Contract farming effects on technical efficiency of the export-oriented rice production sector in Vietnam

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Abstract:

Improving farming technical efficiency for smallholders by applying contract farming is an interesting topic nowadays. A cross sectional sample of 250 Vietnamese export-oriented rice households was employed to investigate how contract farming improves farming technical efficiency in the country. The Stochastic Frontier Analysis is applied to estimate the production frontier, the technical inefficiency determinants and Propensity Score Matching is used to control self-selection bias. The results show an average technical efficiency score is of 87.33 percent and suggests convincible opportunities for farmers to increase productivity of export-oriented rice in the country by nearly 13 percent. The expenditures on seed, land, and fertilizer are the key determinants of the technical efficiency level in this region. The results reveal the positive relationship of contract farming participation on technical efficiency improvement.

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CONTRACT FARMING EFFECTS ON TECHNICAL EFFICIENCY OF THE EXPORT-ORIENTED RICE PRODUCTION SECTOR IN VIETNAM

Abstract

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JEL Classification: D24, Q2, Q12, Q16.

Keyword: export-oriented rice sector, contract farming, stochastic frontier analysis, technical efficiency, Vietnam.

1. Introduction

Under the pressure of globally increasing demand for food and poverty reduction, the expansion of higher agricultural productivity, gains in efficiency, and sustainability in smallholder agricultural are considered to be very important (GIZ, 2013). Therefore, increasing technical efficiency (TE) in emerging and developing economies' agricultural production and upgrading smallholders' position in modern value chains nowadays receives great attention. Generally, contract farming (CF) is in the existing academic literature considered to be an institutional arrangement that bears the potential for farmers to access markets but also to ensure raw material supplies by contractors subjecting production uncertainty and to support increasing TE (Rawlins, 1985; Eaton and Shepherd, 2001; Da Silva, 2005; Ramaswami et al., 2005; Swain, 2008; Saigenji and Zeller, 2009; Sartorius, 2013; Wang et al., 2014). Moreover, participating in a CF scheme also supports farmers to increase the production frontier (Rawlins, 1985) and to shift risk from the grower to processor through their supply of most of the inputs such as seed, fertilizer, and pesticides (Ramaswami et al., 2005). Thus, CF could offer a solution for dealing with a number of productivity and TE constraints arising from small-scale production including risk coverage and accessibility of inputs, capital resources, and information (Miyata et al., 2009).

Rice, which is a commercialized commodity worldwide and vital food for about a half of the world population, mostly comes from emerging and developing countries (Chen et al., 2006). However, only few studies about rice farming TE under CF scheme in developing countries exist (Binam et al., 2004, Sriboonchitta, 2008, and Cai et al., 2008) finding that CF participation has significant influence on TE among rice producers in different countries (Cai et al., 2008). Among the major rice farming countries in Southeast Asia - Cambodia, Indonesia, Laos, Malaysia, Philippines, Thailand and Vietnam - especially Vietnam is characterized by very favorable natural and social conditions for irrigated rice production in bulk such as high soil quality, tropical monsoon weather, numerous water-flows and a large share of the population (more than 70 percent) working in the agricultural sector (Ya'kub et al., 2012). Due to the lack of information, the shortage of technical assistants and low input qualities, it is assumed that there is still potential to increase rice yields in this country e.g. by further promoting the contract farming scheme (CF) introduced by the Vietnamese government in 2002 (Kompas, 2002; Huynh and Yabe, 2011; Hoang and Yabe, 2012; Vu, 2012). Even though, existing empirical literature has investigated TE in the Vietnamese rice production sector from various perspectives such as by analyzing environmental effects on profit efficiency (Hoang and Yabe, 2012), vocational training effects on TE (Ulimwengu and Badiane, 2010), rice farmers' TE determinants (Khai and Yabe, 2011; Linh, 2012), and market reform effects on TE (Kompas, 2002), the effects of CF on the TE in this sector are still neglected. Our study contributes to the academic literature as the first one providing a better understanding of the effects of CF participation on rice farming TE, simultaneously, to other socio-economic characteristics by specifying a stochastic frontier analysis (SFA) combined with propensity score matching (PSM) for analyzing primary farm level data from Vietnam. Based on the results concrete implications for policy makers, agribusiness, farmers, and other entities to develop supporting programs will be derived.

This paper is structured as follows: after the introduction, section 2 introduces the study design and methodology And section 3 describes the results and discussion. Finally, the last section draws the major findings, conclusions, and policy recommendations of the paper.

