency between contract and non-contract farming can also be evaluated through comparing actual and counterfactual efficiency.

The methodology is similar to that used in estimating the counterfactual profitability. To estimate the counterfactual efficiency of a contract farm (*i.e.*, its profit efficiency when hypothetically operating like a non-contract farm), the first step is to use the estimated profit frontier of non-contract farming to estimate the maximum profit the contract farm would have obtained had it produced like a non-contract farm with 100 percent efficiency.[6] The second step is to use its hypothetical profit estimated from the counterfactual profit simulation to represent its counterfactual profit in non-contract farming. Then the difference between this counterfactual profit and the counterfactual frontier can be used to measure the farm's counterfactual efficiency. The counterfactual efficiency of a non-contract farm can be similarly estimated.

Table 13 shows that contract farms in the entire sample would not have had very different counterfactual efficiency from their actual efficiency (69% vs. 70%) had they operated like a non-contract farm. This mainly reflects the situation in the Northeast, while contract farms in the North would have reduced their efficiency from 74% to 68% by counterfactually operating like a non-contract farm.

With respect to the non-contract farms, generally for the entire sample, non-contract farms would have had slightly higher counterfactual than actual efficiency (69% vs. 66%), which is statistically significant at 10%. Again, this mainly reflects the situation in the Northeast (68% vs. 59%), while surprisingly the non-contract farms in the North would have had lower counterfactual efficiency than their actual efficiency (69% vs. 77%).

In summary, the results from the counterfactual efficiency estimations are mixed and do not generally support the hypothesis that contract farming enhances profit efficiency. Indeed, the efficiency patterns appear to be different between the North and Northeast.

Table 13 Counterfactual vs. actual efficiency

Counterfactual vs. actual[1]	**Average profit efficiency**[2]		
Contract farming	**Entire**	**North**	**Northeast**
Contract counterfactual	0.6879	0.6798	0.6928
Contract actual	0.6988	0.7409	0.6736
p-value	0.4965	0.0326	0.3096
Non-contract farming	**Entire**	**North**	**Northeast**
Non-contract counterfactual	0.6854	0.6873	0.6841
Non-contract actual	0.6596	0.7658	0.5913
p-value	0.1284	0.0009	0.0000

1. 222 contract farms (83 in the North; 139 in the Northeast); 212 non-contract farms (83 North; 129 Northeast). 2. Raw efficiency scores; slightly different from the efficiency score indices reported in previous tables that include the 9 non-contract farms with negative profits (see footnote 9).

In the Northeast, while the frontier estimations indicate that contract farms had higher actual efficiency than non-contract farms in the same region, the counterfactual

[6] Similar to the estimation of counterfactual profits, we use the rice prices of non-contract farms to simulate contract farms' counterfactual rice prices.

simulations show that their efficiency would have been as high had they counterfactually operated like a non-contract farm. Thus, it seems that in terms of efficiency, these Northeastern contract farms did not significantly benefit from contract farming. However, contract farming seems to be able to help those Northeastern non-contract farms to significantly improve their efficiency, since the counterfactual simulations indicate that they would have improved their efficiency greatly had they operated like a contract farm.

The situation is different in the North. The counterfactual simulations show that in terms of efficiency, Northern contract farms have benefited from contract farming in the sense that their counterfactual efficiency under non-contract farming would have been significantly lower than their actual efficiency under contract farming. However, it seems that the non-contract farms in the North would not have had improved efficiency from contract farming; rather, their counterfactual efficiency under contract farming would have been significantly lower than their actual efficiency under non-contract farming. One possible explanation of this situation is that the Northern contract and non-contract farms represent two distinct groups of farms (perhaps formed by contracting as a categorizing process) right for contract and non-contract farming respectively from an efficiency point of view.

