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Rice contract farming in Cambodia: Empowering farmers to move beyond the contract toward independence

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**Rice Contract Farming in Cambodia: Empowering Farmers
to Move Beyond the Contract Toward Independence**

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Abstract

From the farmer's perspective, contract farming provides stable market access, credits, extension services, infrastructure and other benefits, but has drawbacks such as limiting the flexibility of farming and marketing. Based on a survey of rice contract farming for export in Cambodia, this paper uses simple mean comparison, propensity score matching comparison, and switching regression comparison to assess the impact of contract farming on farmers' performance. Farmers with larger family sizes, younger and more educated household heads, less asset value, and those with farm locations closer to the highway are more likely to join the contract. The results provide evidence that contract farming of non-certified organic rice has a positive impact on farmers' profitability. They also suggest that progressive farmers living near the highway tend to join the contract first, but leave contract farming early, while farmers in more remote areas remain under contract. It appears that the sample former-contract farmers' profitability did not decline after leaving contract farming as they further intensified their farming systems to produce for the less chemical conscious market. Thus, contract farming may be involved in the process of helping subsistence farmers develop into independent commercial farmers.

This study provides empirical evidence that contract farming of safe food in remote areas where land is less contaminated could be an effective private-sector led poverty reduction strategy. However, since contract farming in this case is not inclusive of the poorest farmers, public sector support is required to lower the transaction costs of working with them.

JEL Classification: D02, Q12, R32

Contents

I.	Introduction	1
II.	Objectives	1
III.	Contract Farming: Pros and Cons	1
IV.	Contract Rice Farming in Cambodia	2
V.	Houeshold Characteristics	4
	A. Family Size and Farm Size	5
	B. Household Head Characteristics	5
	C. Household Economic Conditions	5
	D. Credit	5
	E. Incomes	6
	F. Geographical Position	6
VI.	Farming Characteristics	7
	A. Rice Fields (hectares)	7
	B. Rice Price (riel per kg of rice)	8
	C. Revenue (riels per hectare)	8
	D. Yield (kilos of rice per hectare of land)	8
	E. Cost (riels per hectare or riels per kg of rice production)	8
	F. Profitability (riels per hectare)	9
	G. Labor Structure	9
	H. Material and Operating Costs	10
VII.	Propensity Score Matching Analysis	13
	A. Contract Farmers vs. Never-Contract Farmers (Entire Operations)	14
	B. Contract Farmers vs. Former-Contract Farmers (Commercial Operations)	16
	C. Contract Farmers vs. Former-Contract Farmers (Entire Operations)	17
VIII.	Switching Regression	18
	A. Methodology	18
	B. Indicators for Premiums of Joining the Contract	19
	C. Indicators for Farmers' Relative Performance With and Without the Contract	20
	D. Comparison of Contract Farmers' and Non-Contract Farmers' Profitability in Commercial Rice Farming	21
IX.	Summary	24
X.	Conclusions and Recommendations	26
	References	27

I. INTRODUCTION

In spite of accelerated expansion in other sectors such as industry and services since 1993, agriculture remains the backbone of the Cambodian economy. The sector employed more than 70% of Cambodia's labor force in 2004 and accounted for more than 30% of the country's GDP.

Rice farming is the major agricultural activity in Cambodia, accounting for nearly one third of the country's total agricultural value added. However, due to inefficient farming techniques and limited irrigation networks, the yield level of rice farming in Cambodia is well below that of its neighbours. Given the current low yields and the large remaining uncultivated area, there is significant scope for rice farming development in Cambodia.

Cambodia is endowed with natural resources and weather conditions that favour rice farming, but its comparative advantage in rice farming has yet to be exploited. The country's rice production is mainly for self-sufficiency, and commercial rice exports are still at an early stage.

Limited market access and underdeveloped agricultural infrastructure are two major bottlenecks constraining rice farming development in Cambodia. While the Cambodian government can help ease these constraints through extension services and public investments, contract farming is an institutional arrangement in the private sector that may eventually help to overcome some of the constraints.

For smallholder farmers in transition economies, market access is especially important because it means their production is not limited by their own consumption or the local market. The access to broader markets via contract farming allows smallholder farmers to exploit their comparative advantages in natural resources, environment, and other areas. For example, when farmers produce for local consumption, it may not be an advantage that they have clean soil as a result of the less intensive use of chemicals because local consumers may be indifferent to the organic features of farm products. However, when farmers produce for international markets where consumers with higher income levels are willing to pay premiums for organic products, having clean soil becomes a comparative advantage.

Rice contract farming in Cambodia has been implemented by Angkor Kasekam Roongroeng Co Ltd (AKR). This company has been introducing large-scale contract farming arrangements of non-certified organic rice since 2001 and the accumulative number of farmers who have joined the contract is reportedly over 32,000 households. A survey has been conducted to compare contract and non-contract rice farmers in terms of their farming practices, economic conditions and social characteristics. Data obtained using this survey allows us to assess the impacts of contract farming on rice farmers' performance in Cambodia.

II. OBJECTIVES

The main objective of this study is to assess the impact of contract farming on farmers' performance in the context of Cambodia. Based on the survey data, this paper is intended to: 1) provide a comprehensive comparison between contract rice farming and non-contract rice farming; 2) identify factors that affect Cambodian rice farmers' decisions to join the contract; and 3) assess rice farmers' performance with and without the contract.

III. CONTRACT FARMING: PROS AND CONS

Contract farming is an institutional arrangement widely adopted in agricultural production (see Roy, 1963; Glover and Kusterer, 1990; and Glover and Ghee, 1992). Contract farming represents an agreement between farmers and contractors (mostly processing and/or

marketing firms) for the production and supply of agricultural products. Under contract farming, farmers usually agree to deliver specific commodities in predetermined quantities and to meet predetermined quality standards, while contractors agree to provide production support (e.g., supply of input and provision of technologies) and accept products at predetermined prices (Eaton and Shepherd, 2001).

Contract farming is beneficial to farmers because it opens up otherwise unavailable markets (especially to smallholder farmers), providing materials, technological and financial support, and reducing farmers' costs and the risks involved in selling products. It also benefits contractors by allowing them to establish close relationships with farmers and by reducing uncertainties in purchases through predetermined timing, prices, and quality standards (see Glover, 1984; Key and Runsten, 1999; Singh, 2002; and Setboonsarng, 2008).

While contract farming is a conceptually sound institutional arrangement, lack of flexibility is one of its main liabilities, and coordination problems are faced during its implementation (see Glover and Kusterer, 1990; and Little and Watts, 1994).

As contract farmers are often required to grow new crops or adopt unfamiliar farming techniques, they tend to encounter greater production risks (Key and Runsten, 1999). They are also likely to face greater credit risks because of excessive advances, which tend to jeopardize the sustainability of their operations in the long run (see Glover, 1984; and Glover and Kusterer, 1990).

Supports from contractors can help reduce these risks. However, overdependence on a contractor not only makes farmers less adaptive and hence more vulnerable to economic shocks, but also tends to reduce their bargaining power in contract negotiations (see Key and Runsten, 1999; and MacDonald et al., 2004). Contract farming may also be biased against poor farmers in remote areas while favoring better-off farmers with extensive land who are living in areas with good infrastructure (Setboonsarng, 2008).

Contract enforcement is another major issue. Farmers may breach the contract by diverting inputs supplied on credit to other purposes or selling outside the contract for higher prices, while contractors may breach the contract (e.g. with unfair quality standards, low quality inputs, poor technical assistance, incomplete purchases, delayed payments, etc.) because of inefficient management or marketing problems (see Glover, 1984, 1987; and Singh, 2002).

IV. CONTRACT RICE FARMING IN CAMBODIA

The largest contract rice farming operation in Cambodia is organized by Angkor Kasekam Roonroeng Co Ltd (AKR), a private Cambodian firm established in 1999. Its main business is to export non-certified organic *Neang Malis* (an aromatic Cambodian rice variety introduced by AKR) to the international market¹. AKR has invested about US\$8 million in a high-tech rice mill that has a processing capacity of up to 10 tons per hour or up to 30,000 tons per year. In 2005, the company worked with farmers in four provinces (Kandal, Kampong Speu, Takeo, and Kampot), which were selected based on their ideal agronomic conditions for the cultivation of the *Neang Malis* organic rice.

At the start of the contract farming operation, only about 100 farmers joined the contract because of a lack of trust in AKR's contract arrangement as well as the company's low milling capacity. Subsequently, the total number of contracted households reached 27,346 in 2003 and 32,005 in 2004. More than 80% of the contract farmers are located in a province

¹ *Neang Malis*, a variety similar to Thai aromatic rice, *Hom Mali*, is relatively non-responsive to chemical fertilizers, so it is appropriate for organic production. However, due to the high cost of certification, AKR opted to encourage farmers to produce non-certified organic rice, a product of which still commands a high price in the international market.

