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Estiamting the Profit Efficiency of Contract and Non-Contract Rice Farms in Taiwan

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A Meta-Frontier and A Cross-Frontier Appraoch Applications

by

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Abstract

Trade liberalization and globalization have placed significant pressures on farmers and processors including more stringent quality control and product varieties. Small family farms in land-locked countries are particularly vulnerable unless proper institutional arrangement is available to assist their transition from subsistence farming to market-driven production. A meta-frontier methodology of Battese et al (2004) is adopted to estimate simultaneously the efficiencies and the technological gaps for productions under different technologies relative to the potential technology available as a whole as well. Another approach that is based on Cummins et al (1999) is also applied to estimate the cross-frontier profit efficiency. The result indicates that an average contract farm is 20 percent more efficient than an average non-contract farm in a comparable operating environment. Although contract farming has potential to improve the profit of smallholders, it is not a sufficient condition for such improvement. The empirical resulst also found that the contract technology does not dominate the non-contract rice farmers' technology and vice verse. However, the fact that the contract frontier dominates the non-contract frontier has been founded.

Keywords: Contract farming, Rice, Profit frontier, Meta-frontier, Switching regression

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I. Introduction

Contract farming has been proposed as an avenue for private sector to take over the roles previously served by the government in the provision of information, inputs or credit for small-scale farmers in the developing countries (World Bank, 2001). Increasing attention has been given to whether contract farming can provide small farmers with improved income or sufficient protection from incurring losses due to price fluctuations. In the literature, the positive relationship between the use of contracts and the increasing productivity is found (Cochrane, 1993, and Ahearn *et al.*, 2005). A fair amount of effort has been directed at assessing the relative efficiency of contract farming over independent production. Knoeber (1989) showes that the use of production contracts in the hog and broiler industry help the diffusion of the new technologies and lead to the improvement of productivity. Key and McBride (2003) provide evidence that contracts are assoicated with high productivity performance in hog production in the U.S. Hu (2013) also finds some evidence that contract farming might increase the average returns for the corn and soybean farmers in the U.S. Morrison *et al*. (2004) use the US farm-level data to compare the efficiecny effects of contracting in major corn-producing and livestock-producing states. Their results show that smaller opertaions are in general less efficient than larger and more contract-intensive entities. This finding not only suggests competitive pressures on smaller farms but also point out the barriers for smaller growers to participate in contract farming scheme. For developing countries, Ramaswami *et al.* (2006) evaluate how the efficiency gains of poultry contracts are shared between growers and processors in India. Cost reduction from better technology and produciton practices is counted as efficiency gain for the processors, while average return is viewed as efficiency gain for the growers.

However, there is little direct evidence regarding the potential of contract farming to increase profitability through increases in profit efficiency. Setboonsarng *et al.* (2005) use a stochastic profit frontier model to examine the profit efficiency of organic rice contract farming in the north and notheastern regions of Thailand. They identify a significant profit margin for contract farms across all scale of operations as compared to the non-contract farms, but efficiency gain is not as significant for the largest farm sizes. Their approach assumes that all farms are operating under a common profit frontier and cannot distinguish the effect of organic farming from contract farming. Thus, the large profit efficiency gain may contain both the technology change from adopting the new organic practices and the true efficiency improvement from the contract scheme.

In our study by using a very special survey data from Taiwan, besides the technology /productivity efficiency, we will be able to compare the profit efficiency between contract and non-contact farms. Meta-frontier methodology of Battese et al (2004) will be adopted to correct the bias caused by estimating simultaneously the comparable efficiencies and the technological gaps for productions under different technologies relative to the potential technology available as a whole. A switching regression method will also be used to account for the self-selection biases. The results will be used to test the hypothesis whether contract farms are more efficient and/or profitable operations than the non-contract ones in a comparable operational and technical environment. Policy recommendations on whether contract farming can be an effective institutional reform to increase profitability for small-scale family farms will be drawn.

The remainder of this study is organized as follows. In the next section, we give some background information and introduce the rice industry in Taiwan. The third section describes the survey design and a brief description of the sample data. Section four discusses the meta-frontier and cross-frontier efficiency using graphic analysis in illustration, and section five presents the empirical estimation strategy. Section six shows our empirical results and the final section concludes.

II. Rice Porduction in Taiwan

Like many of its neighboring countries in Asia, rice production in Taiwan is largely based on small family holdings with less than one hectare per farm for more than five decades. Most rice farmers are independent producers who sell their products individually and have little bargaining power with buyers and input suppliers. However, farmers learn to gain production and scale efficiencies by organizing custom farming teams to work for those who do not own machineries (Fujiki, 1999).

Over the years, Taiwanese government’s guaranteed procurement at a support price 20 percent above the average production costs has increased rice production and created imbalances in the supply and demand in the rice market. The government procurement scheme has also served as a major vehicle to stabilize rice prices which are two to three times the world level. Importation of rice is banned to provide extra protection for the domestic high-cost producers. However, after formally joining the WTO in January 2002, Taiwan began to open up its market to imports of rice. A total of 144,000 metric tons of rice are imported annually under the quota system, which is equivalent to about 8 percent of annual consumption. The steady increase in imported rice has brought downward pressures on both the price and income levels for the rice farmers. Moreover, the present rice marketing system has failed to provide a conducive environment to assist their transformation from subsidized farming to market-driven production due to the insufficient forward and backward linkages after a long history of government protections.