CONCLUSIONS

The results of the empirical analysis lend credence to the contention that contract farming can be an effective institutional mechanism to increase profitability and to reduce the transaction costs faced by particularly the small-scale rice farmers. These are supported by the following empirical findings:

1. Contract rice farmers in Thailand are more profitable than non-contract farmers by a significant margin. This is also true for each of the two regions in the sample.
2. Even when non-cash costs (family labor, own seed supply and own organic fertilizer supply valued at market prices) are included, contract farmers are still more profitable than non-contract farmers by a significant margin. Again, this is also true for the two regions in the sample.
3. Contract farmers are more profitable than non-contract farmers for all scale of operation.
4. Counterfactual simulations indicate that the observed relatively high profitability among contract farms in Thailand supports the hypothesis that contract farming enhances profitability.
5. There is significant profit inefficiency among the sample rice farmers in Thailand. Overall, rice farmers in Thailand could increase their profit by more than 30% equivalent to 842 baht/rai through improvements in technical, allocative and scale efficiency. The efficiency losses for contract and non-contract farms are 28% (906 baht/rai) and 36% (778 baht/rai) respectively.
6. For contract (and by implication) organic farms, the major determinants of profit inefficiency include experience in fragrance rice farming (positive impact), use of family labor (positive impact), and age of household head (negative impact). For non-contract farms, use of family labor and the importance of rice in farm income are two major factors that have positive impacts on profit efficiency.
7. Contract farmers appear more profit efficient than non-contract farmers for the sample rice farmers in the Northeast region, but not for the farmers in the North.
8. Similar to profitability, contract farmers are more profit efficient than non-contract farmers for all scale of operation, except for those with the largest farm sizes.

9. Profit and profit efficiency are higher for smaller contract farmers.
10. Although the overall results of the counterfactual efficiency simulations could not support the hypothesis that contract farming enhances efficiency consistently in all cases, the results do indicate that contract farming has improved the profit efficiency of contract farms in the North and would have improved the profit efficiency of non-contract farms in the Northeast.
11. The above findings can also be applied to a comparison of organic farms versus conventional farms since all contract farmers are organic framers and all non-contract farmers are conventional farmers. Unfortunately, we are unable to separate the effects of contract farming against organic farming due to the nature of the data.
12. With respect to the development of organic farming, results from the present study show to distinctive development path. In Northeast Thailand where farmers converted from chemical farming to organic farming, profitability of the initial year was lowest and increased with the number of years of operation. In other words, during the transition years, profits are low and as ecosystems restore themselves, the farms become more profitable and profit efficient. In Northern Thailand where new marginal land were brought into organic production, a similar pattern of increasing profit and profit efficiency over the years is also found. However, since farms in Northern Region are on less degraded land than Northeast Thailand, the increase in profitability and profit efficiency over the years are less significant than in Northeast Thailand.

While we are unable to separate out the effects of organic farming from contract farming in this study, all indications have pointed to the fact that organic practice has also been effective in enhancing the profitability and efficiency of rice farming. In particular, the more mature organic farmers are more profitable and efficient. Furthermore, the benefits of organic farming will be even more pronounced when the environmental benefits (e.g. point and non-point pollution from agro-chemicals leaching) and health factors (*e.g.*, farmers not having to be exposed to pesticides and consumer not having to intake pesticide residue) of organic farming are factored into the equation.

The findings from the study points to the fact that combination of contract and organic farming has been effective in enhancing profitability and efficiency of small-scale rice farmers in Thailand. Particularly in the case of provinces in Northeast Thailand where a majority of the poor resides and where the green revolution has not been effective in addressing poverty, and has worsened ecosystems, contract farming of organic rice is shown to be effective in addressing the double bottom line of income and non-income benefits. There are lessons here for Lao PDR and Cambodia.

References

Abdulai, A. and Huffman, W. (2000). Structural adjustment and economic efficiency of rice farmers in northern Ghana. *Economic Development and Cultural Change*, 48(3), 503-521.

Ali, M., Flinn, J.C. (1989). Profit efficiency among Basmati rice producers in Pakistan Punjab. *American Journal of Agricultural Economics*, 71, 303-310.

Araujo, C. and Bonjean, C.A. (1999). Mesure de l'Efficacite economique des Modes de Faire Valoir au Bresil. *Canadian Journal of Agricultural Economics*, 47, 181-97.

Bailey, D., Biswas, B., S.C. Kumbhakar, and Schulthies, B.K. (1989). An analysis of technical, allocative and scale efficiency: the case of Ecuadorian dairy farms. *Western Journal of Agricultural Economics*, 14, 30-37.

Battese, G.E. and Coelli, T.J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, **20**, 325-332.

Battese, G.E. and Coelli, T.J. (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Econometrics*, 38, 387–399.

Bhattacharyya, A. and Glover, T.F. (1993). Profit inefficiency of Indian farms: A system approach. *Journal of Productivity Analysis*, 4, 391-406.