(Kampong Speu) near the AKR headquarters where the condition of the agriculture infrastructure is generally good.

AKR's experience shows that contract farming was generally successful in Kampong Speu province and in some nearby areas in Takeo province. Field observations indicate that the distance from the operating sites to the AKR headquarters is not a factor determining the success of contract farming. Rather, most of the successful cases were farmers in former forestland and land close to mountains where rice can be produced at higher quality and yield. On the other hand, farmers that are close to AKR (and therefore close to main roads) and have more market experience tend to have higher levels of defaulting on the contracts. This latter group of farmers is made up of the former contract farmers of the survey.

AKR is involved in every stage of rice production and marketing. Its roles include: 1) identifying areas suitable for growing fragrant paddy; 2) establishing farmer associations based on existing commune structures and bringing these under its management; 3) using these associations to recruit farmers; 4) delivering improved seeds and technical advice to contract farmers; 5) monitoring and solving production problems; 6) collecting and purchasing rice output at AKR's gate; 7) sorting milled and packaged paddy into different types; and 8) exporting rice to international markets, including Europe, Australia and Hong Kong. Since all steps of production and processing are well coordinated, AKR shortens the supply chain under contract farming and thus lowers transaction costs for rice export, relative to the normal supply chain.

According to AKR's contract arrangement, the company distributes *Neang Malis* seeds in credit during July and buys back the output from October to January of the following year. This arrangement requires farmers to repay the credit seeds and transport the harvested paddy to the company's rice mills. The amount of seeds that farmers need to return, the minimum guaranteed price, and the penalties for contract defaults, are explicitly stated in the contracts. However, while contract farmers agree to obey AKR's quality control mechanisms, conditions related to production methods are not clearly specified in the contracts. The contracts also do not clearly state AKR's liabilities if it does not buy contracted rice at the predetermined prices. The contracts state that AKR is obligated to buy rice from farmers at the minimum price without clearly specifying the terms of purchase in detail. In practice, AKR often uses technical reasons to reject or lower the prices of rice that farmers have transported to the firm.

AKR establishes commune associations to help enforce contracts. Each commune association consists of a head, a deputy and the village head. The head and deputy are trained by the firm to understand the basic technical aspects of organic farming and the farming of *Neang Malis*. Each association routinely observes the progress of its members and reports to the AKR management. The progress report includes every stage of production from plowing, transplanting, water management, and harvesting. Each association also provides basic technical advice to its members, advises them not to use chemical fertilizers, and helps them grow other crops after the harvesting season. The associations also help members develop mixed or integrated agriculture (e.g., growing vegetables and raising livestock) to increase incomes and reduce poverty. Commune associations report to AKR any issues related to the production process such as drought, flood, disease, insect and other significant issues that affect production. The firm channels its policies through the associations and provides extension services via its agents. At present, these associations are tightly controlled by the firm and have little bargaining power. However, they have a promising future and could develop into independent organizations representing the interests of the community.

AKR associations appear to be a good model for community-based agricultural development. They provide the basis and experiences for the future development of farmers' associations in Cambodia where farmers are predominantly smallholders.

V. HOUSEHOLD CHARACTERISTICS

The survey was conducted in 2005 in 615 households, consisting of 178 contract farmers, 220 former-contract farmers, and 217 never-contract farmers. Table 1 presents the sample farmers' basic characteristics.

Table 1: Farmers' Characteristics

Variables	Contract ^a	Former Contract ^a	Never Contract ^a
No. of family members	6.19a	5.56b	5.41b
No. of family members older than 14	4.21a	3.93a	3.56b
Percentage of females in family (%)	52a	51a	54a
Total land (ha)	1.71a	1.30b	1.03c
Own land (ha)	1.68a	1.27b	1.00c
Rented land (ha)	0.021a	0.011a	0.006a
Percentage of own land (%)	98.5a	96.9a	97.9a
Percentage of land for rice (%)	96.7b	98.1ab	99.4a
Age of household head	45.25b	47.64a	44.62c
Education of household head (years)	2.83a	2.70a	2.41b
Gender of household head (male=1; female=0)	0.86a	0.83a	0.73b
No. of TVs	0.74a	0.78a	0.61b
No. of tractors	0.028a	0.009a	0.023a
No. of plows	0.96a	0.93a	0.80b
No. of threshes	0.006a	0.009a	0.004a
No. of pumps	0.17a	0.16a	0.08b
No. of bikes	1.21a	1.10ab	0.99b
No. of motorbikes	0.50a	0.56a	0.37b
Value of livestock (millions of riel)	3.51a	3.36a	2.51b
Monthly consumption expenditure per person (1000 riel)	27a	23b	23b
Percentage of home-grown in consumption expenditure	23a	22a	22a
Credit total (1000 riel)	274a	348a	289a
Percentage of credit from moneylenders (%)	3.7b	3.7b	11a
Percentage of credit from MFI (%)	27b	44a	37ab
Percentage of seed credit (%)	44a	11b	1.4c
Percentage of fertilizer credit (%)	7.8b	13a	12a
Percentage of credit from family (%)	17c	26b	36a
Income per adult from non-rice sources (1000 riel)	333b	566a	553a
Income per adult from other crops (1000 riel)	52a	36ab	27b
Income per adult from off-farm activities (1000 riel)	280b	530a	526a
Ratio of off-farm income in non-rice income (%)	76b	80b	88a
Ratio of handcraft in off-farm income (%)	9a	9a	13a
Ratio of wage in off-farm income (%)	30a	19b	33a
Ratio of remittance in off-farm income (%)	22a	24a	19a
Ratio of other activities in off-farm income (%)	39b	48a	34b
Distance to farm-to-market road (km)	6.35a	5.28b	6.28a
Distance to highway (km)	10.37a	9.95a	9.99a

a. The three columns represent the average value of each group for the variables. The letters (a, b, or c) following each number indicate the significance of the differences across the three groups under pair-wise mean comparisons. The significance level is 10%. For each variable under comparison, numbers with the same letter are not significantly different; numbers with letter a are significantly greater than numbers with letter b or c; numbers with letter b are significantly greater than numbers with letter c.

A. Family Size and Farm Size

On average, contract farmers have larger families and more land (Table 1). The average family size for contract farmers is 6.19 persons (4.21 adults) per household, greater than former-contract farmers' 5.56 persons (3.93 adults) and never-contract farmers' 5.41 persons (3.56 adults). On average, a contract farming household controls 1.71 hectares of land (1.68 hectares of own land), greater than former-contract farmers' 1.30 hectares (1.27 hectares of own land) and never-contract farmers' 1.03 hectares (1.00 hectare of own land).

The relatively large family and land size may reflect the scale requirements for contract farming. As farmers usually need to split their land for commercial and self-consumption operations due to 'taste' preferences in the traditional rice varieties, farmers with small areas of land tend to have insufficient land for planting AKR varieties. According to many pilot experiments conducted by AKR, farmers should own at least one hectare of land so as to be efficient under the contract. Thus, the company stipulated that farmers should own at least one hectare of land to be eligible to join the contract. However, AKR also allows farmers with good reputations but with small areas of land to join their land together to meet the minimum requirement of one hectare per single contract. The requirement on minimal land size also came from the experience that small farmers are more likely to break the contract as the costs of breaching it tend to be relatively low for them. Dealing with farmers with larger areas of land can help AKR reduce transaction costs. Because larger areas of land require more labor, a larger family size tends to be an advantage for contract farming.

B. Household Head Characteristics

On average, contract and former-contract farmers' household heads are older, more educated, and less likely to be female (Table 1). Farmers who are older, more educated and male tend to have large areas of land. Moreover, they usually have better access to first-hand information and hence are in a better position to make decisions. Farmers in other groups usually follow the decisions of farmers in successful groups. Social connections and interactions are key factors affecting farmers' contract choices.

C. Household Economic Conditions

On average, never-contract farmers exist in relatively poor economic conditions. They own less land, and fewer TVs, plows, pumps, bikes, motorbikes, and livestock than contract or former-contract farmers. They also have lower monthly expenditure per household adult member (Table 1).

Poor economic conditions may be a factor hindering farmers from joining the contract because they tend to produce rice for subsistence. In addition, poor economic conditions usually coincide with smaller land areas. Also, poor people are less reliable when it comes to honoring the contract because the costs of breaching the contract are relatively low for them.

D. Credit

Although the three types of farmer do not differ significantly in their total credits, the sources of their credits are quite different (Table 1).

As farmers under the contract are required to plant seeds provided by AKR, the average ratio of seed credit to their total credit (44%) is much higher than in former or never-contract farmers (Table 1). According to the farmers being surveyed, the availability of seed credits under the contract is one of the major factors affecting farmers' decisions to join the contract, especially as the interest rates on seed credit are relatively much higher.