2. Data and methodology

2.1 Study design and data collection

The data-set consists of farm level data collected in the 2015/2016 from smallholder rice farmers in the Mekong River Delta (MRD), the dominant export rice production region in Vietnam (Young et al., 2002). The target population of 250.000 households in the three main export rice production regions of the area, namely the Kien Giang, Can Tho, and An Giang provinces were selected (USDA, 2015, Duy, 2012). MRD has a tropical climate with dry and rainy season around the year, which is suitable for three harvests of rice with the main rice season from November to March. Together with rice farming, households in the area also produce different green vegetables, livestock, and aquaculture, but most of outputs are for self-consumption. Apart from farming, they also participate in small local trading and other off-farm activities. Using a structured questionnaire, 250 households from the aforementioned provinces were randomly chosen. Thereby to ensure the comparability of contract and non-contract farmers, 134 contract farmers from five different contractors' lists and 116 non-contract farmers from the village official lists of 12 villages (in the same area with contract farmers) were randomly selected based on two criteria: firstly, they had to be located in the same area of the contract participants and secondly, they also had to produce export rice. The type of CF under investigation in this study is production contract including agreements on specified producing practices, inputs (seed, fertilizer, pesticide) and extension service advisory. Most of the surveyed farmers in this study purchase their inputs from the contractors at the beginning of the cropping season and the cost is deducted from payments at harvesting time. Contracted farmers also receive technical advisory during their production and pay for the collection and transport of the final product at the harvesting period. Farmers can also store their product at the contractor's warehouse for up to one month if they want to wait for higher market selling prices (for negotiable-price term contracts). Other CF arrangements only supply the inputs without purchasing outputs. Some firms only purchase products without providing the inputs. For those cases, the contractors are willing to pay a premium price over the market price at harvest time to ensure their market supply.

2.2 Methods

2.2.1 Stochastic frontier analysis

In order to observe the influences of CF on farm TE, we follow the approach by Meeusenand (1977) and Lovell et al., (1977) on efficiency measurement of a firm with a given level of output at the lowest expenditure of inputs. Currently, especially SFA is commonly applied in research studies about agricultural production in emerging and developing economies (Ali and Flinn, 1989; Kolawole, 2006; Rao et al., 2012; Chiona et al; 2014). It is also applicable to employ a cross sectional frontier model to evaluate the effects of agricultural adoption on the level of TE (Rawlins, 1985). In this paper, SFA is applied to estimate the production function of export-oriented rice farming in Vietnam (Kumbhakar et al., 2000) since the SFA serves to correct for controlling errors and other noise measurement in the data set which easily occurs in primary farm level data in developing countries like Vietnam (Kolawole, 2006).

The conceptual framework of our empirical analysis is developed based on the study by Hoang (2013) which describes how the inputs and socio-economic characteristics influence the output-level in the export-oriented rice production sector. Thereby, we analyze the production frontier of contract and non-contract participants to compare the TE levels as well as to evaluate the effects of technical inefficiency determinants on rice production in particularly. Since we specifically pay attention to the hypothesis that contract participants have higher TE, CF participation status is treated as a dummy variable. Because this treatment variable could be endogenous due to self-selection bias, a frontier approach is necessary. Following Battese and Coelli (1993) and Coelli and Battese (1996), we use the method of maximum likelihood in order to estimate the production frontier with an assumption that all the farmers have the same farming practices in rice producing except for participation in CF scheme which could affect the TE levels. Variables representing household characteristics could influence the technical inefficiency (Wollni and Brümmer, 2009; Mayen,et al., 2010) In this regard, rice farming experience, educational level, contract participation status (yes or no), accessibility of credit and off-farm income are included to check as possible determinants of TE.

Therefore, TE is measured by $\mathrm{Y_a}$ divided by $\mathrm{Y^*}$ (TE= $\frac{\mathrm{Y_a}}{\mathrm{Y^*}}$) where Y is the observed current output and $\mathrm{Y^*}$ is the optimal output (maximum) level (Battese and Coelli, 1993; Kumbhakar and Lovell, 2000) . The stochastic frontier model is employed as follows:

$$\mathrm{y_i} = \mathrm{f}\left(\mathrm{x_{i;}}\,\alpha\right)\exp(\varepsilon_\mathrm{i})\ (1)$$