Bravo-Ureta, B.E. and Pinheiro, A.E. (1993). Efficiency analysis of developing country agriculture: a review of frontier function. *Agricultural and Resource Economics Review*, 22, 88-101.

Coelli, T.J. (1995). A Monte Carlo analysis of the stochastic frontier production function. *Journal of Productivity Analysis*, 6, 247-268.

Coelli, T.J., Rao, D.S.P. and Battese, G. E. (1998). *An introduction to efficiency and productivity analysis*. Kluwer Academic Publishers, Boston, USA.

Delgado, C.L., Narrod, C.A., and Tiongco, M.M. (2003). Policy, Technical, and Environmental Determinants and Implications of the Scaling-up of Livestock Production in Four Fast-Growing Developing Countries: A Synthesis. Report submitted to FAO. http://www.fao.org/WAIRDOCS/LEAD/X6170E/x6170e00.htm.

Heckman, J. (1976). The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator of such models. *Annals of Economic and Social Measurement* 5, 475-92.

Kumbhakar, S.C. and Lovell, C.A.K. (2000). *Stochastic Frontier Analysis.* Cambridge University Press.

Larsen. K. and Foster, K. (2005). Technical efficiency among organic and conventional farms in Sweden 2000-2002: A counterfactual and self-selection analysis. Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27, 2005.

Maddala, G. S. (1983). *Limited-Dependent and Qualitative Variables in Economics*. Cambridge University Press.

Rahman, S. (2003). Profit efficiency among Bangladesh rice farmers. *Food Policy*, 28, 487-503.

Setboonsarng, S. and Penkett, C. (2005). Discussion paper on contract farming and poverty reduction in Cambodia and Lao PDR. *ADB Discussion Paper* forthcoming

Wang, J. Cramer, G.L., Wailes, E.J. (1996). Production efficiency of Chinese agriculture: evidence from Rural Household Survey data. *Agricultural Economics* 15, 17-28.

Wang, J., Wailes, E.J., and Cramer, G.L. (1996). A shadow-price frontier measurement of profit efficiency in Chinese agriculture. *American Journal of Agricultural Economics*, 78, 146-156.

Warnings, M. and Key, N. (2002). The social performance and distributional impact of contract farming: An equilibrium analysis of the *Arachide de Bouche* Program in Senegal. *World Development*, 30, 255-263.

APPENDIX

Following the standard assumption that farmers maximize variable profits, the general form of the single-output stochastic profit frontier function for cross-sectional data can be represented as:

$$\pi_i = f(P_i, X_i; \beta)\exp(v_i - u_i) \quad (1)$$

where subscripts *i* refer to the *i*-th farm in the sample; π_i denotes normalized variable profit defined as gross revenue less variable cost, divided by farm-specific output price; P_i is a vector of normalized farm-specific input prices; X_i is a vector of fixed factors; β is a vector of unknown parameters to be estimated; v_i is an independently and identically distributed normal N(0, σ_v^2) random error; and u_i is a non-negative random variable, associated with profit inefficiency. Although there is generally no *a priori* justification for the choice of a particular distributional form for the profit inefficiency effects, the generalized truncated-normal distribution has been most frequently used in empirical applications because of its computational simplicity. Following Battese and Coelli (1995), profit inefficiency effects, u_i are assumed to be independently distributed and truncations (at zero) of the normal distribution with mean, $Z_i\delta$, and variance, σ_u^2 [(|N($Z_i\delta$, σ_u^2)|)], where Z_i is a vector of observable farm-specific variables hypothesized to have an influence on profit inefficiencies and δ is a vector of unknown parameters to be estimated. The profit efficiency of the *i*-th firm in the sample, denoted as PE_i, is derived as follows:

$$PE_i = exp(-u_i) \quad (2)$$

The prediction of profit efficiencies is based on the conditional expectation of expression (2), given the model specifications (Battese and Coelli, 1988).