While former-contract farmers are still able to receive 11 percent of their total credits from seed credits, a very small percentage (1.4%) of never-contract farmers' total credits come

from seed credits (Table 1). As AKR is not a seed company, it only makes the seed available for farmers under the contract. Former-contract farmers usually keep seeds for their own use. When they face a seed shortage, they may either borrow seeds from each other or from farmers under the contract.

Both former-contract farmers and never-contract farmers obtained their credits mainly through micro-finance institutions (MFI) (44% and 37% respectively). Never-contract farmers obtained a higher percentage of their credits from moneylenders and family members or relatives (Table 1).

Since AKR discourages farmers from using chemical fertilizers and pesticides, contract farmers appear to receive less credit (in percentage terms) on fertilizers than former- and never-contract farmers (Table 1).

E. Incomes

On average, contract farmers have less income from non-rice sources (333,000 riel) than former-contract farmers (566,000 riel) and never-contract farmers (553,000 riel). This mainly reflects contract farmers' relatively lower off-farm incomes compared with the other two types of farmers (Table 1). Contract farmers on average have more income from other crops than never-contract farmers because AKR provides extension services on the integrated farming system and encourages farmers to grow other crops after the harvesting season. These income patterns indicate that contract farmers are more rice- (or agriculture-) oriented than former-contract and never-contract farmers.

The three types of farmers have similar compositions of off-farm incomes, except that former-contract farmers have a relatively small percentage of off-farm incomes from wages, but more from other activities. Most of the former-contract farmers live close to the market and they tend to engage in trading activities rather than wage employment. It is common for them to be merchants, traders, micro-businesses, micro rice millers, government officials, etc.

F. Geographical Position

On average, former-contract farmers are closer to the market than contract farmers. This may be a factor affecting their decisions not to continue staying in the contract. After a few years of AKR's operation, *Neang Mali* seeds became available in the local market in the four provinces where AKR is operating. Moreover, a market for *Neang Mali* rice also emerged as local traders purchased it to sell in Vietnam. Since farmers have the option of using their own seeds or purchasing *Neang Mali* seeds to produce AKR varieties to sell to traders instead of joining the contract, farmers weigh the costs and benefits based on their circumstances. Therefore, farmers closer to the market may be able to obtain more information and hence their decisions tend to be different. In the case here, a possibility is that former contract farmers may realize that they would be able to do better by themselves and hence choose not to join the contract.

During the survey year, the demand for rice was very strong as the neighboring Vietnamese trader came to purchase rice in Cambodia making the rice price in the open market very competitive. Thus, the minimum price offered by AKR was not very attractive; and farmers expected to earn more profits from operating with their own seeds and using more fertilizer to increase the yield to sell in the open market. In addition, farmers near the market may find it easier to take advantage of the price fluctuations in the market. Market information and trend are crucial for farmers to help them decide on strategies to sell their output. As the supply after harvesting is fixed, rice prices depend on demand and storage capacities and facilities and hence tend to be highly fluctuated after the harvest season. Therefore, people close to the market have better access to market information and hence are able to sell their outputs at better times.

VI. FARMING CHARACTERISTICS

The sample farmers plant rice for both commercial purposes and self-consumption. Due to taste preference, farmers generally plant traditional varieties on the consumption plots. In the following we compare the three types of farmers' production characteristics in their commercial operations, which are presented in Table 2. Table 2 also presents the farmers' entire operations (including farming for own consumption).

Table 2: Farm Production: Revenue, Cost and Profit

Variables	Contract ^a	Former Contract ^a	Never Contract ^a
Commercial operation			
Plant area (ha)	0.76a	0.37b	0.08c
Percentage of plant area harvested (%)	46b	59a	70a
Revenue (1000 riel/ha)	722b	920a	684ab
Rice price (riel/kg)	747a	684b	645b
Yield (kg/ha)	947b	1343a	1059ab
Cost (1000 riel/ha)	1493a	1803a	1661a
Cost (riel per kg of rice production)	3238a	3023a	2823a
Ratio of cash in cost (%)	34b	38b	46a
Ratio of labor cost in total cost (%)	79a	78a	71b
Profit per area of land (1000 riel/ha) ²	-771a	-882a	-977a
Cash profit per area of land (1000 riel/ha) ²	213a	332a	-30a
Entire operation			
Total plant area	1.64a	1.26b	1.02c
Percentage of land for commercial rice	46a	27b	5.4c
Percentage of plant area harvested (%)	46b	55a	50ab
Revenue (1000 riel/ha)	600b	720a	610ab
Rice price (riel/kg)	632a	604b	570c
Yield (kg/ha)	920b	1210a	1121ab
Cost (1000 riel/ha)	1355ab	1616a	1291b
Cost (riel per kg of rice production)	4175a	2555b	2394b
Ratio of cash in cost (%)	37b	41a	42a
Ratio of labor cost in total cost (%)	77a	75ab	74b
Profit per area of land (1000 riel/ha) ²	-755a	-896a	-681a
Cash profit per area of land (1000 riel/ha) ²	129a	135a	79a

Note: a. The three columns represent the average value of each group for the variables. The letters (a, b, or c) following each number indicate the significance of the differences across the three groups under pair-wise mean comparisons. The significance level is 10%. For each variable under comparison, numbers with the same letter are not significantly different; numbers with letter a are significantly greater than numbers with letter b or c; numbers with letter b are significantly greater than numbers with letter c. 2. Profit is equal to revenue minus total cost including both cash and non-cash costs. Major non-cash costs include family labor and homemade manure. Cash profit is equal to revenue minus cash costs only.

A. Rice Fields (hectares)

On average, contract farmers have larger rice fields and use a higher percentage of their rice fields for commercial purposes (Table 2). An average contract farmer controls 1.71 hectares of land (including both own and rented land) and uses 1.64 hectares of the land for rice farming, 46% of which is used to plant commercial rice. An average former-contract farmer

controls 1.30 hectares of land and uses 1.26 hectares of the land for rice farming, 26% of which is used to plant commercial rice. An average never-contract farmer controls 1.03 hectares of land and uses 1.02 hectares of the land for rice farming, 5.4% of which is used to plant commercial rice (Table 2). The low percentage of commercial rice fields for never-contract farmers indicates that most of them are subsistence farmers.

On average, contract farmers have a lower harvest ratio (46%) than former-contract farmers (55%) for the entire operation. The difference is even greater in commercial fields (Table 2).

B. Rice Price (riel per kg of rice)

Compared to former- and never-contract farmers, contract farmers enjoy significant price premiums in their commercial operations. On average, contract farmers can sell their commercial rice at 747 riel per kg, higher than former-contract farmers' 684 riel per kg and never-contract farmers' 645 riel per kg (Table 2).

High rice price is a major factor attracting farmers to join the contract, which not only subjects them to strict quality standards but also constrains their freedom in farming activities such as the use of seeds and chemicals. Former-contract farmers' average commercial rice price is not significantly different from that of never-contract farmers.

C. Revenue (riels per hectare)

As contract farmers can sell their rice at higher prices, one may expect that they would have higher revenues, which nevertheless turns out not to be the case.

On average, contract farmers' revenue (per hectare) from commercial operations is 722,000 riel, which is lower than former-contract farmers' 920,000 riel but not significantly different from never-contract farmers' 684,000 riel.

D. Yield (kilos of rice per hectare of land)

The reason that contract farmers' price premiums do not give them higher revenues is because of their relatively low yields.

Contract farmers' average yield in the commercial field is 947kg per hectare, which is lower than former-contract farmers' 1,343kg but not significantly different from never-contract farmers' 1,059kg (Table 2). This may indicate that the organic practice recommended by AKR for contract farmers did not lead to lowering yield from traditional practice.

The yield differences between contract and former-contract farmers indicate that inflexibility in farming practices may be a factor motivating farmers to abandon the contract. That is, farmers would choose to abandon the contract if the freedom to farm more intensively could compensate for the lost price premiums and if there was a market for their rice.

E. Cost (riels per hectare or riels per kg of rice production)

On average, contract farmers spend 1,493,000 riel on one hectare of commercial rice operation, which appears lower than former-contract farmers' 1,803,000 riel and never-contract farmers' 1,661,000 riel. However, the differences are not statistically significant (Table 2).

For commercial operations, the average ratio of contract farmers' cash costs to their total costs is 34%, which is not significantly different from former-contract farmers' 38%, but lower than never-contract farmers' 46% (Table 2).

For commercial operations, the average ratio of contract farmers' labor costs to their total costs is 79%, which is not significantly different from former-contract farmers' 78 % but higher than never-contract farmers' 71% (Table 2).

F. Profitability (riels per hectare)

The average profit (cash and non-cash inputs included) for contract farmers in commercial operations is -711,000 riel per hectare, which appears higher than former-contract farmers' -882,000 riel and never-contract farmers' -977,000 riel. But the differences are not statistically significant (Table 2).