On the other side of the market, trade liberalization and globalization has also modernized the food retail sector in Taiwan, affecting consumers, producers and trade patterns. Consumers have been willing to pay for more varieties and better quality rice. Beginning in 2006, the Agricultural and Food Agency plans to open up four regional rice trading centers as a channel to promote the consumption growth of high-quality and safe domestic rice by enabling rice buyers, supermarkets, and food manufacturers to easily procure inspected rice which meet the national safety standards. These changes have placed additional pressures on farmers and processors to provide more stringent quality control and more varieties.

To overcome such bottleneck, the government has launched a rice marketing contract program in 2005 to assist rice farmers and the agri-business chain to work together as partners. The minimum scale for each contract is 50 hectares of adjacent rice paddies with 50 participants including rice farmers, seedling providers, millers and marketing agents. Locally-adapted improved seedling and low-input technologies are provided to the rice farmers and millers under the contract program supervised by the experts from local extension services and experiment stations. The participating farmers have to adopt the production traceability and book-keeping system and agree not to sell their products to other buyers including the government. Basically, the institutional design is beneficial for the participating rice farmers to acquire new technologies and managerial know-how and for rice millers to meet consumers´ demand for quality and safe products. Eventually, a partnership between rice growers and rice millers can be established without government involvement.

III. Survey Design and Sample Characteristics

In order to evaluate the outcome of the 2005 rice production-marketing contract program, a survey is conducted in the summer of 2005 after the first (spring) crop is harvested. Information of prices, value of outputs, major variables and fixed inputs are collected along with characteristics of the farms and farmers. The survey covers 80 contract farmers in 7 provinces producing different varieties of rice throughout the major production districts. For comparison purposes, 246 non-contract farmers are also interviewed in the same or nearby villages within the same province or in adjacent provinces. The distribution of farm size is quite similar with an average of 2.09 and 2.00 hectares for the contact and non-contract farms respectively. The survey results show that for a contract farm the average revenue is NT$145,000 per hectare, which is about 11 percent higher than the average revenue of the non-contract farm. The per hectare cost of production in a contract farm is about 13 percent lower than that is in a non-contract farm. As a result, the average profit margin under contract is 50 percent higher than without contract.

. In the survey, both contract and non-contract farms are interviewed. The choice of survey sites was based on the official record of the contract. Geographical dispersions are also taken into consideration because the rice variety is affected by the climate and local production environment. For example, Taigon No. 9 and Tainon No. 71 are widely adopted varieties in the northern and central regions, while Taigon No. 2 and Kaoshung No. 139 are more popular in the southern and eastern regions.

To enhance the sample's geographic variations, a stratified sampling procedure is adopted. First, the sample size in each township is determined in proportion to the hectares under contract. Then, the sample farms are randomly drawn from the contract list provided by the rice millers who offer these contracts. The non-contract farms from the sample province or nearby provinces are selected in proportion to the planting hectares provided by the extension specialists of the local Farmer Associations. Ten farms were interviewed for the questionnaire pretest purposes followed by a formal on-site survey conducted in July 2005. Table 1 lists the sample distributions by province and township. The numbers of contract and non-contract farms interviewed are 80 and 246, respectively.

Questions regarding previous planting experiences, rice varieties, contract prices, production costs, and demographic factors are addressed in the questionnaire. Demographic factors included socio-economic data, household size and off-farm income. Table 2 illustrates the socio-economic characteristics of the household heads of the sample farms. For the contract farms, most of the household heads are 50 years old, males, with elementary-level educations but no off-farm jobs. The non-contract farm household heads have similar characteristics except a much higher off-farm job participation rate. Overall speaking, the household heads of contract farms are younger and more specialized in rice farming than non-contract farms. Therefore, sample selection bias may exist and should be dealt with in our follow-up efficiency comparisons.

Table 3 compares the average revenues and production costs of contract and non-contract farms in each region on per hectare basis. First, the average revenues of contract farms are higher than those of non-contract farms in most regions. The rice yields per hectare, however, are about the same. Therefore, the major reason of higher revenues is due to higher rice quality. A flooding event in 2005 damaged the first crops in many agricultural provinces in the southern region. So, most of the contract farms receive higher prices except those in the southern region. However, the contract farms still outperform the non-contract farms by higher yields with higher revenues.

Next, the contract farms spend more on their seeds due to variety differences. However, due to strict restriction on fertilizer and chemical usages, these contract farms spend much less on the chemical expenditures. Therefore, on average the total expenditure of contract farms is 20 percent lower than that of non-contract farms.

Third, both the gross and net revenues of contract farms are higher than those of the non-contract farms for all regions. The profit margins on the gross basis range widely from NT$6,000 in the northern region up to NT$60,000 in the east. On the net basis, the profit margin of entering the contract arrangement is about NT$40,000 in the central region and NT$60,000 for those located the southern and eastern regions. However, farms in the northern region have the smallest profit margin or no benefit at all from participating contract farming.

