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The role of access to credit in rice production efficiency of rural households in the Mekong Delta, Vietnam

Vuong Quoc Duy[1]

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[1] School of Economics and Business Administration, Can Tho University, Vietnam

Abstract

Currently, rice production in the Mekong Delta region accounts for more than 50% of Vietnam's total paddy production and 90% of its rice export volume. Therefore, increasing the efficiency of rice production systems and enhancing the comparative advantage of Vietnam's rice industry have been an important focus area for policy makers and researchers for many years. Access to credit has been identified as a key factor for improving rice production. This fact is validated in this study by considering the production and technical efficiency levels of rice production for a sample of farmers in the Mekong Delta. The study focuses particularly on the effects of both formal and informal credits on production levels and production efficiency by using a Stochastic frontier analysis and a quantile regression. The results confirm the positive influence of credit on production and production efficiency. Both formal and informal credit appear to be important.

JEL: E5, G2, O2

Key words: Stochastic frontier analysis, quantile regression, access to credit, rural households.

1. Introduction

Since Vietnam launched its innovation policy in 1986, the government has recognized the significant role played by agriculture. It has liberalized rice and agricultural input markets and implemented policies to promote the cultivation of high-yielding crop varieties. Since then Vietnam has experienced a steady increase in rice production and exports. Rice production reached 99 million tons in 2010 with rice yields of 5.32 tons/ha (GSO, 2010). The country has been a major rice exporter since 1989, currently among the top exporters in the world. In 2010, it exported as much as 6.88 million tons for 3.23 billion US dollars, up by 15.4% in volume and 21.2% from the previous year (GSO, 2010). These results were achieved with widely applied modern rice technology, resulting in the widespread adoption of high yielding modern rice varieties, whose use increased from 17% in 1980 to nearly 90% in 2000 (Ut and Kajisa, 2006).

The Mekong Delta is recognized as the rice bowl of Vietnam and rice production is the main income source for farmers in the region. It accounts for more than 50% of the country's total paddy production and 90% of national rice export volumes (GSO, 2010). Yet not all farms seem to produce at their optimal level. There may possibly be room for improvement which could contribute to rural household income and continue to increase the comparative advantage of Vietnam's rice production. Credit access can be important in the further improvement of a farming system because of its ability to create access to other production factors (Oladeebo and Oladeebo, 2008). Rashid et al. (2002) found that small farmers without credit in Bangladesh allocated less land to rice even when the magnitude of the effects of credit was very small. The availability of credit can affect fixed production costs (Brambilla and Porto, 2005) and farmers will use fewer seeds and fertilizer if they are credit constrained. Through its effect on production, output and covering marketing costs, credit may also influence farmers' participation in marketing systems and increase their ability to generate higher incomes.

This paper investigates the contribution of credit to rice production and technical efficiency levels. Credit is different from input subsidies or technology provision because it is not free and loans need to be repaid at maturity (CGAP, 2006), which is why lenders require collateral. Previous studies on rice production have been concerned with only the general role of credit, whether through Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis (DEA) approaches. This paper investigates whether scale matters for the effect of credit on production levels by applying a quantile regression, and a stochastic frontier to analyse the influence of credit access on efficiency levels is estimated. While descriptive analysis and the SFA have shown large differences in production and efficiency between borrowers and non-borrowers, it is not clear whether the positive effect is due to the access to credit or to differences in scale. The quantile regression confirms that credit contributes to production across the different production quantiles. This paper also distinguishes formal from informal credit in rice production functions.

The rest of this chapter is constructed as follows. Section 2 gives a literature review on studies on rice production efficiency conducted in Vietnam and elsewhere in the world. Section 3 presents the research methodology used in the present study. The empirical results of the study are given in section 4. Finally, section 5 offers a conclusion.

2. Literature review

Technical efficiency in agricultural (including rice) production has been widely studied (Coelli and Battese, 1996; Kyi and Oppen, 1999; Coelli, 2002; Rahman, 2003; Amaza and Maurice, 2005; Moses and Adebayo, 2007). Coelli and Battese (1996) investigated the determinants of technical efficiency among Indian farmers using a two stage panel data approach consisting of a SFA and technical inefficiency effects models. Their findings showed that farmer age, level of education, farm size and survey years had a significant influence on the inefficiency effects of farmers in the study areas. Kyi and Oppen (1999) also used a SFA approach but paid more attention to physical and human capital in irrigated rice production in Burma. Their findings indicated that seed use, human resource capability and knowledge of farmers were significant determinants of rice productivity. An additional finding was that inefficiency effects seemed to be different for large farmers using fertilizer compared to small and large farmers not using fertilizer. Rahman (2003) analyzed profit efficiencies among Bangladeshi rice farmers using a stochastic profit frontier and an inefficiency effects model to calculate technical, allocative and scale efficiency levels. The results showed high levels of inefficiency. Variations in inefficiency levels were explained by differences in infrastructure, soil fertility, experience, extension services, tenancy and share of non-agricultural income.