While contract farmers' average total profit is negative, their average cash profit is 213,000 riel per hectare, which reflects the fact that most of their costs (66%) are non-cash costs (mainly family labor). Former-contract farmers' 332,000 riel of cash profit appears higher than that of contract farmers, but the difference is not statistically significant (Table 2).

There are only 27 never-contract farmers reporting activities in commercial rice farming; and their average cash profit is only -30,000 riel (Table 2).

G. Labor Structure

On average, contract farmers spend 1,250,000 riel on labor costs (266,000 riel in cash) on one hectare of commercial operation, lower than former-contract farmers' 1,522,000 riel (308,000 riel in cash) and never-contract farmers' 1,308,000 riel (361,000 riel in cash), but the differences are not statistically significant (Table 3).

On average, contract farmers spend 2,695 riel on labor costs to produce one kg of rice in their commercial operations, higher than former-contract farmers' 2,237 riel and never-contract farmers' 2,261 riel, but the differences are not statistically significant (Table 3).

On average, the three types of farmers are not significantly different in their commercial operations with respect to the ratio of family labor in total labor, the ratio of hired labor in total labor, or the ratio of females in total labor. However, contract farmers use a relatively lower percentage of exchanged labor in their commercial operations (Table 3).

Table 3: Labor Cost

Variables	Contract^a	Former Contract^a	Never Contract^a
Commercial operation			
Labor cost (1000 riel/ha)	1250a	1522a	1308a
Labor cost (riel per kg of rice production)	2695a	2237a	2261a
Cash labor cost (1000 riel/ha)	266a	308a	361a
Cash labor cost (riel per kg of rice production)	409a	409a	500a
Ratio of family labor in total labor (%)	86a	86a	83a
Ratio of hired labor in total labor (%)	9.6a	7.9a	11a
Ratio of exchanged labor in total labor (%)	4.3b	6.3a	6ab
Ratio of females in total labor (%)	48a	47a	53a
Entire operation			
Labor cost (1000 riel/ha)	1106ab	1305a	1017b
Labor cost (riel/kg)	3424a	1847b	1991b
Cash labor cost (1000 riel/ha)	222a	274a	257a
Cash labor cost (riel/kg)	143a	144a	180a
Non-cash labor cost (1000 riel/ha)	884ab	1031a	760b
Non-cash labor cost (riel/kg)	711a	580a	581a
Ratio of family labor in total labor (%)	85a	82ab	80b
Ratio of hired labor in total labor (%)	7.7b	12a	12a
Ratio of exchanged labor in total labor (%)	10a	9.5a	10a
Ratio of females in total labor (%)	49b	48b	52a

a. The three columns represent the average value of each group for the variables. The letters (a, b, or c) following each number indicate the significance of the differences across the three groups under pair-wise mean comparisons. The significance level is 10%. For each variable under comparison, numbers with the same letter are not significantly different; numbers with letter a are significantly greater than numbers with letter b or c; numbers with letter b are significantly greater than numbers with letter c.

H. Material and Operating Costs

On average, contract farmers spend 242,000 riel on material costs (including transportation costs) per hectare of commercial field, lower than former-contract farmers' 280,000 riel and never-contract farmers' 353,000 riel, but the differences are not statistically significant (Table 4).

On average, contract farmers use 543 riel of material costs to produce one kg of rice, lower than former-contract farmers' 786 riel and never-contract farmers' 561 riel, but the differences are not statistically significant (Table 4).

Table 4: Material and Operating Cost Structure

Variables	Contract^a	Former Contract^a	Never Contract^a
Commercial operation			
Material cost (1000 riel/ha)	242a	280a	353a
Material cost (riel per kg of rice production)	543a	786a	561a
Seed cost (1000 riel/ha)	52b	74a	53b
Seed cost (riel per kg of rice production)	135a	153a	109a
Seed price (riel/kg)	693a	664a	685a
Chemical fertilizer cost (1000 riel/ha)	59b	70b	110a
Chemical fertilizer cost (riel per kg of rice production)	180ab	90b	224a
Chemical fertilizer price (riel/kg)	1153a	1154a	1153a
Compost cost (1000 riel/ha)	66b	64b	103a
Compost cost (riel per kg of rice production)	126a	285a	133a
Compost price (riel/cart)	5311a	4460b	6130a
Pesticide cost (1000 riel/ha)	1.21a	0.61a	0.68a
Pesticide cost (riel per kg of rice production)	4.04a	0.43b	0.28ab
Irrigation cost (1000 riel/ha)	16b	34ab	42a
Irrigation cost (riel per kg of rice production)	22a	133a	36a
Rental machine cost (1000 riel/ha)	50a	42a	44a
Rental machine cost (riel per kg of rice production)	73a	124a	58a
Transportation cost (riel per kg of rice)	44a	8.1ab	5.3b
Entire operation			
Material cost (1000 riel/ha)	248b	311a	274ab
Material cost (riel/kg)	751a	547a	564a
Seed cost (1000 riel/ha)	48b	63a	48b
Seed cost (riel per kg of rice production)	42a	42a	40a
Seed price (riel/kg)	622a	615a	598a
Chemical fertilizer cost (1000 riel/ha)	86b	126a	109ab
Chemical fertilizer cost (riel per kg of rice production)	70a	79a	81a
Chemical fertilizer price (riel/kg)	1237ab	1167b	1481a
Compost cost (1000 riel/ha)	58b	70a	74a
Compost cost (riel per kg of rice production)	36b	56a	62a
Compost price (riel/cart)	5586a	5262a	6724a
Pesticide cost (1000 riel/ha)	0.75a	0.74a	0.88a
Pesticide cost (riel per kg of rice production)	0.48a	0.79a	0.31a
Irrigation cost (1000 riel/ha)	15a	24a	13a
Irrigation cost (riel per kg of rice production)	6.6a	10.5a	9.7a
Rental machine cost (1000 riel/ha)	33a	36a	37a
Rental machine cost (riel per kg of rice production)	18a	19a	34a

a. The three columns represent the average value of each group for the variables. The letters (a, b, or c) following each number indicate the significance of the differences across the three groups under pair-wise mean comparisons. The significance level is 10%. For each variable under comparison, numbers with the same letter are not significantly different; numbers with letter a are significantly greater than numbers with letter b or c; numbers with letter b are significantly greater than numbers with letter c.

1. Seed

On average, contract farmers spend 52,000 riel on seeds for one hectare of commercial operation, which is lower than former-contract farmers' 74,000 riel but not significantly different from never-contract farmers' 53,000 riel (Table 4).

On average, the three types of farmers do not differ significantly in their seed costs in terms of per kg of rice production. Their seed prices are also not significantly different (Table 4).

2. Chemical Fertilizer

With respect to commercial operations, the average chemical fertilizer costs per hectare for contract farmers and former-contract farmers (59,000 riel and 70,000 riel respectively) are significantly lower than for never-contract farmers' (110,000 riel) (Table 4). It is noted that while AKR recommends that contract farmers do not use chemical fertilizer, it is not strict in its monitoring system. There is a lack of clarity on what is considered organic practice as defined by AKR. During field visits, farmers explained that they used chemical fertilizers only during land preparation but not during the cultivation period, so they considered that they were complying with AKR's requirements.

On average, former-contract farmers spend 90 riel of chemical fertilizers in producing one kg of rice, lower than contract farmers' 180 riel and never-contract farmers' 224 riel (Table 4). As AKR promotes soil improvement techniques to farmers under the contract, this factor may have contributed to former-contract farmers' relatively high efficiency in the use of chemical fertilizer (in terms of cost per kg of rice production). In contrast, never-contract farmers' rice fields have a relatively low efficiency in the use of chemical fertilizer as soil improvement techniques were never extended to them. Hence, they usually need to use more chemical fertilizers to produce a given amount of rice.

There is no significant difference in the prices of chemical fertilizer encountered by the three types of farmer (Table 4).

3. Compost

On average, contract farmers use 66,000 riel of compost on one hectare of commercial field, which is similar to former-contract farmers' 64,000 riel but lower than never-contract farmers' 103,000 riel (Table 4). In general, the requirement for compost declines as soil structure improves after a few years of organic practice. Nevertheless, it is not clear in this sample whether lower use of compost among contract and former-contract farmers is due to a better quality of land or a lack of available compost.

It is interesting also to note that the price of compost is significantly higher for never-contract farmers (6,130 riel per cart compared to 5,311 riel per cart for contract farmers and 4,460 riel per cart for former-contract farmers). This may be due to the fact that never-contract farmers have a significantly lower number of livestock and hence have to rely on purchased manure (Table 1).

To what extent the promotion of the use of compost by AKR resulted in raising awareness among other groups of farmers about the importance of using compost would be an interesting topic for further investigation.