The maximum likelihood estimation provides the estimators for β as well as δ if the Battese and Coelli (1995) model for a technical inefficiency effect is also involved. The likelihood function is expressed in terms of its variance components, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$. In terms of its value and significance, γ is an important parameter in stochastic frontier analysis. The rejection of the null hypothesis, H_0: γ = 0, implies the existence of a stochastic frontier, while H_0: γ = 1 implies that all deviations from the frontier are due entirely to inefficiency (Coelli et al., 1998). Besides H_0: γ = 0, various other null hypotheses involving restrictions on β and δ can also be tested in order to ascertain the structure of underlying technology (such as functional forms and returns to scale) and to identify significant firm-specific factors affecting the levels of profit efficiency. These hypotheses can be tested using the generalized likelihood-ratio statistic, λ, given by

$$\lambda = -2[\mathrm{Ln}\{L(H_0)\} - \mathrm{Ln}\{L(H_1)\}] \quad (3)$$

where $L(H_0)$ and $L(H_1)$ denote the values of likelihood function under the null (H_0) and alternative (H_1) hypotheses, respectively. If the given null hypothesis is true, λ has approximately χ^2 distribution or mixed χ^2 distribution when the null hypothesis involves γ = 0 (Coelli, 1995).

Profit Efficiency

The estimation of profit efficiency requires the specification and estimation of the respective profit frontier. Consistent with much of the profit efficiency literature in agriculture, a single-output translog profit frontier is used because of its flexibility in parameter estimation when it is not desirable to impose rigid assumptions about substitution relations among inputs and factors in the model specification. The translog functional form to be estimated is as follows:

$$\ln\pi = \beta_0 + \sum_{i=1}^{6}\beta_i \ln P_i + \frac{1}{2}\sum_{i=1}^{6}\sum_{j=1}^{6}\beta_{ij}\ln P_i \ln P_j + \sum_{i=1}^{6}\sum_{k=1}^{2}\phi_{ik}\ln P_i \ln X_k + \sum_{k=1}^{2}\alpha_k \ln X_k + \frac{1}{2}\sum_{k=1}^{2}\sum_{l=1}^{2}\alpha_{kl}\ln X_k \ln X_l + v - u \quad (4)$$

where □ denotes the normalized variable profit defined as gross revenue less total cash cost of variable inputs normalized by the price of rice. P_i denotes the normalized input price (again divided by price of rice) of the i^{th} variable input where i=1 for seed, 2 for hired labor, 3 for chemical fertilizer, 4 for organic fertilizer, 5 for machinery power, and 6 for fuel.[7] X_k denotes the quantity of the two fixed inputs where k=1 for land and 2 for capital assets. v is the two-side random error and u is the non-negative random inefficiency term. β, φ and α are parameters to be estimated.

Following Battese and Coelli (1995), we assumed u_i are independently distributed and truncations (at zero) of the normal distribution with mean, $\mu = Z_i\delta$, and variance, σ_u^2 [(|N(□, σ_u^2)|)], where Z_i is a vector of observable farm-specific variables hypothesized to have an influence on profit inefficiencies and δ is a vector of unknown parameters to be estimated. Thus, μ can be specified as follows:

$$\mu = \delta_0 + \sum_{m=1}^{11} \delta_m Z_m \quad (5)$$

where Z_m's are 11 farm-specific characteristics representing different levels of transaction costs faced by each farm thought to affect relative inefficiency. They include demographic characteristics of household head, farm characteristics and endowments, and production practices. The four farm characteristics and endowments variables are: (1) a regional dummy where Z_1 = 1 for North and 0 for Northeast;[8] (2) farm size (rai); (3) a dummy variable for land ownership, Z_4 =1 if land is owned and 0 otherwise;[9] and (4) rice income in total agricultural income (%). The four demographic characteristics of household head are: (5) experience in fragrant rice farming (years); (6) level of formal education of household head (years); (7) age of household head (years); and (8) non-agricultural income in total household income (%); The three general production practices variables are: (9) amount of own labor (in % of total labor); (10) amount of own organic fertilizer (in % of total organic fertilizer); and (11) amount of own seed (in % of total seed).

The translog functional form requires that we use logarithmic transformation of the variables and hence cannot handle observations with negative and zero profits. There are several possible remedies to this problem but none is universally acceptable in all situations. The possible solutions are: (1) drop all negative and zero observations; (2) add a constant for each observation of the profit variable such that profit for each farm is positive; and (3) use a different functional form. In our case the magnitude of the most negative profit in the sample is very large and thus the resulting bias from a nonlinear transformation of the data is unacceptable. Therefore, solution (2) is deemed inappropriate in the present situation. We also feel that using a less appropriate

[7] We do not include the price of pesticide/herbicide in the specification because only a few organic farms and one third of conventional farms in the sample utilized it. Furthermore, expenditures on pesticides and herbicides constituted only a very small portion (less than 2%) of the total variable cash costs of farms that do use them.