In Nigeria, Amaza and Maurice (2005) investigated factors influencing the technical efficiency of rice-based production systems among farmers in Adamawa State. A SFA was applied on a cross sectional data set of 122 farmers collected in 2002-2003. The results showed that relative technical efficiency levels varied widely between farms, ranging between 0.26 and 0.97, with a mean technical efficiency of 0.80. They concluded that the efficiency of rice production among farmers in Adamawa State could increase by 20% through better use of available resources such as seeds, irrigation water and fertilizer, and through farmer education. Several other studies have been conducted in Nigeria using parametric or non-parametric analysis approaches (Idiong, 2007; Moses and Adebayo, 2007; Oladeebo and Fajuyigbe, 2007). Their findings suggest that human capital such as the farmer’s educational level and age, as well as membership in a cooperative/farmer association and access to credit has a significantly positive influence on efficiency (Idiong, 2007; Oladeebo and Fajuyigbe, 2007). In addition, physical capital, such as seed use, size of land and quantity of herbicide and/or fertilizer used (Moses and Adebayo, 2007) influences technical efficiency calculated for rice production.

In Vietnam, a number of studies have analysed rice production efficiency. Nguyen (2003) studied the technical efficiency in the Mekong Delta using a SFA. Findings revealed that the average technical efficiencies in the three growing seasons - winter-spring, spring-summer and summer-autumn - are 86%, 79%, and 80%, respectively. Technical inefficiency was explained by variables such as land size, rice variety used, integrated pest management adoption, sowing techniques and availability of credit. Chi and Yamada (2005) also calculated the technical efficiency of rice farmers in Can Tho province using a production frontier function. Their results suggest that the technical efficiency of rice production is significantly affected by the education level and technical knowledge of the household head/farmer and the inputs used. Similarly, Vu (2007) study of the efficiency of Vietnamese rice farming households (based on both DEA and SFA) found that differences in technical efficiency could be explained by differences in length of education (as well as regional fixed effects).

In this paper we break new ground by combining SFA and quantile regressions to analyze the contribution of credit to rice production efficiency and rice yields. And, as mentioned in the introduction, we suspect that scale economies may be involved. Some of the above-cited papers confirm that farm size matters for efficiency levels. This paper applies a quantile regression to check whether scale of production also has an effect on the role played by access to credit.

3. Methodology

3.1 Stochastic Frontier Analysis (SFA)

SFA, originally proposed by Aigner et al. (1977) and Meeusen and Vandenbroeck (1977) and modified by Jondrow et al. (1982), is popular in determining farm efficiency levels for cross-sectional data. It specifies the relationship between output and input levels using two error terms. One error term is the traditional normal error term in which the mean is zero and the variance is constant. The other is the technical inefficiency level, expressed as a half normal, truncated normal, exponential or two parameter gamma distribution (Coelli, 1996). The two error terms in the maximum likelihood estimation of the production function determine inefficiency levels.

In a SFA, output Y_i is function of inputs X_i as follows (Greene, 2008)

$$Y_i = f(x_i\,;\beta) + \varepsilon_i = f(x_i\,;\beta) + (v_i - u_i) \qquad i = 1 \ldots\ldots N \tag{1}$$

where: Y_i is the production level (or log production) of the i-th farm and X_i is a 1xK vector of transformation of input quantities of the i-th farm. The function f(.) is typically a Cobb-Douglas production technology or translog technology. Both functional forms are used extensively in the literature (Thiam et al., 2001). The forms of Cobb-Douglas and Translog can be expressed as follows (Van Passel et al., 2009):

Cobb-Douglas function:

$$\log(y_i) = \beta_0 + \sum_{k=1}^{n} \beta_k \log(x_{ik}) + v_i - u_i \tag{2}$$

Translog function:

$$\log(y_i) = \beta_0 + \sum_{k=1}^{n} \beta_k \log(x_{ik}) + \sum_{k=1}^{n} \beta_{kk} (\log(x_{ik})^2 + \sum_{k=1}^{n} \beta_k \beta_t (\log(x_{ik}).\log(x_{it})) + v_i - u_i \tag{3}$$

This paper assumes a Cobb-Douglas model. A translog specification would require a larger sample.