4. Pesticides

All three types of farmer have very low pesticide costs for one hectare of commercial operation, which are not statistically different (Table 4). It should be noted that the pesticides used by contract farmers could be biological pesticides because AKR extended technologies for making biological pesticides using herbal extract to farmers under contract. Unfortunately, the questionnaire did not distinguish between biological and chemical pesticides.

5. Irrigation

Contract farmers' average irrigation cost for commercial operations is 16,000 riel per hectare, lower than former-contract farmers' 34,000 riel per hectare (not statistically significant) and never-contract farmers' 42,000 riel (Table 4). This indicates that contract farmers may have a better water supply and/or they have better agricultural land.

6. Machinery

Contract farmers' average machinery cost of 50,000 riel per hectare appears higher than former-contract farmers' 42,000 riel and never-contract farmers' 44,000 riel, but the differences are not statistically significant (Table 4). Their machinery costs in terms of per kg of rice production are also not statistically significant (Table 4).

7. Transportation

Contract farmers' average transportation cost (per kilo of rice production) is 44 riel, higher than former-contract farmers' average 8.1 riel (not statistically significant) and never-contract farmers' average 5.3 riel.

VII. PROPENSITY SCORE MATCHING ANALYSIS

As the above comparisons do not control for farmers' characteristic differences, the mean differences in farming performance between contract and non-contract farmers may be caused by farmers' characteristics rather than their contract or non-contract states. In the following we use the "propensity score matching" (p-score) method (Becker and Ichino, 2002) to conduct a more refined comparison by controlling for farmers' characteristic differences.

The first step of the p-score approach is to estimate farmers' propensity scores based on their basic characteristics (i.e., characteristics that are not affected by the choice of contract). The propensity score of each farmer measures his/her tendency to join the contract. The magnitude of a propensity score is between 0 and 1; the larger the score, the more likely the farmer would be to join the contract.

After farmers' propensity scores are estimated, the second step is to divide farmers into groups. Farmers in each group have similar propensity scores. In addition, each group should be balanced in the sense that the basic characteristics of the farmers in it are not significantly different.

After the balanced groups are formed, we can compare different types of farmers in each group. As such comparisons control for farmers' characteristic differences, the performance differences between contract and non-contract farmers are more likely to be caused by contract farming rather than by farmers' basic characteristics.

The above p-score comparison method is usually called "stratification" comparison in that the two groups under comparison are stratified into one-to-one matching sub-groups for comparison. Besides the stratification comparison, another comparison method called the "nearest neighbor" comparison is to compare each contract farmer to the non-contract farmer with the most similar p-score (Becker and Ichino, 2002).

In this paper we use the stratification comparison as the main approach and the nearest-neighbor comparison as an additional approach to enhance the robustness of the comparisons. For example, if both comparison approaches indicate that contract farmers have higher profits than never-contract farmers, and the differences are statistically significant, we would have the confidence to conclude that contract farming tends to improve profitability. If both approaches indicate that contract farmers have higher profits, and the difference is statistically significant under one approach but not under the other, the conclusion that contract farming improves profitability would still be sound but less robust

than in the first situation. The most troublesome situation would be where one approach indicates that contract farmers have significantly higher profits while the other approach indicates the exact opposite. Fortunately, we do not encounter such situations in this study.

We include the following variables in the p-score estimation: 1) the size of own land; 2) the value of production assets; 3) the value of consumption assets; 4) the age of the household head; 5) the gender of the household head; 6) the educational level of the household head; 7) the number of adult family members; 8) the female ratio in the family; 9) the distance from the farm to the market; 10) the distance from the farm to the highway; 11) a dummy variable identifying province 2; 12) a dummy variable identifying province 3; and 13) a dummy variable identifying province 4.

We use the p-score approach to conduct three comparisons. One is to compare contract farmers and never-contract farmers' performance in their entire operations (including both commercial and self-consumption operations); another is to compare contract farmers and former-contract farmers' performance in their entire operations; and the last one is to compare contract farmers and former-contract farmers' performance in their commercial operations.

A. Contract Farmers vs. Never-Contract Farmers (Entire Operations)

Table 5 shows the results of the p-score comparison of contract farmers and never-contract farmers' performance in their entire operations.

Since contract farmers (as the treatment group) are compared to different never-contract farmers (as the control group) under the stratification approach and the nearest-neighbor approach, the results based on the two approaches may not be consistent. As mentioned above, we use the nearest-neighbor comparisons to examine the robustness of the results from the stratification comparisons.

The ideal situation would have been to compare the commercial operations of contract and never-contract farmers. Unfortunately, as never-contract farmers have very limited areas for commercial purposes, there are only 27 never-contract farmers reporting their commercial operations (compared to 170 contract farmers), which makes the p-score comparisons highly imbalanced and uninformative. Therefore, we use the p-score approach to compare contract and never-contract farmers' performance in their entire operations only. It should be noted that since the sizes of consumption fields operated by contract farmers differ widely, the combined impacts may dilute the findings on the impact of commercialization.

**Table 5: P-score Comparison of Contract and Never-Contract Farmers
(Entire Operations)**

Variables	Difference (Stratification)	Difference (Nearest Neighbor)
No. of observations (contract vs. never-contract)	178 vs. 197	178 vs. 63
Rice price (riel/kg)	26	17
t-ratio	1.231	0.766
Revenue (1000riel/ha)	158	183
t-ratio	2.649	2.978
Yield (kg/ha)	159	194
t-ratio	1.411	1.761
Cost (1000 riel/ha)	392	302
t-ratio	3.617	1.940
Cost (riel per kg of rice production)	1,777	1,195
t-ratio	1.968	0.972
Cash cost (1000 riel/ha)	29	37
t-ratio	0.444	0.318
Cash cost (riel per kg of rice production)	417	245
t-ratio	0.933	0.589
Profit (1000 riel/ha)	-244	-119
t-ratio	1.964	1.501
Cash profit (1000 riel/ha)	129	146
t-ratio	2.002	1.884

- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a higher average rice price than never-contract farmers in their entire operations, but the difference is not statistically significant under either approach.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have higher average revenue than never-contract farmers in their entire operations; and the difference is statistically significant under both approaches.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a higher average yield than never-contract farmers in their entire operations; the difference is significant under the nearest-neighbor comparison but not under the stratification comparison.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a higher average cost in terms of per hectare of rice field than never-contract farmers in their entire operations; and the difference is statistically significant under both approaches. Both comparisons indicate that contract farmers also have a higher average cost in terms of per kg of rice production than never-contract farmers in their entire operations; and the difference is statistically significant under the stratification approach but not under the nearest-neighbor approach.

- Both the stratification and nearest-neighbor comparisons indicate that compared to never-contract farmers, contract farmers have a higher average cash cost in terms of per hectare or per kilo of rice production in their entire operations, but the difference is not statistically significant under either approach.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a lower average profit than never-contract farmers in their entire operations. The difference is statistically significant under the stratification approach but not under the nearest-neighbor approach.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a higher average cash profit than never-contract farmers in their entire operations; and the difference is statistically significant under both approaches.

B. Contract Farmers vs. Former-Contract Farmers (Commercial Operations)

Table 6 shows the results of the p-score comparison of contract farmers and former-contract farmers' performance in their commercial operations.

Table 6: P-score Comparison of Contract and Former-Contract Farmers (Commercial Operations)

Variables	Difference (Stratification)	Difference (Nearest Neighbor)
No. of observations (contract vs. former contract)	178 vs. 191	178 vs. 58
Rice price (riel/kg)	63	64
t-ratio	4.052	3.748
Revenue (1000 riel/ha)	-377	-976
t-ratio	1.316	2.235
Yield (kg/ha)	-651	-1,487
t-ratio	1.917	2.349
Cost (1000 riel/ha)	-329	-788
t-ratio	1.021	1.357
Cost (riel per kg of rice production)	932	1,328
t-ratio	1.317	1.836
Cash cost (1000 riel/ha)	-65	-300
t-ratio	0.557	1.605
Cash cost (riel per kg of rice production)	114	250
t-ratio	0.565	1.032
Profit (1000 riel/ha)	-48	-188
t-ratio	0.243	0.740
Cash profit (1000 riel/ha)	-312	-676
t-ratio	1.466	2.205

- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a higher average rice price than former-contract farmers in their commercial operations; and the difference is statistically significant under both approaches.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have lower average revenue than former-contract farmers in their commercial operations. The difference is statistically significant under the nearest-neighbor approach but not under the stratification approach.
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a lower average yield than former-contract farmers in their commercial operations; and the difference is statistically significant under both approaches.
- Both the stratification and nearest-neighbor comparisons indicate that compared to former-contract farmers, contract farmers have a lower average cost (or cash cost) in terms of per hectare of rice field in their commercial operations, but the difference is not statistically significant under either approach. Both comparisons indicate that compared to former-contract farmers, contract farmers have a higher average cost (or cash cost) in terms of per kilo of rice production in their commercial operations, but the difference is only statistically significant for the average cost under the nearest neighbor approach. The cost comparisons indicate that former-contract farmers tend to farm more intensively (i.e., higher cost per hectare of rice field); and the higher intensity tends to increase their efficiency in input use (i.e., lower cost per kilo of cost production).
- Both the stratification and nearest-neighbor comparisons indicate that contract farmers have a lower average profit than former-contract farmers in their commercial operations, but the difference is not statistically significant under either approach. Both comparisons indicate that contract farmers also have a lower average cash profit than former-contract farmers in their commercial operations; and the difference is statistically significant under the nearest neighbor approach but not under the stratification approach. According to the profit comparisons, former-contract farmers seem to be the most progressive farmers. Their experience in contract farming with AKR may have helped them become independent commercial farmers who are able to explore their own markets. Without the constraints imposed by contract farming, these farmers are able to adopt more profitable farming practices.