IV. Meta-Frontier Efficiency and Cross-Frontier Efficiency

Suppose the input-output bundle for contract and non-contract rice farmers are denoted as (y_C, x_C) and (y_{NC}, x_{NC}). The isoquant curves for contract and non-contract farmers will be $C(y)$ and $NC(y)$ as shown in Figure 1. Therefore, the efficiency measurement through the distance function value for non-contract and contract rice farmers are defined as follows $D_{NC}(Y_{NC}, X_{NC}) = \frac{ob}{oa} > 1$, $D_C(Y_C, X_C) = \frac{oh}{og} > 1$.

Suppose there exists a meta-frontier for these two groups and the meta-isoquant will be the enveloped curve from the isoquant by contract and non-contract rice farmers. The technology gap ratio for a non-contract rice farmers when the input-output bundle is at *b* will be $\frac{ad}{bd}$. Similarly, the technology gap ratio for a contract rice farmers when the input-output bundle is at *h* will be $\frac{gf}{hf}$. This technology gap ratio represents that the percentage of rice farmers on the potential output given the technology available to the industry as a whole. In other words, it represents the average gap between the groups with respect to the meta-frontier. So the meta-frontier efficiency will be one minus the value of the distance, then times the technology gap ratio.

If the non-contract isoquant is on the left-hand side of contract rice farmers' isoquant for all input combinations, the distance of the non-contract rice farmer from the contract frontier is defined as $D_C(y_{NC}, x_{NC}) = \frac{ob}{oc} < 1$, and the distance of the contract rice farmer from the non-contract frontier is $D_{NC}(y_C, x_C) = \frac{oh}{oe} < 1$, i.e., each rice farmer is using an input vector that dominates the other group's technology. .

If the cross-frontier efficiency is greater than 1, it means that a firm's input-output bundle is infeasible using the other group's technology. In here, the cross-frontier efficiency for contract and non-contract rice farmer are defined as the following.

$$CF_C(y_C, x_C) = 1 - \frac{D_{NC}(y_C, x_C)}{D_C(y_C, x_C)} = 1 - \frac{TE_C(y_C, x_C)}{TE_{NC}(y_C, x_C)},$$

$$CF_{NC}(y_{NC}, x_{NC}) = 1 - \frac{D_C(y_{NC}, x_{NC})}{D_{NC}(y_{NC}, x_{NC})} = 1 - \frac{TE_{NC}(y_{NC}, x_{NC})}{TE_C(y_{NC}, x_{NC})}.$$

If $CF_C(y_C, x_C)$>0, it means contract technology dominates non-contract technology. The comparison of profit efficiency is defined similarly.

V. Empirical Model

This section describes the empirical procedure we use to compare the profit efficiency between the contract farmers and non-contract farmers. The profit inefficiency is defined as loss of profit from not operating on the profit frontier (Ali and Flinn, 1989). It can be measured by the following Rahman (2003)'s approach in which both technical and allocative inefficiency are simultaneously taken into account. Technical inefficiency is defined as the loss of profits from failing to meet the production efficient frontier. Allocative inefficiency is the loss of profits from failing to observe or respond to the relative prices of inputs and outputs.

The stochastic profit frontier is defined as

$$\pi = f(p, w, Z)e^{\varepsilon}, \tag{1}$$

where π is the vector of profit defined as gross revenue minus variable cost; p and w are the vectors of output and input prices, respectively; and Z is the vector of fixed inputs. The error term (ε) is assumed to be consisted of a two-sided random error (v) and a non-negative profit inefficiency variable (*u*), and can be expressed as follows:

$$e = v - u \,, \tag{2}$$

where *v* is assumed to be independent of *u*, and identically distributed, i.e., $v \sim N(0, \sigma_v^2)$; *u* is the non-negative random variable of inefficiency which is assumed to be independently distributed at a truncated normal distribution with a positive mean and variance σ_u^2. Under this specification, profit inefficiency represents the inability of a farmer to achieve the highest possible profit under the given output and input prices along with the levels of fixed inputs. This is a better measurement since it combines information of the cost inefficiency and the income inefficiency.

A rice farmer's decision on whether to sign up a production-marketing contract is a self-selection problem and such a problem can be described by a switching regression model and a criterion function (Lee, 1978; Huang et al., 2002). Suppose the i^{th} rice farmer has two choices, joining or not joining a contract, and this decision is determined by the following profit functions, π_C and π_N, for contract and non-contract farmers respectively:

$$\pi_{Ci} = f_C(p, w, Z) e^{\varepsilon_{Ci}} \,, \tag{3a}$$

$$\pi_{Ni} = f_N(p, w, Z) e^{\varepsilon_{Ni}} \,, \tag{3b}$$

where subscript *C* and *N* denotes the contract farm and non-contract farm, respectively. The farmers' decision on joining the contract depends on the profit differential among contract, non-contract using and other non-profit considerations, and can be described by a criterion function as follows:

$$I_i^* = X_i\alpha + \gamma(\pi_{Ci} - \pi_{Ni}) + \eta_i \tag{4}$$

where X_i is a vector of non-profit variables while the random variable η_i represents the unobservable factors that affect the selection of signing a contract; α and γ are parameters needed to be estimated. The criterion function in equation (4) assumes that a rice farmer may join the contract if the profit from joining the contract is higher than the profit without the contract. Since the farmer can only choose either to sign a contract or to stay independent, only one of the two profits (π_{Ci} or π_{Ni}) can be observed. Therefore, the dependent variable $I_i^* > 0$ if the profit of joining contract is observed, or $I_i^* \le 0$ when the profit of non-joining contract is found.