Where Yi is the scalar output quantity of export rice household i; Xi is representing the vector of input quantities; α is the vector of unknown parameters referring to production technology, and ε_i is the random error term including two independent components which can be described as $\varepsilon_\mathrm{i} = \mathrm{v_i} - \mathrm{u_i}$. The $\mathrm{v_i}$ values are a two-sided stochastic term that is expected to be independent and identically distributed as N $(0,\sigma_\mathrm{v}{}^2)$ and indicate the measurement error, missing variables, and statistical interference. The $\mathrm{u_i}$ values are the one-sided random variable half-normally distributed with zero modes ($\mathrm{u_i} \sim N^+\ (0, \sigma_\mathrm{u})$) with variance parameter σ_u. The $\mathrm{u_i}$ vector is a function of nonnegative unobservable variables related to the technical inefficiency of production (Battese and Broca, 1997). The stochastic terms v_i and u_i are assumed to be uncorrelated. The variation of u_i is specified by:

$$\mathrm{VAR}(u_i) = \frac{\pi - 2}{\pi}\sigma_u^2 \quad = \quad \frac{\mathrm{VAR}(u_i)}{\mathrm{VAR}(u_i) + \sigma_v^2} \quad (2)$$

Based on Battese (1992), the farmer-specific technical inefficiency is the ratio of the observed output and the farmer-specific stochastic frontier output. In this sense, the TE of rice farmer i can be estimated as:

$$\mathrm{TE}_i = \exp(-u_{i;}) = \frac{q_i}{\exp(x_i'\beta + v_i)} = \frac{\exp(x_i' + v_i - u_i)}{\exp(x_i' + v_i)} \quad (3)$$

Where TE_i is the scalar vector of TE of farmer i. In order to estimate the relationship between y and x_i in equation (1), we calculate a trans-log model as follows:

$$y = exp\left(\beta_0 + \sum_{n=1}^{N} \beta_n \, lnx_n + \frac{1}{2}\sum_{n=1}^{N}\sum_{m=1}^{N} \beta_{nm} \, lnx_n lnx_m\right) \quad (4)$$

Regarding the trans-log model for the β_n parameter, the logarithms of both sides of the equation (3) are calculated as follows:

$$\mathrm{Ln}\ y = \beta_0 + \sum_{n=1}^{N} \beta_n \, lnx_n + \frac{1}{2}\sum_{n=1}^{N}\sum_{m=1}^{N} \beta_{nm} \, lnx_n lnx_m + v_i - u_i \quad (5)$$

The disadvantage of this model is that it requires the estimation of many parameters. The estimated variance (γ) shows the variation in production (Coelli and Battese, 1996) as follows:

$$\gamma = \frac{\sigma_u^2}{\sigma^2} \qquad \text{With } \sigma^2 = \sigma_u^2 + \sigma_v^2 \quad (6)$$

The value of γ must range between zero and one; γ represents the deviations from the frontier due to noise, and values of 1 refers to the technical inefficiencies (Aigner et al., 1977).

2.2.2 Propensity Score Matching“?

Among the previous efficiency studies, controlling for sample selection bias has been neglected when estimating divergent technology sets using production frontiers (Latruffe et al., 2005; Wollni and Brümmer, 2012). Yet, if households decide to participate in contractual arrangement or not based on their expected performance under the chosen technology, the two sub-samples will systematically differ with respect to certain farm and household characteristics (Heckman, 1979). In this paper, the production frontier is estimated with the assumption that all farmers in the sample have access to the same technology and they are free to join the CF scheme. The SFA also assumes that all the unobserved variables in the selection equation are correlated with the noise (γ) (*see* Equation (6)). Similarly, the existing studies do not report adjusted standard errors, which is required in the context of two-step models (Lee, 1978; Heckman, 1979; Greene, 2000) or Data Envelopment Analysis (DEA) estimations in which the statistic noises are ignored (Linh, 2012).

For the observed variables, with regard to the contract group, some contract participants would have higher TE levels before participating in contract scheme, consequently increasing the self-selection bias. The decision to participate in the CF scheme may be modeled as a propensity that depends on observed socio-demographic characteristics specified as follows:

$$\partial_i = w_i \alpha + e_i \quad (7)$$

where α is a vector of parameters and e_i is a random error. If any of the determinants of technology choice (in this case CF), w_i, also affects rice production but is not included explicitly in equation (1), then the contract participation variable in (1) is correlated with the error term ε_i. In this case, estimations of β_n in equation (5) that do not account for the endogeneity of the technology choice are biased. For those observed variables, we employ PSM technique proposed by (Mayen et al., 2010) which is appropriate for productivity and TE analysis to control for any self-selection bias. The matching approach allows us to measure the effects of adopting CF on TE score of contract participants based on three-step procedure.