C. Contract Farmers vs. Former-Contract Farmers (Entire Operations)

Table 7 shows the p-score comparisons of contract and former-contract farmers' performance in their entire operations. The results are mostly similar to the comparisons of their commercial operations. One exception is that the stratification comparison shows that contract farmers' profit in their entire operations is significantly higher than former-contract farmers'.

**Table 7: P-score Comparison of Contract and Former-Contract Farmers
(Entire Operations)**

Variables	Difference (Stratification)	Difference (Nearest Neighbor)
No. of observations (contract vs. former contract)	178 vs. 191	178 vs. 85
Rice price (riel/kg)	24	18
t-ratio	2.064	1.120
Revenue (1000 riel/ha)	-161	-237
t-ratio	1.651	1.909
Yield (kg/ha)	-321	-429
t-ratio	2.266	2.246
Cost (1000 riel/ha)	-172	-59
t-ratio	0.823	0.260
Cost (riel per kg of rice production)	1,980	1,926
t-ratio	2.579	1.077
Cash cost (1000 riel/ha)	-84	-122
t-ratio	0.881	0.961
Cash cost (riel per kg of rice production)	699	676
t-ratio	2.179	2.243
Profit (1000 riel/ha)	11	-178
t-ratio	0.052	0.833
Cash profit (1000 riel/ha)	-78	-115
t-ratio	1.207	1.205

VIII. SWITCHING REGRESSION

While the p-score comparisons in the above try to compare the performance of contract and non-contract farmers with similar intrinsic characteristics, they cannot correct hidden bias because p-score comparison only controls for observed variables (to the extent that they are perfectly measured). For example, farmers' motivation may be an unobserved covariate affecting both farmers' performance and their choices about joining the contract.

Selection models can be used to address unobservable selection bias in deciding whether to join the contract or not. In this section we use an endogenous switching regression model to account for selection biases. We use the model to examine how farmers' characteristics affect their decisions to join the contract and their performance with or without the contract. We also compare farmers' expected performance under the contract and without the contract.

A. Methodology

Consider the following model that describes farmers' choices about joining the contract and their performance with and without the contract:

If $\gamma Z_i + u_i > 0$, farmer i chooses to join the contract, which is described by $I_i = 1$;

If $\gamma Z_i + u_i \leq 0$, farmer i chooses not to join the contract, which is described by $I_i = 0$;

Farmer i 's profitability with the contract ($I_i = 1$) is $y_{1i} = \beta_1 X_{1i} + \varepsilon_{1i}$;

Farmer i 's profitability without the contract ($I_i = 0$) is $y_{0i} = \beta_0 X_{0i} + \varepsilon_{0i}$;

In the model, Z_i is a vector of farm characteristics that affect farmers' decisions to join the contract; X_{1i} and X_{0i} are two vectors of farm characteristics that affect farmers' performance under the contract and without the contract; and y_{1i} and y_{0i} are dependent variables measuring farmers' profitability. γ , β_1 and β_0 are vectors of parameters subject to estimation. u_i , ε_{1i} , and ε_{0i} are three random error terms that follow trivariate normal distribution.

After the parameters are estimated, we can calculate

$$xb_{1i} = E(y_{1i}|x_{1i}) = x_{1i}\beta_1 \quad (1)$$

$$xb_{0i} = E(y_{0i}|x_{0i}) = x_{0i}\beta_0 \quad (2)$$

$$yc_{1_{-1i}} = E(y_{1i}|I_i = 1, x_{1i}) = x_{1i}\beta_1 + \sigma_1\rho_1 f(\gamma Z_i) / F(\gamma Z_i) \quad (3)$$

$$yc_{0_{-1i}} = E(y_{0i}|I_i = 1, x_{1i}) = x_{1i}\beta_0 + \sigma_0\rho_0 f(\gamma Z_i) / F(\gamma Z_i) \quad (4)$$

$$yc_{0_{-0i}} = E(y_{0i}|I_i = 0, x_{0i}) = x_{0i}\beta_0 - \sigma_0\rho_0 f(\gamma Z_i) / [1 - F(\gamma Z_i)] \quad (5)$$

$$yc_{1_{-0i}} = E(y_{1i}|I_i = 0, x_{0i}) = x_{0i}\beta_1 - \sigma_1\rho_1 f(\gamma Z_i) / [1 - F(\gamma Z_i)] \quad (6)$$

xb_{1i} represents the unconditional expectation of farmers' performance under the contract; xb_{0i} represents the unconditional expectation of farmers' performance without the contract; $yc_{1_{-1i}}$ represents the conditional expectation of contract farmers' performance under the contract; $yc_{0_{-1i}}$ represents the conditional expectation of contract farmers' performance without the contract; $yc_{0_{-0i}}$ represents the conditional expectation of non-contract farmers' performance without the contract; and $yc_{1_{-0i}}$ represents the conditional expectation of non-contract farmers' performance with the contract. σ_1 and σ_0 are the standard errors of ε_{1i} , and ε_{0i} ; ρ_1 is the correlation coefficient between ε_{1i} and u_i ; and ρ_0 is the correlation coefficient between ε_{0i} and u_i .

B. Indicators for Premiums of Joining the Contract

Based on equations (1) to (6), three indicators can be constructed to compare farmers' profitability with and without the contract.

$$(1) \quad \Pi = xb_{1i} - xb_{0i}$$

According to equations (1) and (2), Π is equal to a general farmer i 's (irrespective of his/her choice of contract farming) expected performance under the contract minus his/her expected performance without the contract. The mean of Π measures farmers' average profitability premiums from joining the contract.

$$(2) \quad \Pi_1 = yc_{1_{-1i}} - yc_{0_{-1i}}$$

According to equations (3) and (4), Π_1 is equal to a sample contract farmer i's expected performance under the contract minus his/her expected performance without the contract. The mean of Π_1 measures the sample contract farmers' average profitability premiums from joining the contract.

$$(3) \Pi_0 = yc_{1_0i} - yc_{0_0i}$$

According to equations (5) and (6), Π_0 is equal to a sample non-contract farmer i's expected profitability under the contract minus his/her expected profitability without the contract. The mean of Π_0 measures the sample non-contract farmers' average profitability premiums from joining the contract.

C. Indicators for Farmers' Relative Performance With and Without the Contract

$$(4) \Lambda_{1_1} = yc_{1_1i} - xb_{1i} \text{ and } \Lambda_{0_1} = yc_{0_1i} - xb_{0i}$$

According to equations (1) and (3), Λ_{1_1} compares a sample contract farmer i's average profitability under the contract (measured by yc_{1_1i}) to the profitability of a general farmer (with the same characteristics) under the contract. A positive mean of Λ_{1_1} indicates that under the contract, farmers who actually joined the contract tend to have higher profitability than those who did not.

According to equations (2) and (4), Λ_{0_1} compares a sample contract farmer i's average performance without the contract (measured by yc_{0_1i}) to the profitability of a general farmer without the contract. A positive mean of Λ_{0_1} indicates that outside the contract, farmers who actually joined the contract would also have a higher profitability than those who did not.

$$(5) \Lambda_{0_0} = yc_{0_0i} - xb_{0i} \text{ and } \Lambda_{1_0} = yc_{1_0i} - xb_{1i}$$

According to equations (2) and (5), Λ_{0_0} compares a sample non-contract farmer i's average profitability outside the contract (measured by yc_{0_0i}) to the profitability of a general farmer (with the same characteristics) outside the contract. A positive mean of Λ_{0_0} indicates that outside the contract, farmers who did not join the contract tend to have higher profitability than those who did.

According to equations (1) and (6), Λ_{1_0} compares a sample non-contract farmer i's average performance outside the contract (measured by yc_{1_0i}) to the profitability of a general farmer outside the contract. A positive mean of Λ_{1_0} indicates that under the contract, farmers who did not join the contract tend to have higher profitability than those who did.