[8] The regional dummy is excluded in the estimation for contract farms because of convergence difficulty with the maximum likelihood estimation process.

[9] Farms with more than 50% of lands owned are considered an owners farm; those with less than 50% of lands owned are considered a rented farm.

functional form will create unnecessary compromise in modeling the profit frontier. That leaves us with the solution of dropping the observations with negative and zero profits. Fortunately, only 9 out of a total of 445 observations show a negative variable profit (gross revenue less total variable cash cost) and all 9 observations are non-contract farmers. Dropping these 9 observations has no significant impact on the estimation of profit efficiency. In addition, we have also dropped two outliers from the sample resulting in a total of 434 observations (222 and 212 for contract and non-contract farms respectively) for the ensuing estimation.

The frontier module of Stata version 8 is used to estimate the above specified profit frontiers. The frontier module estimates all the unknown parameters of the profit frontier and the inefficiency effects model simultaneously by the maximum likelihood method. The likelihood function is expressed in terms of the variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$.

Table A.1 shows the maximum likelihood estimates of the specified contract and non-contract profit frontiers and the inefficiency effects model as expressed in equations (4) and (5), respectively. As indicated by the Wald χ^2, the stochastic frontier estimation with inefficiency effects is statistically significant for both contract and non-contract farms, suggesting that the model can explain the profit variations among these two types of farms relative to their respective profit frontiers. The estimated value of χ is also significantly different from 0 for both types of farms, suggesting that the inefficiency effects model is significant in explaining the levels and variations in variable profit. Thus, the farm-specific variables involved in the inefficiency model contribute significantly as a group to the explanation of profit inefficiency in both contract and non-contract rice farming in Thailand.

Table A.1. Maximum likelihood estimates of stochastic profit frontier and inefficiency effects model for rice farming in Thailand (contract vs. non-contract)

Variables	Parameters	Contract farming		Non-contract farming	
		Coefficients	p-value	Coefficients	p-value
Profit function					
Constant	β_0	3.3419	0.170	6.6895	0.030
P_1	β_1	1.3370	0.413	2.4983	0.166
P_2	β_2	1.2305	0.060	-1.0222	0.426
P_3	β_3	-2.7236	0.328	-2.5588	0.497
P_4	β_4	-0.6807	0.117	0.5404	0.473
P_5	β_5	0.0559	0.858	0.8985	0.021
P_6	β_6	0.8132	0.068	2.3511	0.001
$0.5(P_1 \times P_1)$	β_{11}	-2.2633	0.035	-0.5369	0.446
$0.5(P_2 \times P_2)$	β_{22}	-0.0005	0.993	0.0668	0.767
$0.5(P_3 \times P_3)$	β_{33}	-3.1243	0.315	0.2065	0.939
$0.5(P_4 \times P_4)$	β_{44}	0.0141	0.748	-0.1091	0.206
$0.5(P_5 \times P_5)$	β_{55}	0.0200	0.508	-0.1083	0.051
$0.5(P_6 \times P_6)$	β_{66}	-0.0074	0.834	-0.0128	0.875
$P_1 \times P_2$	β_{12}	0.3962	0.117	-0.2503	0.604
$P_1 \times P_3$	β_{13}	1.4277	0.418	-0.6218	0.602
$P_1 \times P_4$	β_{14}	0.1136	0.583	0.1784	0.287
$P_1 \times P_5$	β_{15}	-0.0069	0.968	0.0843	0.444