First, a probability of CF participation is estimated (probit estimation) and used to calculate the probability or propensity score of being contract participant rather than non-participant for each observation. It can be estimated as the average treatment effect on the treated (ATT) value:

$$\text{ATT} = \text{E}(\Delta|Z, D = 1) = \text{E}(Y^1|Z, D = 1) - \text{E}(Y^0|Z, D = 1) \quad (8)$$

Where, Y^1 represents the TE score of contract participant (D=1) and Y^0 represents the TE score of non-contract participant (D=0). Z is a vector of conditioning variables including any x_i variable from production inputs (*see* equation (1)) and other observed variables from socio-demographic characteristics or technical inefficiency determinants (*see* equation (7)). The mean value $\text{E}(Y^1|Z, D = 1)$ can be readily identified through the contract group data. But for the counterfactual mean $\text{E}(Y^0|Z, D = 1)$ the assumption has to be done regarding the TE of CF participants had they not adopted CF. The differences in outcomes of self-selected non-contract participation $\text{E}(Y^0|$ Z, D = 0) and approximate $\text{E}(Y^0|$ Z, D = 1) reveals the selection bias. The selection bias results are illustrated as follows:

$$\text{B(Z)} = \text{E}(Y^0|\text{ Z, D} = 1) - \text{E}(Y^0|\text{ Z, D} = 0) \quad (9)$$

Secondly, every single contract household is then matched to a non-contract household with a similar propensity score. In this step, we follow Mayen et al. (2010) to employ the nearest- neighbor matching technique in which each contract participant is paired with the non-contract participant that has the closest propensity score. All other non-contract households are ignored for this step (Dehejia and Wahba, 2002). The matching procedure serves to find an alternative result for $\text{E}(Y^0|$ Z, D = 1) based on the statistical independence of (Y^0, Y^1) and D conditional on Z (technology is exogenous after conditioning on Z). This condition is also referred to as "selection on observables" (Imbens, 2004). Rosenbaum and Rubin (1983) prove by conditioning on a propensity score P(Z), the independence condition is also satisfied. This method reduces the dimensionality of having to match on Z. If the assumptions of this method hold, then E(Y^0| P(Z), D = 1) = E(Y^0| P(Z), D = 0) = E(Y^0| P(Z), allowing unbiased estimates of E(Y^1 – Y^0 | Z, D = 1).

Finally, we estimate the SFA on the sub-sample of contract participants and matched non-contract participants to test the hypothesis that these farms employ a homogeneous technology and compare their TE with t-test estimations.

2.2.3 Model specification

Stochastic trans-log production function is used instead of Cobb-Douglas to estimate the production function for contract and non-contract rice smallholders due to its flexibility and less restrictiveness on production and substitution elasticity (Battese and Coelli, 1992; 1995). Table 1 presents the detailed information of the variables used in the TE estimation.

Table 1: Description of included variables

Variable	Description
Production model	
Seed	Expenditure on seed per year (ton)
Fertilizer	Expenditure on fertilizer year/ton
Pesticide	Expenditure on pesticide and chemical per year (1000.VND)
Machine	Expenditure on machine (1000.VND per year)
Labor	Expenditure on labor per year (1000VND)
Land	Total land use for rice production per year ha)
Output	Total output of export rice household (ton per year)
Technical inefficiency model	
Off-farm	Off-farm income (1000.VND)
Contrice	Dummy for Contract farming participation (1 = yes; 0 = no)
Edulevel	Schooling years of HH head (1-15 years)
Riceexper	Rice farming experience (years)
Credit	Dummy for the accessibility of credit (1= yes)
PSM- Probit estimates	
Landhh	Total agricultural land size for rice farming of HH
Agmem	Total family member work in agricultural
Gender	Gender of HH head
Age	Age of household head

1EURO = 25.000VND (average of currency exchange rate is applied at the time of data collection)

In this study, the rice production information refers to up to three harvests per year in the MRD. The exported rice in total volume per year is the single output. The inputs include labor, fertilizer, seeds, machinery, land, and pesticides. For the labor variable, the total costs for labor are calculated by the expenditure for hired labor per man and day and the costs of family labor by the wage rate paid to permanent hired labor. The rice farming area for land is in hectares. Total costs of fertilizer, seeds, and pesticides are calculated. Machinery costs such as irrigation, machine purchasing, and tools are also included in the total expenditure. A household that produces at the production frontier has a TE of 100 percent. The CF participation status is treated as a dummy variable as suggested by Coelli and Battese (1996). Derived from the literature review, the four major socio-economic characteristics, namely off-farm income, educational level (year of schooling), rice farming experience and credit accessibility are included in the technical inefficiency estimation with the expectation that those variables would support rice farming households in the MRD to optimize their rice production (Khai and Yabe, 2011; Duy, 2012).