Λ_{1_1} , Λ_{0_1} , Λ_{0_0} , and Λ_{1_0} measure farmers selection bias on contract farming. There are four patterns.

$$(1) \Lambda_{1_1} > 0; \Lambda_{1_0} < 0 \text{ and } \Lambda_{0_1} > 0; \Lambda_{0_0} < 0$$

This situation indicates that the sampled contract farmers tend to have higher profitability no matter whether they are under the contract or outside the contract. That is, better farmers tend to choose to join the contract.

$$(2) \Lambda_{1_1} > 0; \Lambda_{1_0} < 0 \text{ and } \Lambda_{0_1} < 0; \Lambda_{0_0} > 0$$

This situation indicates that the sampled contract farmers tend to have higher profitability under the contract but lower profitability outside the contract. That is, farmers who have a comparative advantage in contract farming tend to choose to join the contract, while those who have a comparative advantage outside the contract tend to choose to stay outside the contract.

$$(3) \Lambda_{1_1} < 0; \Lambda_{1_0} > 0 \text{ and } \Lambda_{0_1} > 0; \Lambda_{0_0} < 0$$

This situation indicates that the sampled contract farmers tend to have lower profitability under the contract but higher profitability outside the contract. This is an unlikely scenario because it implies that farmers who do not have a comparative advantage in contract farming tend to choose to join the contract, while those who do have a comparative advantage in contract farming nevertheless tend to choose to stay outside the contract.

$$(4) \Lambda_{1_1} < 0; \Lambda_{1_0} > 0 \text{ and } \Lambda_{0_1} < 0; \Lambda_{0_0} > 0$$

This situation is the exact opposite of the first one. It indicates that the sampled contract farmers tend to have lower profitability whether they are under the contract or outside the contract. That is, better farmers tend to choose to stay outside the contract.

D. Comparison of Contract Farmers' and Non-Contract Farmers' Profitability in Commercial Rice Farming

Based on the above switching regression model, we use the “movestay” module (Lokshin and Sajaia, 2004) in the STATA program to evaluate factors that affect farmers' decisions to join the contract and their performance with or without the contract. We measure farmers' performance according to their profits per hectare in their commercial operations.

In the selection model we include the following variables:

- The rice price and input prices (i.e., seed, wage, chemical fertilizer, compost, irrigation, and machinery) under contract and without contract. For contract (or non-contract) farmers, the prices without contract (or under contract) are unobservable. We estimate such counterfactual prices by using farmers' geographical locations and their land sizes as two regressors.
- Household characteristics including the age, gender, and education level of the household head, family size, and the ratio of females in the household.
- Farm characteristics, including the size of own land, the value of production assets, the value of consumption assets (e.g. TV), the distance from the farm to the market, the distance from the farm to the highway, the total number of plows and pumps, and the number of motorbikes.
- Three province dummies to identify farmers from four different provinces

In the profit functions, we include the rice price, the input prices, the size of own land, the value of production assets, and the three province dummies. For the non-contract profit function, we also include a dummy to differentiate former-contract and never-contract farmers.

Table 8 shows the estimation results for the selection function, which suggest the following:

- Households with less asset value are more likely to join the contract.
- Households with younger household heads are more likely to join the contract.
- Households with more educated household heads are more likely to join the contract.

- Households with larger family size are more likely to join the contract.
- Households closer to the highway are more likely to join the contract.

Table 8: The Selection Function

Selection model	Coefficient	Std. Err.	Z	P>z	Confidence Interval (95%)	
Rice price under contract	-0.1102	0.4717	-0.2300	0.8150	-1.0347	0.8143
Rice price without contract	-0.5235	0.9183	-0.5700	0.5690	-2.3233	1.2762
Seed price under contract	-0.0992	0.5456	-0.1800	0.8560	-1.1685	0.9701
Seed price without contract	0.1211	0.7405	0.1600	0.8700	-1.3303	1.5724
Chemical price under contract	-0.3862	0.9196	-0.4200	0.6750	-2.1886	1.4162
Chemical price without contract	-0.1967	0.9044	-0.2200	0.8280	-1.9693	1.5758
Compost price under contract	-0.0821	0.2853	-0.2900	0.7730	-0.6413	0.4770
Compost price without contract	0.0539	0.2391	0.2300	0.8220	-0.4147	0.5226
Irrigation price under contract	-0.0127	0.1933	-0.0700	0.9480	-0.3916	0.3662
Irrigation price without contract	0.0230	0.2135	0.1100	0.9140	-0.3955	0.4415
Machinery price under contract	-0.1348	0.1762	-0.7600	0.4440	-0.4802	0.2106
Machinery price without contract	-0.2716	0.2047	-1.3300	0.1850	-0.6728	0.1296
Own land	0.1803	0.1636	1.1000	0.2710	-0.1404	0.5010
Fix production asset	-0.0154	0.0217	-0.7100	0.4760	-0.0579	0.0270
Consumption asset	-0.0130	0.0220	-0.5900	0.5540	-0.0560	0.0300
Age	-0.0191	0.0074	-2.5900	0.0100	-0.0336	-0.0047
Gender	0.2374	0.2101	1.1300	0.2590	-0.1745	0.6492
Education	0.0049	0.0571	0.0900	0.9310	-0.1071	0.1169
Family size	0.0847	0.0589	1.4400	0.1500	-0.0307	0.2002
Female ratio in household	0.2162	0.4423	0.4900	0.6250	-0.6508	1.0832
Distance to market	0.3687	0.1380	2.6700	0.0080	0.0982	0.6392
Distance to highway	-0.3249	0.0832	-3.9000	0.0000	-0.4880	-0.1617
Province 2 (dummy)	0.5725	0.4414	1.3000	0.1950	-0.2927	1.4377
Province 3 (dummy)	-1.4150	0.5059	-2.8000	0.0050	-2.4066	-0.4234
Province 4 (dummy)	0.2630	0.2413	1.0900	0.2760	-0.2099	0.7358
Constant	13.31	12.38	1.08	0.2820	-10.95	37.56
σ_0	1.3792	0.1030			1.1914	1.5966
σ_1	0.9551	0.0521			0.8582	1.0630
ρ_0	-0.4266	0.1966			-0.7290	0.0152
ρ_1	0.0337	0.3299			-0.5466	0.5922

Table 9 shows the estimation results for the profit functions with and without contract; based on which we can estimate the sample farmers' profits under contract and outside contract. With the estimated results we can then calculate contract and non-contract farmer's premiums from joining the contract and compare their profitability under contract and outside contract. The results are summarized in Table 10.

Table 9: Profit Functions Under Contract and Without Contract

Variables	Coefficient	Std. Err.	z	P>z	Confidence Interval (95%)	
Profit without contract (log)						
Rice price	2.8848	0.9549	3.0200	0.0030	1.0132	4.7564
Wages	-0.8163	0.1958	-4.1700	0.0000	-1.2000	-0.4326
Seed price	-2.4547	0.7967	-3.0800	0.0020	-4.0163	-0.8932
Chemical fertilizer price	-0.1323	0.9476	-0.1400	0.8890	-1.9896	1.7250
Compost price	-0.1384	0.2415	-0.5700	0.5670	-0.6118	0.3350
Irrigation price	-0.2866	0.2003	-1.4300	0.1520	-0.6791	0.1059
Machinery price	-0.7162	0.1970	-3.6400	0.0000	-1.1024	-0.3301
Own land	-0.0937	0.1947	-0.4800	0.6300	-0.4752	0.2878
Fixed production asset	0.0488	0.0285	1.7100	0.0870	-0.0071	0.1047
Province 2 (dummy)	-0.1505	0.5869	-0.2600	0.7980	-1.3008	0.9998
Province 3 (dummy)	0.6623	0.4471	1.4800	0.1380	-0.2139	1.5385
Province 4 (dummy)	-0.5076	0.3120	-1.6300	0.1040	-1.1192	0.1040
Contract experience (Yes=1; No=0)	0.3038	0.2796	1.0900	0.2770	-0.2442	0.8517
Constant	1883.80	9.21	204.53	0.0000	1865.75	1901.85
Profit under contract						
Rice price	0.3290	0.3558	0.9200	0.3550	-0.3684	1.0265
Wage	-1.1878	0.1604	-7.4100	0.0000	-1.5021	-0.8734
Seed price	0.3698	0.3843	0.9600	0.3360	-0.3834	1.1231
Chemical fertilizer price	-0.5378	0.6530	-0.8200	0.4100	-1.8178	0.7421
Compost price	-0.0307	0.1922	-0.1600	0.8730	-0.4074	0.3460
Irrigation price	-0.4034	0.1274	-3.1700	0.0020	-0.6531	-0.1536
Machinery price	-0.4166	0.1464	-2.8500	0.0040	-0.7036	-0.1296
Own land	-0.1504	0.1755	-0.8600	0.3910	-0.4943	0.1936
Fixed production asset	0.0040	0.0204	0.2000	0.8430	-0.0360	0.0441
Province 2 (dummy)	-0.9086	0.3405	-2.6700	0.0080	-1.5759	-0.2413
Province 3 (dummy)	0.8378	0.6411	1.3100	0.1910	-0.4188	2.0943
Province 4 (dummy)	0.3871	0.2141	1.8100	0.0710	-0.0324	0.8067
Constant	1885.31	6.69	282.01	0.0000	1872.21	1898.42

Table 10: Profitability Comparison based on Switching Regression

Farmer type	Profit premium from joining contract ^a (millions of riel)	Profit difference under contract ^b (millions of riel)	Profit difference outside contract ^c (millions of riel)
All farmers (Π)	0.43***	n.a.	n.a.
Contract farmers (Π_1, Λ_1 , and Λ_0)	0.99***	0.03***	-0.52***
Former-contract farmers (Π_0, Λ_1 , and Λ_0)	-0.18**	-0.03***	0.51***
Never-contract farmers (Π_0, Λ_1 , and Λ_0)	0.17	-0.03***	-0.57***

***(1% significance level); **(5% significance level); *(10% significance level)

a. Each type of farmer's average profits under contract minus their average profits without contract.

b. Each type of farmers' average profits under contract minus the average profit of all the sample farmers under contract.

c. Each type of farmers' average profits outside contract minus the average profit of all the sample farmers outside contract.