Variables	Parameters	Contract farming		Non-contract farming	
		Coefficients	p-value	Coefficients	p-value
$P_1 \times P_6$	β_{16}	0.0786	0.681	-0.1616	0.263
$P_2 \times P_3$	β_{23}	-1.2817	0.010	0.3793	0.613
$P_2 \times P_4$	β_{24}	0.2563	0.002	-0.4536	0.015
$P_2 \times P_5$	β_{25}	-0.1970	0.000	-0.0162	0.854
$P_2 \times P_6$	β_{26}	-0.0320	0.474	-0.3677	0.039
$P_3 \times P_4$	β_{34}	-0.3170	0.304	0.1110	0.838
$P_3 \times P_5$	β_{35}	0.2462	0.312	-0.2049	0.478
$P_3 \times P_6$	β_{36}	-0.2264	0.459	0.6684	0.127
$P_4 \times P_5$	β_{45}	-0.0170	0.580	0.0823	0.171
$P_4 \times P_6$	β_{46}	0.0218	0.489	-0.0383	0.658
$P_5 \times P_6$	β_{56}	-0.0646	0.069	-0.0597	0.220
$P_1 \times X_1$	ϕ_{11}	0.7438	0.022	-0.4428	0.019
$P_2 \times X_1$	ϕ_{21}	-0.1364	0.110	0.1294	0.448
$P_3 \times X_1$	ϕ_{31}	-0.4495	0.297	-0.3686	0.481
$P_4 \times X_1$	ϕ_{41}	-0.0053	0.929	-0.0023	0.978
$P_5 \times X_1$	ϕ_{51}	0.0401	0.289	0.0178	0.754
$P_6 \times X_1$	ϕ_{61}	-0.0931	0.109	0.0389	0.653
$P_1 \times X_2$	ϕ_{12}	-0.3510	0.008	-0.0302	0.789
$P_2 \times X_2$	ϕ_{22}	-0.0126	0.838	-0.0236	0.766
$P_3 \times X_2$	ϕ_{32}	0.5717	0.002	0.3439	0.168
$P_4 \times X_2$	ϕ_{42}	-0.0012	0.971	0.0138	0.806
$P_5 \times X_2$	ϕ_{52}	0.0334	0.118	-0.0454	0.160
$P_6 \times X_2$	ϕ_{62}	-0.0343	0.368	-0.1228	0.011
X_1	α_1	0.3427	0.469	0.4732	0.526
X_2	α_2	0.2455	0.428	0.0147	0.971
$0.5(X_1 \times X_1)$	α_{11}	-0.1354	0.198	-0.1430	0.263
$0.5(X_2 \times X_2)$	α_{22}	-0.0391	0.107	0.0060	0.861
$X_1 \times X_2$	α_{12}	0.0828	0.065	0.0629	0.170
Inefficiency					
Constant	δ_0	-0.3186	0.618	1.4739	0.403
Region (North=1; Northeast=0)	δ_1	n.a.*	n.a.*	-2.8577	0.059
Land size (rai)	δ_2	0.0104	0.376	0.0467	0.327
Land ownership (own=1; rent=0)	δ_3	-0.3079	0.336	0.5608	0.521
Rice in agriculture income (%)	δ_4	0.0014	0.665	-0.0253	0.061
Experience in fragrant rice farming (years)	δ_5	-0.0177	0.063	0.0138	0.612
Education (years)	δ_6	0.0410	0.443	-0.1713	0.410
Age (years)	δ_7	0.0171	0.069	0.0066	0.769
Non-agriculture in total income (%)	δ_8	0.6731	0.128	1.5857	0.135
Own labor ratio (%)	δ_9	-1.1720	0.020	-3.7558	0.036
Own organic fertilizer ratio (%)	δ_{10}	0.2666	0.247	-0.4208	0.451
Own seed ratio (%)	δ_{11}	0.1923	0.267	0.7608	0.228

Variables	Parameters	Contract farming		Non-contract farming	
		Coefficients	p-value	Coefficients	p-value
Variance parameters					
Wald χ^2 (44)	χ^2	892.33		861.85	
$\sigma^2=\sigma_u^2+\sigma_v^2$	σ^2	0.3130		1.3707	
$\gamma=\sigma_u^2/\sigma^2$	γ	0.9595		0.9832	
Log likelihood		-46.28		-103.98	

P1: seed price; P2: hired labor wage; P3: chemical fertilizer price; P4: organic fertilizer price; P5: machinery price; P6: fuel price. All prices are normalized by the output price and in log form. X1: land; X2: capital. Both fixed inputs are in log form. *The region dummy not included in the estimation for the contract farming.

Counterfactual analysis

Methodologically, our counterfactual simulations are based on a switching regression model (Maddala 1983, Chapter 8 and 9) and follow the two-stage estimation process suggested by Heckman (1976).

Let $p_i = 1$ if farm *i* is a contract farm; and $p_i = 0$ otherwise. Then we first use the probit model to estimate a selection model specified as

$$I_i^* = \delta Z_i + \varepsilon_i ,$$

where I_i^* is a latent index capturing how farms choose between contract and non-contract farming; specifically farm *i* would choose contract farming (*i.e.* $p_i = 1$) if $I_i^* > 0$ and non-contract farming (*i.e.* $p_i = 0$) if otherwise. Z_i are farms' characteristics that affect the probability of their choices between contract and non-contract farming.