3. Results and discussion

3.1 Descriptive statistics

Table 2 shows the mean values and standard deviations for the variables included in the estimations. Additionally, using t-test, CF participants are compared to non-contract participants and the sub-matched sample regarding the differences in production inputs and socio-demographic characteristics.

Table 2. Descriptive statistics for the variables included in the estimations

	Total sample		Non-contract		Contract		Matched ample	
Variable	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std.dev**
Production model								
Seed	1.534	2.147	1.71	2.95	1.38	1.001	1.77	0.45
Fertilizer	4.394	4.448	4.133	4.302	4.619	4.574	4.40	0.67
Pesticide	43.442	41.193	41.937	40.720	45.556	41.805	45.87	4.808
Machine	33.608	93.732	36.920	104.486	30.740	83.611	45.693	16.802
Labor	43.759	41.193	42.479	37.046	44.867	33.709	44.473	5.123
Land	10.297	7.978	10.281	8.296	10.309	7.722	9.49	0.88
Output	63.705	3.26	61.99	5.04	65.18	4.27	58.678	5.59
Technical inefficiency model								
Off-farm	40.550	68.329	34.617	64.303	45.690	71.473	35.287	8.161
Edulevel	8.128	2.956	7.93	2.90	8.3	3.00	8.29	0.36
Riceexper	23.396	10.24	24.67	10.90	22.29	9.52	22.230	1.11
Credit	0.376	0.4853	0.37	0.485	0.38	0.488	0.41	0.061

Source: author's own calculations

For the input variables, the results show that there is no significant difference in mean values. The average output of the total sample is about 63.705 tons per year. The rice farmers in the sample use about 4.394 tons of fertilizer per year on average. The average expenditure on pesticides and chemicals is nearly equal to labor expenditure representing 43.44 million VND and 43.759 million VND, respectively. The mean values and standard deviation of the expenditure on fertilizer, pesticide, and labor are higher for contract participants even though there is no significant difference among the groups. However, the differences of expenditure on seed and the total output per year are slightly below the threshold of significance and, thus, allow the hypotheses of their appropriateness as part of the production frontier and inefficiency estimations. Regarding the variables representing social-economic characteristics which are expected to affect farmers' ability to improve higher TE also, most of the variables do not show any significant difference between the groups.

3.2 Parameter estimations

3.2.1 Determinants of rice production technical efficiency in the MRD

The coefficients of the production frontier estimation conducted with total sample data are illustrated in Table 3.

Table 3 : Stochastic translog estimation for export-oriented rice in the Mekong River Delta

Variable	Full sample (250)		Sub-matched group (199)	
	Coeff.	**Std.error**	**Coeff.**	**Std.error**
Lnseed	0.25986***	0.04307	0.310401***	0.0519671
Lnpesticide	0.00917	0.02460	0.0023999	0.0298567
Lnfertilizer	0.17266***	0.03415	0.1369919 ***	0.043012
Lnlabor	0.10017**	0.04430	0.1141643***	0.0537549
Lnland	0.49204***	0.04632	0.4735377***	0.0507841
Lnmachine	0.00279*	0.00169	-0.0015767	0.0062302
Lnseed x lnseed	-0.25315***	0.05786	-0.5112465 ***	0.1269272
lnpesticide x lnpesticide	0.02068	0.03405	0.035153	0.0413255
lnfertilizer x lnfertilizer	-0.19891**	0.09788	-0.0248053	0.1334538
lnlabor x lnlabor	-0.20408	0.15830	-0.0356796	0.18888
lnland x lnland	0.40716***	0.13637	-0.3729227 ***	0.2243556
lnmachine x lnmachine	-0.0014089	0.0012329	-0.0007494	0.001243
Lnseed x lnpesticide	-0.05792	0.06118	-0.0208557	0.0723636
Lnseed x lnfertilizer	0.09578	0.12611	0.0859865	0.1443597
Lnseed x lnlabor	0.21412	0.14206	0.1022833	0.2047012
Lnseed x lnland	0.01010	0.12553	0.4395752***	0.2002246
Lnseed x lnmachine	0.00094	0.00664	0.0008259	0.0067744
Lnpesticide x lnfertilizer	-0.04789	0.05234	-0.0205589	0.0590875
Lnpesticide x lnlabor	0.00368	0.07421	-0.0551594	0.0842733
Lnpesticide x lnland	0.09554	0.07788	0.0580271	0.0904588
Lnpesticide x lnmachine	0.00419	0.00329	0.0029647	0.004323
Lnfertilizer x lnlabor	0.19923*	0.11746	0.0260494	0.1439669
Lnfertilizer x lnland	-0.04780	0.10025	-0.0775044	0.1009701
Lnfertilizer x lnmachine	0.00307	0.00556	-0.0030802	0 .0062466
Lnlabor x lnland	-0.36491***	0.13282	-0.0980056	0.1692907
Lnlabor x lnmachine	-0.01244*	0.00693	-0.0047026	0.0074467
Constant	0.16148***	0.04751	0.202***	0 .0707063
Number of observation: 250			199	
Prob>chi2: 0.0000			0.0000	
Log-likelihood: 97.147427			86.535.502	