註解 [WH1]: Not sure about this. Not only the difference of the profits will affect the decision but also the non-profit variables X, right?

Equations (3) to (4) cannot be estimated directly because the decision to sign contract may be determined by unobserved variables (e.g., farmers' characteristics, management ability) that may also affect performance. Therefore, the error terms in (3)~(4) will be correlated. A standard two-stage procedure of Lee (1978) and Willis and Rosen (1979) is adopted to allow unbiased estimation. First, two inverse Mills ratios M_{Ci} and M_{Ni} are derived from equation (4) using the probit model. Then, the estimated inverse Mill's ratios, $\hat{M}_{Ci}$ and $\hat{M}_{Ni}$, are incorporated into equations (3a) and (3b) to correct the sample selection bias as follows:

$$\pi_{Ci} = f_C(p, w, Z, \hat{M}_{Ci})e^{\varepsilon_{Ci}} \quad \text{for} \quad I_i = 1, \tag{5a}$$

$$\pi_{Ni} = f_N(p, w, Z, \hat{M}_{Ni})e^{\varepsilon_{Ni}} \quad \text{for} \quad I_i = 0, \tag{5b}$$

The idea of this procedure is to find the expression for the means of $E(e^{\varepsilon_{Ci}} \mid I_i = 1)$ and

$E(e^{\varepsilon_{Ni}} \mid I_i = 0)$, and to adjust the error terms such that they will have zero means. In the second stage, the coefficients in equations (5a) and (5b) can be estimated by a meta-frontier method based on Battese et al.(2004) to obtain profit efficiency for contract and non-contract farmers under alternative technologies as well as their technology gap.

Suppose a meta-profit-frontier function for the i^{th} rice farmer is expressed by

$$\pi_i^* = f(p, w, Z, \hat{M}; \beta^*) = f(X_i, \beta^*) = e^{X_i \beta^*}, \tag{6}$$

where X is the vector of explanatory variables including *p*, *w*, *Z*, and $\hat{M}$, and β^* denotes the vector of parameters. Since there are two groups of farmers (i.e. contract and non-contract), the profit frontier for each group is defined by

$$\pi_i = f(X_i, \beta_{(j)}) e^{v_{i(j)} - u_{i(j)}} = e^{X_i \beta_{(j)} + v_{i(j)} - u_{i(j)}}, \quad i = 1, 2, ..., N_j, \; j = 1, 2 \tag{7}$$

where N_j is the number of samples and subscript *j* denotes the group.

The alternative stochastic profit function in equation (7) can be expressed in terms of the meta-frontier function of equation (6) by

$$\pi_i = e^{-U_{i(j)}} * \frac{e^{X_i \beta_{(j)}}}{e^{X_i \beta^*}} * e^{X_i \beta^* + V_{i(j)}}. \tag{8}$$

The first term on the right-hand side of equation (8) is the profit efficiency relative to the stochastic profit frontier for the j^{th} group and can be expressed as

$$PE_i = \frac{\pi_i}{e^{X_i \beta_{(j)} + V_{i(j)}}} = e^{-U_{i(j)}} \tag{9}$$

The technology gap ratio (*TGR*) can be found in the second term on the right-hand side of equation (8) which is written as

$$TGR_i = \frac{e^{X_i \beta_{(j)}}}{e^{X_i \beta^*}} \tag{10}$$

Finally, the profit efficiency (PE) relative to the meta-frontier for the ith firm is defined as follows:

$$PE_i^* = \frac{\pi_i}{e^{X_i \beta^* + V_{i(j)}}} = PE_i * TGR_i \tag{11}$$

The estimation procedure for (9)~(11) is illustrated below:

Step 1. A stochastic profit frontier model of equation (1) is estimated assuming a truncated normal distribution in which the non-negative random terms represent the profit inefficiency as follows:

$$E(\exp(-u_i) \mid e_i) = \frac{1 - \Phi(\sigma_A + \gamma e_i / \sigma_A)}{1 - \Phi(\gamma e_i / \sigma_A)} \exp(\gamma e_i + \sigma_A^2 / 2), \tag{12}$$

where $\sigma_s^2 = \sigma^2 + \sigma_v^2$, $\gamma = \sigma^2 / \sigma_s^2$, $\sigma_A = \sqrt{\gamma(1-\gamma)\sigma_s^2}$, $e_i = \ln(\pi_i) - x_i \beta$, and Φ is a distribution function of a standard normal random variable. The variances σ^2 and σ_v^2 can be estimated, respectively, by the method of moments (Olson et al., 1980) as follows:

$$\hat{\sigma}^2 = [\frac{m_3}{\sqrt{2/\pi}(4/\pi - 1)}]^{2/3}, \text{ and}$$

$$\hat{\sigma}_v^2 = m_2 - [1 - \frac{2}{\pi}]\hat{\sigma}_u^2 \quad ,$$

where m_2 and m_3 are the second and third moments of the residuals.