- For all the sample farmers on average, joining the contract would tend to raise profit by 0.43 million riel.
- For the sample contract farmers, joining the contract would raise their average profit by nearly one million riel.
- For the sample former-contract farmers on average, had they joined the contract, their profits would have been 0.18 million riel lower than their actual profits.
- For the sample never-contract farmers on average, had they joined the contract, their profits would have been increased by 0.17 million riel, but the difference is not statistically significant. Note that the small sample size (27 never-contract farmers only) may be a factor affecting the significance level.
- Under contract, the sample contract farmers on average have higher profits than the sample former-contract and never-contract farmers; their average profit under contract is 0.03 million riel above the average of all the sample farmers.
- Outside contract, the sample former-contract farmers on average have higher profits than the sample contract and never-contract farmers; their average profit outside the contract is 0.51 million riel above the average of all the sample farmers.

IX. SUMMARY

Contract farming can provide stable market access, credits, extension services, infrastructure and other benefits to promote agricultural development. However, contract farming also has drawbacks such as limiting farmers' flexibility in choosing farming practices, increasing risks, and reducing farmers' bargaining power. In the process of establishing and implementing contracts the challenges of asymmetric information and coordination failures between farmers and the contractor are also faced.

Based on the data provided by a survey of Cambodian rice farmers, we use different approaches (including simple mean comparisons, p-score comparisons, and switching regression comparisons) to examine the impact of contract farming on farmers' performance.

We first use the simple mean test to compare the average performance of contract, former-contract, and never-contract farmers. The results show that compared to never-contract farmers, contract and former-contract farmers have larger family sizes and farm sizes. Their household heads are older, more educated, and less likely to be female. They are richer farmers with more assets like plows, pumps, bikes, motorbikes, livestock and TVs and higher monthly expenditure per person. Their credits are mainly from MFI and seed credit comes from Angkor Kasekam Roongroeung Co Ltd (AKR) and they rely less on informal sector lenders i.e. moneylenders and family members or relatives. They have more income from non-rice crops. They have larger rice fields and use a higher percentage of their rice fields for commercial operations. With respect to commercial operations, they have higher rice prices and revenues, a higher percentage of non-cash costs in total production costs because of the use of more family labor; and they spend less on chemical fertilizer, compost, and irrigation.

The simple mean comparisons show that compared to former-contract farmers, contract farmers have larger family sizes and farm sizes and younger household heads. They rely more on seed credits but less on fertilizer credits and credits from family members or relatives. Their farms are further away from the market. They have larger rice fields and use a higher percentage of their rice fields for commercial operations. With respect to commercial operations, they have higher rice prices but lower revenues because of lower yields; they spend more labor cost producing the same amount of rice mainly because of their higher non-cash costs from the use of family labor; and they use less exchanged labor (in percentage terms) than former-contract farmers.

Finally, the simple mean comparisons show that contract farmers have higher average profits as well as cash profits than never-contract farmers; and they have higher average profits but lower average cash profits than former-contract farmers. However, none of these differences are statistically significant at 10%.

Although the simple mean comparisons show that contract farmers have higher average profits than non-contract farmers, we cannot use this result to conclude that contract farming improves profitability, because contract farmers' higher profit may not be due to contract farming but could be caused by farmers' selection bias.

To account for selection bias, we use p-score comparisons to examine the impacts of contract farming on farmers' performance. The results show that contract farmers have higher average rice prices, revenues as well as cash profits, than never-contract farmers in their entire operations including both commercial rice farming and rice farming for self-consumption. The p-score comparisons show that contract farmers have lower average profit (i.e., cash profit minus non-cash costs) than never-contract farmers, which is mainly due to their use of more family labor. Note that we use the cost of hired labor to estimate the shadow value of family labor, which may overestimate contract farmers' non-cash labor costs. In addition, cash profit is a better measure of the total value-added obtained by farmers' from their farming activities.

As there are only very few never-contract farmers reporting their commercial activities, we are unable to use the p-score approach to compare the performance of contract and never-contract farmers in commercial operations. Fortunately, we are able to do so for contract and former-contract farmers. The p-score comparisons show that although contract farmers have higher rice prices than former-contract farmers in commercial operations, they nevertheless have lower revenues because of lower yields. The results also show that in commercial operations contract farmers have lower profits as well as cash profits than former-contract farmers, but the differences are not statistically significant. Thus, former-contract farmers' profitability does not appear to be affected by their choices of not joining the contract. This result shows that contract farming may be a useful experience to help farmers develop into independent commercial farmers.

As p-score comparison cannot correct hidden bias, we use a selection model (i.e., the endogenous switching regression) to further refine the comparison. The switching regression comparisons also allow us to examine each type of farmers' benefits from contract farming and compare their farming performance with and without the contract. The results show that on average the sample farmers would increase their profits by joining the contract, but the impacts are different for each group: The sample contract farmers appear to be able to improve their profits significantly by joining the contract, while the sample former-contract farmers appear to have lower profits under contract farming. The sample never-contract farmers would have slightly higher profits under contract farming, but the difference is not statistically significant.

The results from switching regression comparison also show that under contract farming, the sample contract farmers would have higher average profits than the sample former- and never-contract farmers, but their average profits without contract would be similar to the sample never-contract farmers' and lower than the sample former-contract farmers'.

The switching regression also identifies factors affecting farmers' choices regarding joining the contract. The results show that farmers with larger family size, with younger and more educated household heads, with less asset value, and farmers with farm location closer to the highway are more likely to join the contract.

X. CONCLUSIONS AND RECOMMENDATIONS

Overall, the results show that rice contract farming by Angkor Kasekam Roongroeung Co Ltd (AKR) brings a number of benefits to smallholder farmers in Cambodia. Through contract farming, there are new income earning opportunities to produce high-value rice for the export market with minimal expense by the public sector. By introducing new institutional arrangements taking advantage of the existing commune structure established during the socialist regime, AKR successfully establishes farmers' organizations and uses them effectively to deliver credit for seeds and to extend organic rice farming practice, including integrated farming practice, to farmers. Most importantly, by promoting farming practices in which the poor in remote areas have a comparative advantage, AKR successfully facilitated coordination and intermediation to provide market access for farmers living in remote areas where organizational capacity in the public sector is weakest.

The characteristics of farmers who benefited the most are farmers with larger land sizes, larger family sizes, younger household heads, and farmers with a higher level of education. Progressive farmers living near the highway are likely to be the first group joining contract farming. However, it is interesting to note that this same group of farmers is also more likely to leave contract farming early as there are more market opportunities in areas where infrastructure is more developed. Since production under contract is restricted and in particular AKR restricts the use of agrochemicals to address the demand in the export market, farmers who have access to the local market for chemical rice moved on to intensify their farming practices to increase profit. It could be said that by undergoing organic contract farming, farmers were empowered to become independent farmers who intensify farming systems in a more sustainable way than farmers who have never undergone contract farming.

For farmers who live far away from the highway or live near the forest where soil fertility is good, arrangements under AKR to produce organic rice for export appear to be appropriate and long-lasting. From the point of view of poverty, this is a highly positive outcome for farmers in remote areas, as contract farming brings to them market access along with the introduction of sustainable farming practice.

Nevertheless, the results point to the fact that contract farming by AKR is not inclusive of the poorest farmers typically with land size below one hectare and with lower levels of education. Public sector attention will be required for this group of farmers. Overall, contract farming under AKR is not without problems and public attention may be required in the areas of empowering farmers' groups to increase bargaining power with this firm that is currently holding a monopsony position. More firms should be encouraged to enter into contract farming.

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