The error term in equation (1) is composed of two components (Aigner et al., 1977):

$\varepsilon_i = v_i - u_i$

where: v_i is the symmetric component which it accounts for random variation in output due to factors outside the farmer's control such as weather and diseases and which is assumed to be independently and identically distributed with $N(0, \delta_v^2)$;

u_i captures technical inefficiency in production and is also assumed to be an independently and identically distributed non-negative truncation of the $N(\varphi, \delta_u^2)$ distribution. In this paper, we assume u_i to be half-normal distributed as specified by Greene (2008).

SFA also allows the estimation of the determinants of the TE levels in an inefficiency model. The variable u_i, which estimates technical inefficiency of household , is regressed against the household's socio-economic characteristics Z as follows (Coelli, 1996):

$$u_i = \alpha_0 + \sum_{i=1}^{n} \alpha_i Z_i \tag{4}$$

The SF model enables us to estimate parameters and standard errors, and to test hypotheses by using the maximum likelihood method. The parameter vectors β and δ are estimated together with the variance parameters $\delta^2 = \delta_v^2 + \delta_u^2$ and $\gamma = \delta_u^2 / \delta^2 = \dfrac{\delta_u^2}{\delta_v^2 + \delta_u^2}$.

The Frontier 4.1 program written by Coelli et al. (1998) is used for the SFA estimation in this paper.

3.2 Quantile regression

The Cobb-Douglas model estimated in the SFA does not allow allocation for non-linearity in production scale. To check scale effects on production and to check if the effect of credit differs over production scale, a quantile regression is estimated. The quantile regression model was first introduced by Koenker and Bassett (1978) and was developed in Koenker and Hallock (2001). The θ^{th} quantile for random variables X is defined as the value m_θ, such that the probability of X is less than m_θ. Mathematically this becomes (Koenker and Hallock, 2001):

$$\Theta = \Pr[X \leq m_\theta] = F(m_\theta) \tag{5}$$

which is the cumulative distribution function of X. The value $m\hat{}_\theta$ for a sample quantile can be derived using the inverse of the cumulative distribution function, which is the quantile function Q(θ), under the assumption of a strictly monotonic, continuous distribution function, namely (Koenker and Hallock, 2001):

$$m\hat{}\ \theta = F^{-1}(\theta) = Q(\theta) = \inf \{ X \in R: 0 \leq F(X\ \theta)\} \tag{6}$$

with inf{} defined as the greatest lower bound of m^ θ. Therefore, the function Q(θ) returns the lowest value for which the statement is true.

The term quantile model is used to distinguish between the number of equal size subsets used. For instance, four quantiles refer to quartile (θ = 0.25; 0.5; 0.75 and 0.95) positions, dividing the data set into four equal-size groups. The 0.5 quantile is the median.

3.3 Model specification

Both the SFA and quantile models take rice production in tons (efficiency and yield) as the dependent variable. The independent variables considered for the Cobb-Douglas SFA model are the basic production factors: area under rice cultivation, expenditure on seed, fertilizer and pesticides, expenditure on hired labour and cost of hiring machines (table 5.1). Factors suspected to influence inefficiency levels (following the literature cited above) are household characteristics (age, gender, education level and experience of the head of household, family size and Vietnamese ethnicity), farm characteristics (use of new technology and access to amenities such as electricity), market orientation (percentage of sales and distance to the market centre), location and finally the uptake of formal or informal credit. The same variables are used in the quantile regression. The uptake of formal credit is reflected by a dummy variable that takes value one if the farmer has borrowed a sum from one of the financial institutions in the Mekong Delta, and zero otherwise. A similar dummy variable reflects the uptake of informal credit.

3.4 Data collection

The data used in this paper is drawn from a household survey on living standards in Vietnam, the Vietnam Living Standard Survey – VLSS 2008. The survey was conducted by the General Statistical Office of Vietnam (GSO) in 2008, funded by United Nation Development Programme (UNDP) and Swedish International Development Cooperation Authority (SIDA) with technical assistance from the World Bank. It gathered information through community and household level questionnaires. The household questionnaires were organized into nine sections comprising basic demography, employment and labour force participation, education, health, income, expenditure, housing, fixed assets and durable goods, and participation in poverty reduction programmes.