Step 2. The meta-frontier function is a frontier that envelops all frontiers of individual groups such that $x_i \beta^* \geq x_i \beta_{(j)}, \forall j$. The optimal β^* can be obtained by minimizing the sum of absolute deviation (MSAD)[1] of the values on the meta-frontier from the group-specific frontiers at the observed input levels. Battese et al. (2004) point out that the following linear programming formulation is equivalent to the MSAD.

$$\begin{aligned} &\min \quad \bar{x}\beta^* \\ &s.t. \quad \ln(\pi_i(x_i,\beta^*)) \geq \ln(\pi_i(x_i,\hat{\beta}_{(j)})) \qquad \forall \quad i \end{aligned} \tag{13}$$

where $\bar{x}$ is the vector of the means of the all observations in x_i. The PE^* and TGR can be calculated based on the estimates of β^* and the group-specific frontier estimates $\beta_{(j)}$.

VI. Estimation Results

The data in this study were taken from the survey described in Section 2. After deleting the samples with missing observations, the empirical estimation is based on 201 non-contract farms and 80 contract farms. Table 4 summarizes the sample statistics for both contract and non-contract farms. The average planting acreage of the contract farm is 2.21 hectare, which is slightly higher than the average of non-contract farms 1.73 hectare.

The average age of contract farms' household heads is only 43 years old. This is much younger than the 60 years old of the non-contract household heads. 70% of the main contract farm operators are full time farmers, which is higher than the 52 % of the non-contract farms. The percentage of farmers receiving high school or above education for the contract farms is also higher than it is for the non-contract farmers. This suggests that contact farmers tend to have more years of education than the non-contract farmers.

As for production costs, Table 4 shows that chemical and machinery costs for the

[1] The optimal β^* can also be derived from minimizing the sum of the squared deviation of the values on the meta-frontier from the group-specific frontiers. This approach will lead to a quadratic programming problem.

rice contract farmers are less than those for the non-contract farmers, while there is no significant difference in seed cost. The average profit of contract farms is 27 percent higher than the non-contract average.

The empirical model for estimating the decision to join the contract versus to product independently is specified as follows:

$$I_i = \gamma_0 + \gamma_1 (AGE)_i + \gamma_2 (EDU)_i + \gamma_3 (FULL)_i + \gamma_4 (REVENUE)_i + \gamma_5 (REG)_i + \varepsilon_i , \qquad (14)$$

where $I_i = 1$ if a latent profit margin from joining the contract is positive, while it is 0 otherwise. *AGE* is the main operator's age. *EDU* is the main operator's education level. *FULL* is a dummy variable indicating whether the main operator is a full-time or part-time farmer. *REVENUE* is the farm's revenue. *REG* is a regional dummy variable indicating whether the farm is located in the east or not.

The estimation results for equation (14) are shown in Table 5. Table 5 shows that having a primary occupation on-farm raises the likelihood of contracting. This is consistent with our expectations. Increases in years of age and schooling lower the probability that the farmer will join the contract. Older rice farm owners would less likely to join the contract probably because of the habit formation effect. They are reluctant to change unless necessary. More educated farmers may also have a higher income and thus a higher reservation wage to be induced into contract production. Table 5 also suggests that farmers in the eastern region are more likely to accept a contract because they could earn more than farmers in other regions.

The empirical model for estimating the impact of contract production on farm's profit performance taking into account the self-selection processes are denoted as follows:

$$
\begin{aligned}
\ln(\pi)_i = {} & \beta_0 + \beta_1 \ln(SEED)_i + \beta_2 \ln(CHEM)_i + \beta_3 \ln(LABOR)_i + \beta_4 \ln(ACRE)_i \\
& + \beta_5 \ln(SEED * CHEM)_i + \beta_6 \ln(SEED * LABOR)_i \\
& + \beta_7 \ln(CHEM * LABOR)_i + \beta_8 \ln(CHEM * ACRE)_i \\
& + \beta_9 \ln(LABOR * ACRE)_i + \beta_{10} \ln(AGE)_i \quad + \beta_{11} \ln(EDU)_i \\
& + \beta_{12} \ln(FULL)_i + \beta_{13} \ln(REG)_i + \delta_{1i} W_i + \delta_{2i} W_i * \ln(ACRE) + \varepsilon_i ,
\end{aligned} \tag{15}
$$

where subscript $i= c$ for contract farms and $i=n$ for con-contract farms.

The estimation results for equations (15) are shown in Table 6 with the selectivity bias adjusted. First, the farm size (*ACRE*) has a positive and significant impact on the profit of contract farms, but all other inputs like seed (*SEED*), chemical (*CHEM*) and labor (*LABOR*)have no significant impact, except when they are interacted with the farm size. This result suggests that the profit of contract farming is highly correlated with the acreage devoted to the contract. This is expected because the contract usually requires farmers to comply with certain input allocation restrictions. Thus, farmers lose control over their managerial decisions, and the linkage between profit and input usage no longer exists. The other implication is that larger farms benefit more than the smaller ones once they join the contract. The results for non-contract farms are somewhat different in that inputs other than acreage are also among the major determinants of the profit. Thus, the autonomy of input allocations is preserved by the non-contract farmers.

As for the non-input determinants, both the geographic location and employment status play a significant role in the profit. Farms located in the eastern region tend to have higher profits than those located in other regions. However, it is only statistically significant for those under the contract arrangement. Part-time contract farmers earn more profits than their full-time peers. Thus, although full-time farmers have larger probability to participate contract farming, they may not be better off than those part-time contract farmers. This result reflects an interesting trade-off between profit gains and loss of autonomy by the contractual arrangement. In comparison, the case for non-contract farms is opposite. Full-time non-contract farmers enjoy higher profits than their part-time peers because there is no loss of managerial control when farmers produce independently.