*Note: *** p<0.01, ** p<0.05, * p<0.1*
Sources: authors' own calculations

For the log-normalized values, the input coefficients represent the production elasticity at the mean value. The partial production elasticity of expenditures for most of the inputs are significantly positive at the 1, 5, and 10 percent level. In particularly, if a farmer increases expenditures on seeds and fertilizer by one percent each the farm TE score increases by 0.259 and 0,172 percent respectively (both significant at the 1 percent level). With regard to the expenditures on labor, it becomes evident that an increase by 1 percent leads to a TE score increase of 0.1 percent (significant at the 5 percent level). Noticeably, a larger farming size is found to affect the TE positively (0.49

percent) at the 1 percent significance level, proving the existence of economies of scale in the Vietnamese export rice production sector. Expenditure on machinery is also found to positively influence farm TE, however only by 0.0028 percent at the 10 percent level of significance. Still, this result for expenditure on machines confirms the particular importance of investments in machine inventory for the efficiency of rice production in a developing country such as Vietnam even for smallholders (Pingali et al., 1997). However, as it is typical for developing countries in contrast to developed ones, the effect of labor intensity on the TE still exceeds those of machines (Khai and Yabe, 2011). Of even higher values are the coefficients of land use and seed expenditure confirming findings of earlier quantitative research on the key- role of these two input types for improving TE in the MRD (Duy, 2012). Only the (very low) positive result for expenditure on pesticides (0,009 percent) does not show any significance.

Table 4 illustrates the results for the determinants of inefficiency. Negative coefficient results indicate that the variables have positive effects on the TE. It can be seen that there is no strong significant effect of the major variables on TE. However the nearly significance and the signs of the coefficients of contract participation status (β=-0.410, z= 1.25), non-farm income (β=-4.10e, z= 1.29) and credit accessibility (β=-0.404, z= 1.22) may indicate a positive influence of CF on TE. These results are explainable with the circumstance that the CF scheme in Vietnam is still at the beginning stage. Thus, some effects potentially perceive time lags and become visible in the following years. While off-farm activities and the resulting income may support farm TE through increases in knowledge about and affordability of inputs, higher educational level and longer rice farming experience may represent better managerial and production skills reflecting in a better farm TE as it has been observed in earlier analyses (Khai and Yabe, 2011). Exactly the opposite is true for the accessibility of credits. It gives evidence of a negative effect (insignificant) on TE. This could be explained threefold: first interest rates of loans in the region are high, second, many credits are still in the initial years and long-term effects not measurable yet, third, since control is missing in many credit schemes, farmers use their loans for other urgent expenses unrelated to farming activities (Duy, 2012).

Table 4: Inefficiency estimations for export-oriented rice production in the Mekong River Delta

Variable	**Full sample**		**Sub matched sample**	
	Coeff.	**z**	**Coeff.**	**z**
Contract participation (1= yes)	-0.4108349	-1.25	-0.5264824	-1.35
Household income from non-farm activities	-4.10e-06	-1.29	-3.63e-06	-1.16
The accessibility of credit (1=yes)	0.4042186	1.22	0.399199	1.04
Schooling year of household head (number)	-0.0316746	-0.63	-0.0372751	-0.73
Rice farming experience (years)	-0.003418	-0.24	-0.0122209	-0.74
Constant	-2.936974 ***	-4.09	-2.469596***	
Observation	250			

*Note: *** p<0.01, ** p<0.05, * p<0.1*
Sources: authors' own calculations

3.2.2 Effects of contract farming participation on technical efficiency

The levels of production performance for export-oriented rice farmers represented by TE scores are shown in Table 5 and the frequency distribution of predicted TE is visualized in Appendix 1.