Table A.2 Probit estimation of the contract/non-contract selection model

Variables influencing selection between contract (=1) and non-contract (=0)	Parameters	Coefficients	Robust standard errors	p values
Constant	δ_0	-1.0378	0.4659	0.026
Region (North=1; Northeast=0)	δ_1	-0.0047	0.1331	0.972
farm size (rai)	δ_2	0.0253	0.0091	0.006
Soil quality (high salinity=1; others=0)	δ_3	-0.9680	0.6168	0.117
Land ownership (own=1; rent=0)	δ_4	0.7446	0.2217	0.001
Rice in agriculture income (%)	δ_5	0.0035	0.0026	0.181
Experience in fragrant rice farming (years)	δ_6	-0.0127	0.0070	0.071
Education (years)	δ_7	0.1866	0.0612	0.002
Age (years)	δ_8	-0.0083	0.0064	0.199
Non-agriculture in total income (%)	δ_9	-0.4380	0.3007	0.145
Number of observations		443		

Variables influencing selection between contract (=1) and non-contract (=0)	Parameters	Coefficients	Robust standard errors	p values
Wald χ^2		43.28		
Prob > chi2		0.0000		
Pseudo R2		0.0825		
Log pseudo-likelihood		-281.73		

Table A.2 reports the results of this estimation, which indicate that farm size, land ownership and education have statistically significant and positive impacts on farms' probability to choose contract farming, while soil salinity, experience in fragrant rice, age and the off-farm income ratio appear to have negative impacts on the probability of choosing contract farming although with relatively low statistical significance.

The estimate of the selection model allows us to calculate the inverse Mills ratios defined as

$$\lambda_i = \begin{cases} \phi(\hat{\delta}Z_i)/\Phi(\hat{\delta}Z_i) & \text{if } p_i = 1 \\ -\phi(\hat{\delta}Z_i)/[1-\Phi(\hat{\delta}Z_i)] & \text{if } p_i = 0 \end{cases},$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability density and cumulative distribution functions respectively for the normal distribution.

We then use these inverse Mills ratios to adjust for selection biases and estimate the profit functions for contract and non-contract farming respectively based on the following specification:

$$\pi_i = \begin{cases} f(P_i, X_i; \beta_c) + \gamma_c \phi(\hat{\delta}Z_i)/\Phi(\hat{\delta}Z_i) + \eta_i & \text{if } p_i = 1 \\ g(P_i, X_i; \beta_n) + \gamma_n \left\{-\phi(\hat{\delta}Z_i)/[1-\Phi(\hat{\delta}Z_i)]\right\} + \eta_i & \text{if } p_i = 0 \end{cases}.$$

Empirically, we use the ordinary least squares estimator and the same translog functional form as equation (4) for the profit functions.

The estimation results are reported in Table A.3. The coefficients of the Mills ratios are not significantly different from zero in both profit functions, which indicates no significant selection biases between contract and non-contract farming.

Using the parameters in the profit function for non-contract farming, we can estimate contract farmers' counterfactual profits had they operated like non-contract farms. Similarly, the counterfactual profits of non-contract farms can be estimated based on the profit function for contract farming.

Table A.3 Profit functions for contract and non-contract farming

Variables	Parameters	Contract farming		Non-contract farming	
		Coefficients	p-value	Coefficients	p-value
Constant	β_0	3.7045	0.237	10.7176	0.029
P_1	β_1	-1.0976	0.607	1.2244	0.629
P_2	β_2	0.7008	0.476	-3.6998	0.038
P_3	β_3	3.6613	0.322	3.1279	0.603
P_4	β_4	-0.4953	0.370	0.6068	0.615
P_5	β_5	-0.2769	0.502	0.9811	0.085
P_6	β_6	-0.2504	0.585	2.4482	0.048
$0.5(P_1 \times P_1)$	β_{11}	-1.1535	0.428	-0.0022	0.998
$0.5(P_2 \times P_2)$	β_{22}	0.0177	0.832	0.4123	0.186
$0.5(P_3 \times P_3)$	β_{33}	-1.5427	0.680	3.7158	0.328