Because the scale of production has a strong positive correlation with the likelihood of contracting, we also add an interaction term of sample selection and scale (i.e., W_i*ACRE*) along with the two inverse Mill's ratios. The coefficients of the selectivity bias adjustment (W_i) are both significant but have the opposite signs with $\delta_{1c} = -0.84$ and $\delta_{1n} = 0.48$. This result implies that those who choose to join the contract are worse than the average contract farmers in terms of profit earnings. Those who choose to produce independently are better than the average independent farmers. The positive and significant $\delta_{2c} = 0.28$ for the interaction term (W_i*ACRE*) confirms that larger farm size is associated with an increasing profit for contract farms.

1. *Meta-Frontier Profit Efficiency Estimation*

The basic summary statistics estimates of profit efficiency, technology gap ratio, and profit efficiency relative to the meta-frontier using equations (12) and (13) are presented in Table 7. The mean value of technology gap ratios for non-contract and contract rice farmers are 0.985 and 0.976 respectively, which indicates that there is an average of 98% of the potential profit given the technology available to this rice industry as a whole. Please also note that all contact and non-contract rice farmers' frontier are tangent to the metafrontier since the maximum value for the technology gap ratio are one.

The profit efficiency by mean for non-contract rice farmers is 0.885 which is smaller than the contract rice farmers' 0.971. However, contact rice farmers tended to be further from potential profit defined by the metafrontier function since the technology gap ration for contact rice farmers is smaller than that for non-contact rice farmers. After calculating the TGR as shown in the middle row of Table 7, the profit efficiency for each group relative to this meta-frontier could be estimated and are shown in Table 7. The profit efficiency relative to the meta-frontier of non-contract rice farmers is 0.872 while it is 0.947 for the contract rice farmers. We could not determine which group's technology dominates through the meta-frontier estimation. The cross-frontier efficiency will be applied to check it.

2. *Cross Profit Frontier Efficiency Estimation*

To estimate the cross profit frontier efficiency, whether the profit frontier is identical for rice contract and non-contract farmers needs to be tested. The ANOVA statistic is applied here and the test result shows that the null hypothesis of identical profit frontier is rejected. Later, the estimation approach for cross profit efficiency is based on Cummins et al(1999) and the estimation results are shown in Table 8. .

Both the profit efficiencies of the non-contract farmers relative to the contract frontier and the profit efficiencies of contract farmers relative to the non-contract frontier, i.e. the cross-frontier efficiencies are all calculated and shown in Table 8. The non-contract profit efficiency with respect to contract frontier (i.e. $PE_C(Y_{nc}, X_{nc})$) are all smaller than one (i.e. the values of minimum and maximum are smaller than one) which indicates that the non-contract technology does not dominate the contract rice farmers technology. Similarly, the contract profit efficiency with respect to non-contract frontier (i.e. $PE_{NC}(Y_c, X_c)$)

are all smaller than one which indicates that the contract technology does not dominate the non-contract rice farmers technology. However, as we computed the cross-profit-frontier efficiency for contract rice farmers (i.e., $CF_C(y_C, x_C) = 1 - \frac{PE_C(y_C, x_C)}{PE_{NC}(y_C, x_C)} = 1 - \frac{0.971}{0.625} =$ -0.553) and it shows a negative sign which means contract frontier dominates the non-contract frontier. Similarly, the cross-profit-frontier efficiency for non-contract rice farmers is positive which means it is dominated by contract frontier. Such estimation results imply that Taiwan government may promote rice contract to farmers in order to increase their profitability when facing foreign product competition.

VII. Concluding Remark

Contract farming has become an attractive policy instrument for many developing countries to assist small family farms to gain access to markets, information, credits, and necessary services to manage their risk. On the other hand, contract farming may have subtle impacts on both farmers' income and managerial control. Therefore, the success or effectiveness of this policy instrument depends on whether these contracts are attractive enough for the farmers by increase their profits while loss of autonomy can be minimized. In this paper, we conduct an on-farm survey on more than 300 rice farmers in Taiwan. The per hectare cost of production for a contract farm is about 13 percent lower than a non-contract farm. As a result, the average profit margin under contract is more than 50 percent above those without contract.

A switching regression model is adopted to analyze farmers' decision on contract participation and to compare their profit performance. The estimation result indicates that an average contract farms is 20 percent more efficient than an average non-contract farm under a comparable operating environment. These results imply that the contract arrangement can indeed be an effective institutional mechanism to increase profitability and competitiveness for small family farms. We also find that the contract decision is determined not only by a profit comparison between contract and independent producers but also by other demographic determinants like age, education level, employment status and geographical locations. Finally, we find that contract rice farmers have more profit efficiency than non-contract rice farmers given a profit meta-frontier function. The estimation results imply that Taiwan government may promote contracts to farmers, maybe not only in the rice industry but also all agricultural products, in order to increase farmers' profitability when facing foreign product competition.