Table 5: Technical efficiency score for export-oriented rice production in the MRD

	Observation	Mean	Std. Dev.	Std. Err.	Min	Max
TE (full sample, N=250)						
Full sample	250	.8733	.064	.0040	.5648	.9647
Non-contract farmers	116	.8602	.074	.0068		
Contract farmers	134	.8846	.053	.0045		
Degrees of freedom: 248	**t = -3.01*** **					
TE (Sub-matched sample, N=199)						
Full sample	199	.8668	.074	.0052	.5397	.9698
Non-contract farmers	65	.8460	.0928	.8230		
Contract farmers	134	.8769	.0611	.8664		
Degrees of freedom: 197	**t = -2.79*** **					

*Note: *** p<0.01, ** p<0.05, * p<0.1*
Sources: authors' own calculations

The mean of the TE score for the full sample equals 0.8733, implying that, on average, the export-oriented rice farmers in the MRD produce 87.33 percent of the maximum possible output which is in line with findings from earlier studies about the TE score of rice production in Vietnam (Khai and Yabe, 2011). Vice versa, about 13 percent of the potential output is lost due to technical inefficiency. The TE of export-oriented rice production in the MRD ranges between 56.48 percent and 96.47 percent (see Table 5), also confirming the range observed in the comparative study on Vietnam and other developing countries (Khai and Yabe, 2011; Vo and Nguyen, 2016). In total, the scale-effect is about 1.026 which reveals that if farmers increase 1 percent of production inputs, the TE score can increase by 1.026 percent (see Table 3). Thereby, on average, contract participants have higher TE (88.46 percent) in comparison to non-contract participants (86.02 percent). In the two-sample t-test of TE-mean values, there is a significant difference at the 5 percent level with a t-value of 3.01, indicating higher TEs for contract farmers.

3.3 Propensity Score Matching

The propensity of CF participation based on the probit estimations is presented in table 6. There are some significant variables associated with the probability of CF scheme participation. Regarding the "rice farming experience" variables, it can be seen that the more farming experience households have, the less willingness they show to participate in CF (β=-0.023, z= 2.26). Since the more household farming members they have, the more propensity to engage in CF they get (β=-0.2935, z= 2.30), it can be interpreted so far that there is a strong propensity of the rice farming household participating in CF with the expectation to reduce the expenditure on hired labor by using household member In addition, the old farmers have higher propensity to join CF in comparison to the young farmers which is a convincible evidence for the case of Vietnamese rice production in which young farmers perceive independency from arrangement with contractors to be more beneficial (β=0.02, z= 1.91). Nevertheless, educational level is not strongly associated with farmers' marketing decision.

Table 6: Probit estimates of the Contract farming Propensity

Variable	Coef.	Std. Err.	z
riceexper	-0.0231188	0.0102184	-2.26*
edulevel	0 .0266692	0.0291315	-0.92
credit	0 .050614	0.1770455	0.29
offfarm	1.37e-06	1.29e-06	1.06
hhland	-1.60e-07	5.83e-06	-0.03
labor	1.48e-06	3.98e-06	0.37
machine	-3.96e-07	9.27e-07	-0.43
age	0.0200568	0.0105241	1.91*
hhmember	-0.2935064	0.1277223	-2.30**
gender	0.4277729	0.3674826	1.16
_cons	-0.5170229	0.6041934	-0.86
N	250		
Log likelihood			-16.516.629
Correctly classified			60.80 percent

*Note: * p< 0.10, **p< 0.05, *** p< 0.01*

Sources: authors' own calculations

Table 7. Mean and Standard Deviation of Technical Efficiency in PSM matching estimations

	Contract	**Non-contract**	**Difference**	**T-test**
	Mean	Mean	**in Means**	
TE- Probit model (n= 250)				
Unmatched	.8846	.8602	0.024	3.02***
ATT	.8846	.8569	0.027	2.05**