		Contract farming		Non-contract farming	
$0.5(P_4 \times P_4)$	β_{44}	0.0432	0.421	-0.3708	0.005
$0.5(P_5 \times P_5)$	β_{55}	-0.0116	0.782	-0.1930	0.035
$0.5(P_6 \times P_6)$	β_{66}	-0.0119	0.803	-0.0701	0.596
$P_1 \times P_2$	β_{12}	0.6511	0.073	-0.3395	0.616
$P_1 \times P_3$	β_{13}	0.1991	0.922	-2.5875	0.079
$P_1 \times P_4$	β_{14}	0.3214	0.220	0.2844	0.383
$P_1 \times P_5$	β_{15}	0.2116	0.329	-0.0571	0.752
$P_1 \times P_6$	β_{16}	0.0045	0.986	0.0187	0.949
$P_2 \times P_3$	β_{23}	-1.7560	0.005	1.0976	0.383
$P_2 \times P_4$	β_{24}	0.2599	0.024	-0.6338	0.024
$P_2 \times P_5$	β_{25}	-0.1250	0.126	-0.0262	0.846
$P_2 \times P_6$	β_{26}	-0.0300	0.687	-0.2874	0.323
$P_3 \times P_4$	β_{34}	-0.8323	0.066	-0.0321	0.968
$P_3 \times P_5$	β_{35}	-0.0240	0.939	-0.4965	0.283
$P_3 \times P_6$	β_{36}	0.0167	0.970	0.1695	0.822
$P_4 \times P_5$	β_{45}	-0.0168	0.693	0.1051	0.286
$P_4 \times P_6$	β_{46}	-0.0162	0.733	0.0116	0.946
$P_5 \times P_6$	β_{56}	-0.0215	0.611	-0.1231	0.138
$P_1 \times X_1$	ϕ_{11}	0.7370	0.122	-0.5389	0.065
$P_2 \times X_1$	ϕ_{21}	-0.0781	0.523	0.3636	0.164
$P_3 \times X_1$	ϕ_{31}	-0.7849	0.195	-2.2029	0.006
$P_4 \times X_1$	ϕ_{41}	-0.0574	0.489	0.0303	0.811
$P_5 \times X_1$	ϕ_{51}	0.0795	0.143	0.0716	0.410
$P_6 \times X_1$	ϕ_{61}	-0.0639	0.385	-0.0971	0.504
$P_1 \times X_2$	ϕ_{12}	-0.2485	0.195	0.2343	0.119
$P_2 \times X_2$	ϕ_{22}	0.0005	0.995	0.0338	0.791
$P_3 \times X_2$	ϕ_{32}	0.1700	0.530	-0.0014	0.997
$P_4 \times X_2$	ϕ_{42}	-0.0089	0.832	0.0136	0.875
$P_5 \times X_2$	ϕ_{52}	0.0378	0.178	-0.0300	0.454
$P_6 \times X_2$	ϕ_{62}	0.0500	0.149	-0.1126	0.196
X_1	α_1	-0.4460	0.501	0.5777	0.563
X_2	α_2	0.5914	0.106	-0.0070	0.991
$0.5(X_1 \times X_1)$	α_{11}	-0.1517	0.276	-0.1300	0.532
$0.5(X_2 \times X_2)$	α_{22}	-0.0881	0.001	-0.0059	0.908
$X_1 \times X_2$	α_{12}	0.1229	0.025	-0.0041	0.951
Inverse Mills ratios	γ	0.0167	0.901	0.0631	0.755
Number of observations		222		212	
F statistics		11.37		7.71	
Prob > F		0.0000		0.0000	
R-squared		0.7441		0.6762	
Adjusted R-squared		0.6787		0.5885	
Root MSE		0.3770		0.5872	

P1: seed price; P2: hired labor wage; P3: chemical fertilizer price; P4: organic fertilizer price; P5: machinery price; P6: fuel price. All prices are normalized by the output price and in log form. X1: land; X2: capital. Both fixed inputs are in log form.

Non-contract farms in the sample generally sold their rice at lower prices than contract farms. To account for this difference, we use the rice prices of contract (or non-contract) farms in the estimation of the counterfactual profits of non-contract (or contract) farms.[10]

[10] Specifically, we use the average price of the rice produced by contract (or non-contract) farms in the North (or Northeast) as the counterfactual price faced by non-contract (or contract) farms in the same region.