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Figure 1. Meta-Frontier Efficiency and Cross-Frontier Efficiency for Contract and Non-contract Rice Farmers

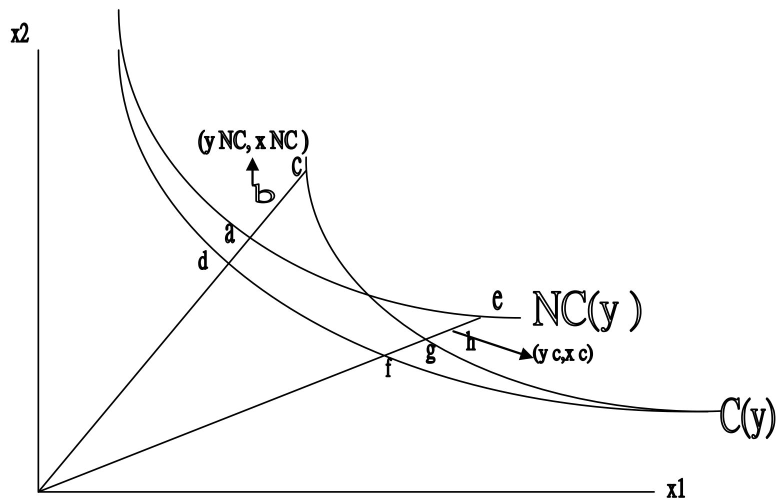

Table 1. Sample Size and Geographical Distribution

Region	Province	Township	Contract farm	Non-contract farms
North	Taoyuan	Shinwu		13(5.3%)
	Miaoli	Yuanli	6(7.5%)	9(3.7%)
		Sub-total	6(7.5%)	22(8.9%)
Central	Taichung	Taichia		19(7.7%)
		Wufeng	5(6.3%)	12(4.9%)
	Chunghwa	Fushing		16(6.5%)
		Pitou	12(15%)	15(6.1%)
		Erlin	9(11.3%)	
		Hermei		15(6.1%)
		Sub-total	26(32.5%)	77(31.3%)
South	Yunlin	Tsutung	3((3.8%)	14(5.7%)
	Chiayi	Taibao		13(5.3%)
		Shinkung		13(5.3%)
		Minshung		12(4.9%)
	Tainan	Hobin		15(6.1%)
		Shenghua		16(6.5%)
		Shiayin	6(7.5%)	
		Baihe	5(6.3%)	
	Kaoshung	Daliao		12(4.9%)
	Pintung	Wondan		13(5.3%)
		Sub-total	14(17.5%)	108(43.9%)
East	Yilang	Jiaoshi		13(5.3%)
	Hualian	Fuli	6(7.5%)	16(6.5%)
	Taitung	Kuanshan	11(13.8%)	7(2.8%)
		Tsushung	17(21.3%)	3(1.2%)
		Sub-total	34(42.5%)	39(15.9%)
TOTAL			**80(100%)**	**246(100%)**

Table 2. Socio-Economic Characteristics of the Sample

	Number of Sample		Percentage in Total (%)	
	Contract	Non-contract	Contract	Non-contract
Gender				
Male	76	236	95.00	98.74
Female	4	3	5.00	1.26
Age				
Below 30	1	0	1.25	0.00
31~40	5	10	6.25	4.25
41~50	11	37	13.75	15.75
51~64	34	106	42.5	45.11
65 and above	29	82	36.25	34.89
Education				
None	9	8	11.25	4.19
Elementary	39	87	48.75	45.55
Middle school	13	46	16.25	24.08
High school	15	41	18.75	17.15
Vocational college	3	8	3.75	3.34
College and above	1	1	1.25	0.41
No. in farming				
1	31	69	38.75	28.87
2	37	131	46.25	54.81
3	8	28	10.00	11.72
4 and more	4	11	5.00	4.60
Type				
Full-time	56	136	70.00	55.28
Part-time	24	110	30.00	44.72

Table 3. Revenues and Production Costs of Sample Farms by Region

	North		Central		South		East		Total	
	Con-tract	Non-contract	Con-tract	Non-contract	Con-tract	Non-contract	Con-tract	Non-contract	Con-tract	Non-contract
Revenue	116,492	109,732	141,697	114,648	121,996	115,646	148,153	85,735	145,289	105,183
Production	7,789	7,625	7,393	7,729	9,550	7,706	6,379	5,887	7,074	7,143
Price	15.0	14.4	19.2	14.8	12.8	15.0	23.2	14.6	20.5	14.7
Total Cost	97,791	91,152	107,337	109,452	84,520	142,934	90,089	96,077	94,062	112,460
Direct	59,608	59,006	66,884	71,864	62,960	107,599	54,598	50,288	60,692	72,909
Seed	8,516	7,909	8,364	7,941	8,652	8,213	7,224	5,578	7,932	7,192
Pesticide	871	6,010	6,787	9,796	9,413	12,220	6,247	4,666	6,794	8,505
Fertilizer	12,514	13,902	11,971	9,683	9,627	11,678	9,287	8,281	10,347	9,863
Material	0	0	2,060	3,459	0	12,419	0	3,451	1,539	6,372
Custom	31,343	29,483	29,777	29,443	25,634	37,539	25,805	16,833	27,323	26,325
Hire labor	3,966	0	5,286	8,446	3,727	14,943	3,385	11,479	3,562	10,340
Energy	2,398	1,701	2,639	3,095	5,907	10,587	2,651	2,812	3,196	4,312
Indirect	38,183	32,146	40,453	37,588	21,560	35,334	35,491	45,789	33,370	39,551
Self-wage	16,696	16,696	21,376	20,987	11,800	14,734	21,484	18,848	18,892	19,298
Land rent	21,487	15,450	19,077	16,601	9,760	20,600	14,007	26,941	14,478	20,253
Gross Profit	56,884	50,726	74,813	42,785	59,036	8,047	93,556	35,447	84,596	32,274
Net Profit	18,701	18,580	34,360	5,196	37,476	-27,287	58,065	-10,342	51,227	-7,277