Note: * p< 0.10, **p< 0.05, *** p< 0.01

The PSM is generated based on probit estimations which the balancing property is satisfied. Given the similar socio-demographic characteristics of both groups, the propensity score of the comparison before and after matching shows that the significant differences in TE scores are resulting from the CF participation. Based on nearest-neighbor matching estimations, the average treatment effects on the treated results are positively significant. Table 7 presents a strongly positive effect of the CF program on TE scores (at 1 percent level of significance). In particular, by the same household (the treated one) in this matching procedure, participating in CF scheme helps him/her to increase the TE score level from 85.69 percent to 88.46 percent in comparison to the case of non-participation in the CF scheme. As the result, for the same households, if they participate in CF, they could increase their TE higher than conventional farming practices. This result supports to reject the hypothesis that there is self-selection bias for the sample and is also in line with the previous literature about the positive impacts of CF schemes on household welfare and agricultural productivity from emerging and developing economies (Ramaswami et al., 2005; Rahman et al., 2009; Rao et al., 2012). The matching estimation results in a sample of 199 observations including 134 contract households and 65 non-contract household with the same socio- economic characteristics. Table 5 presents the TE score value of the matched subsample which is significantly different on the 1 percent level (t= 2.79). This result once again confirms the t-test of the full sample with 250 observations and proves that there is no sample selection bias in our estimations (*see* Appendix 1).

4. Conclusion and policy recommendation

The aim of this study was to analyze the CF effects on TE in Vietnams' export rice production sector. The results from the SFA reveal that the average TE of export-oriented rice production in Vietnam is 87.33 percent implying that TE levels could be increased by nearly 13 percent at the current input level and socio-economic conditions which is in line with previous findings (Duy, 2012; Hoang and Yabe, 2012). Land, seed, fertilizer, machine, and labor are identified as the major inputs of the production frontier. Moreover, socio-demographic characteristics of the farmers in the sample also show influences on rice farming TE, however non-significantly. Remarkably, in our study, "educational level" and "rice farming experience" but also "off-farm income" is found as positive determinants influencing rice farming TE in contrast to the low negative effect of credit accessibility. In addition, CF participation is considered to have an influence (even though no significant) for rice smallholder to increase their farm TE. In this regard, contract participation could support not only larger-scale farmers but also small-scale farmers from developing and emerging economies in improving their production patterns.

In order to promote greater partnership coordination, higher farm TE and household welfare in the country, especially with regard to the Vietnamese export rice production sector, a further development and enhancement of the CF scheme raised in No. 80/2002/QD-TTg decision named "Policy on the Promotion of Agricultural Produce and Purchase through Contracts" and 62/2013 QD-TTg decision is highly suggested. In addition, the availability of credits with lower interest rates and the improvement of control systems should be considered by the government to increase their TE-effects. Furthermore, contracting companies should also take inputs into consideration in their contract design, especially price, quantity and appropriate training for seed and fertilizer are the important criteria to assure efficient usage by farmers.

This paper's findings are based on cross-sectional primary data that has been conducted in the MRD of Vietnam for rice production under CF scheme for a period of one year (three rice cropping seasons). Since CF scheme has been in a very early stage of implementation in the country, a future research with panel data is required to explore the household performance in a long term observation. In this regard, further research should take into consideration to the influence of CF implementation on households' performance and CF empowerment within the Vietnamese export-oriented rice sector, particularly. With regard to the agricultural credit system derived from this paper, there should be more specified evaluation to identify concrete pitfalls diminishing its success on the farm level. In addition, further research about the complex psycho-social decision process of Vietnamese export rice farmers willingness to participate in CF schemes is highly recommend.

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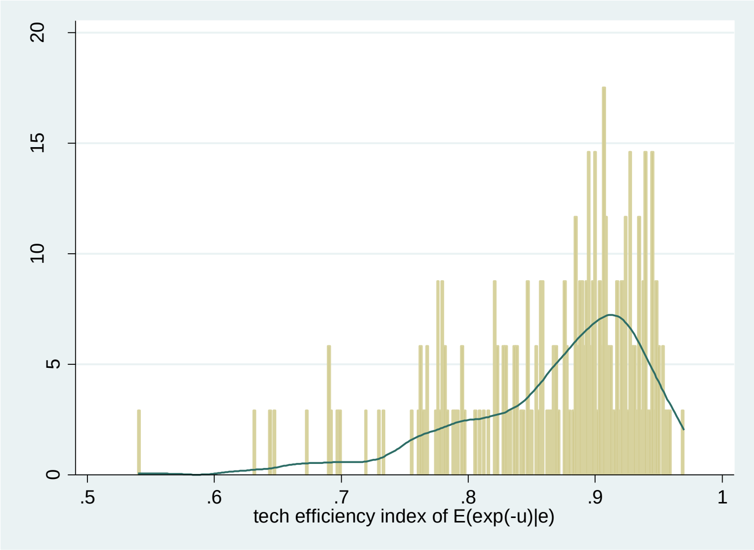
APPENDICES



Appendix1: Technical efficiency distribution for export-oriented rice in the MRD

Sources: authors' own calculations