Unit: Kg/Hectare; NT$/Hectare

Table 4. Sample Statistics: Means and Standard Deviations

Variables	Non-Contract Farms	Contract Farms
Acreage (hectare)	1.73	2.21
	(1.51)	(1.82)
Age	60.27	43.31
	(9.95)	(4.66)
Education (%)	19.90%	23.75%
Full Time (%)	52.06%	70.00%
Seed Cost ($NT)	779.05	777.08
	(1290.4)	(96.69)
Chemical Cost ($NT)	995.96	626.05
	(1802.0)	(386.50)
Fertilizer Cost ($NT)	605.92	922.19
	(1068.8)	(473.87)
Labor Cost ($NT)	3110.5	1812.5
	(3006.5)	(1208.9)
Profit ($NT 1000)	221.35	280.94
	(209.33)	(248.01)

Note: The numbers in the parenthesis represent the standard deviations.
Education is the percentage of sample with education higher than high school level.
Full time is the percentage of full-time farmers in the sample.

Table 5. Probit Estimation of the Sample Selection Model

Variables	Coefficients and Standard Errors
Constant	10.526**
	(2.106)
Age	-0.192**
	(0.039)
Education	-0.695**
	(0.218)
Full Time	0.696*
	(0.440)
Revenue	0.000027*
	(0.11E-05)
Region Dummy	1.586**
	(0.686)
McFadden R-Square	0.7313
LR Statistic	120.48

Note: The region dummy is defined as 1 if the farm is located in the east while it is zero otherwise.

The numbers in the parenthesis are standard errors.

** significant at 5% significance level.

* significant at 10% significance level.

Table 6. Estimation Profit Functions for Contract and Non-Contract Rice Farmers

Variables	Contract	Non-Contract
Constant	24.18	-101.39*
	(40.07)	(61.14)
SEED	-3.13	4.95
	(5.44)	(7.51)
CHEM	-0.46	12.68**
	(3.19)	(4.53)
LABOR	-2.35	14.34**
	(3.74)	(7.30)
ACRE	4.57**	-0.74
	(1.82)	(2.56)
SEED*CHEM	0.19	-0.15
	(0.39)	(0.51)
SEED*LABOR	0.56	-0.71
	(0.52)	(0.89)
CHEM*LABOR	-0.19	-1.43**
	(0.12)	(0.35)
SEED*ACRE	-0.67**	0.84**
	(0.28)	(0.33)
CHEM*ACRE	0.17**	-0.20*
	(0.08)	(0.12)
LABOR*ACRE	-0.04	-0.31
	(0.05)	(0.13)
AGE	-0.01	-0.01
	(0.07)	(0.08)
EDUCATION	0.002	-0.03
	(0.02)	(0.04)
FULL	-0.11*	0.19**
	(0.058)	(0.08)
REGION	0.16**	0.18
	(0.08)	(0.19)
W (Inverse Mills ratio)	-0.84**	0.48*
	(0.40)	(0.26)
*W**ACRE	0.28**	-0.06
	(0.12)	(0.07)
Adjusted R-Square	0.974	0.942

Note: The profit function is a Translog function which means we take logarithm on both the dependent and independent variables except for AGE, EDUCATION, FULL, and REGION variables.

Table 7. Profit Efficiency for Contract and Non-contract Farms

		Mean	Minimum	Maximum	St.Dev
Non-Contract Rice Farmers	Profit Efficiency	0.885	0.588	0.974	0.062
	Technology Gap Ratio	0.985	0.938	1.000	0.012
	Metafrontier Profit Efficiency	0.8722	0.552	0.959	0.062
Contract Rice Farmers	Profit Efficiency	0.971	0.959	0.979	0.004
	Technology Gap Ratio	0.976	0.895	1.000	0.020
	Metafrontier Profit Efficiency	0.947	0.868	0.975	0.020

Table 8. Cross Profit Efficiency for Contract and Non-contract Farms

		Mean	Minimum	Maximum	St.Dev
Non-Contract Rice Farmers	Profit Efficiency $PE_{NC}(Y_{nc}, X_{nc})$	0.885	0.588	0.974	0.062
Contract Rice Farmers	Profit Efficiency $PE_{C}(Y_{c}, X_{c})$	0.971	0.959	0.979	0.004
Non-Contract Rice Farmers	Cross Profit Efficiency $PE_{C}(Y_{nc}, X_{nc})$	0.8903	0.2573	0.9757	0.1180
Contract Rice Farmers	Cross Profit Efficiency $PE_{NC}(Y_{c}, X_{c})$	0.6252	0.2666	0.9429	0.1538