The selection of the total sample of 45,945 households followed a method of stratified random cluster sampling of 3,063 communes/villages in Vietnam to make the data representative for national, rural and urban, and regional levels. The sample is divided into two subsamples: one sample with 9,189 households and another with 36,756 households (GSO, 2008). From the former sample, detailed information needed for household living standards analysis at national and regional levels were gathered; from the latter sample it was not.

As this paper focuses on rice production of households in the Mekong Delta, a subsample of 654 households in this region was selected from the 9,189 households. The criteria for selection were residence in the Mekong Delta, production of rice and availability of sufficiently detailed information on this production. Included in the data is information on household characteristics, access to amenities, market orientation and very importantly, rice input and output levels (table 1).

Table 1: Variable definitions and measurement

Variables	Units	Definitions
Rice production (Y)	Tons	Quantity of rice produced
Area rice (X1)	Hectare	Land area for rice planted
Seeds (X2)	1,000 dongs/hectare	Expenditure on seed
Fertilizer (X3)	1,000 dongs/hectare	Expenditure on chemical fertilizer
Pesticides (X4)	1,000 dongs/hectare	Expenditure on pesticides
Hired labour (X5)	1,000 dongs/hectare	Expenditure on labour hiring
Hired machinery (X6)	1,000 dongs/hectare	Expenditure on hiring farm implements for soil preparation and rice cutting

4. Empirical results

Table 2 compares the household and farm characteristics of borrowers and non-borrowers. There was no difference between both the groups in terms of age, farming experience and family size. The household heads of the borrower group have on average higher education levels. Rice production in the borrower group was significantly higher than that of non-borrowers. Borrowers planted more rice, and spent more on inputs for rice production such as fertilizers, pesticides and hired machinery than non-borrowers except for expenditure on seeds. Additionally, the household characteristics of borrowers and non-borrowers were not significantly different for any of the binary variables except the Viet ethnicity and the adoption of new technology, where, not surprisingly, the percentage of adoption among borrowers was much higher (table 3).

Table 2: Household and farm characteristics of borrowers and non-borrowers

Independent variable n	Non-borrowers 312	Borrowers 342	t- test
Age (years)	52.894 (0.799)	51.169 (0.727)	1.599
Family size (persons)	4.462 (0.097)	4.552 (0.085)	-0.7078
Farming experience (years)	24.840 (0.679)	23.588 (0.608)	1.377
Education (years)	5.644 (0.186)	6.900 (0.194)	-4.673***
Rice production (tons)	21.675 (1.262)	42.633 (2.294)	-7.797***
Rice production (tons/ha)	5.102 (1.377)	5.584 (3.672)	-2.182*
Area with rice (ha)	4.819 (8.225)	7.943 (7.261)	5.158***
Seeds (1,000 dongs)	2,010 (247.428)	2,194 (193.290)	-0.137
Fertilizer (1,000dongs)	9,747 (892.09)	11,503 (1,183)	-1.167
Pesticides (1,000 dongs)	3,494 (387.763)	4,887 (623.019)	-1.857 **
Hired labour (1,000 dongs)	3,990 (896.371)	3,310 (387.573)	0.718
Machinery hired (1,000 dongs)	9,733 (1,115)	13,223 (1,513)	-1.828 **
Distance to market centre (m)	1603 (42.668)	1569 (40.113)	0.569

Notes: *** significant at 1%, ** significant at 5%; * significant at 10%

Table 3: Household characteristics of borrowers and non-borrowers

Independent variables n	Non-Borrowers 312	Borrowers 342	X^2 Test
Gender (% male)	80.13	81.58	0.22
Vietnamese ethnicity (%)	93.07	90.26	2.18*
New technology (% yes)	16.35	93.86	399.69***
Access to electricity (% yes)	98.72	98.25	0.24
Can Tho province (% yes)	4.49	3.51	0.41

Notes: *** significant at 1%, ** significant at 5%; * significant at 10%

The sources and characteristics of credit are presented in table 4. Most borrowers (68%) had taken out a loan from a formal financial institution (Vietnam Bank of Agriculture and Rural Development or Vietnam Bank Social Policy). About 30% of the borrowers had a loan from informal sources who were individual lenders, friends and relatives. The remaining 2% had a loan from semi-formal lenders such as job creation funds and social political associations. There was a difference between loan characteristics among providers. Average loans taken out from formal lenders were larger than those of the other credit sources. The informal lenders charged higher interest rates.

As noted above, the production function was analysed for four quartiles of rice production (table 5). Quartile 95 dominates the other quartiles with respect to all variables that were included in the model. Age and education were lowest for the households in quartile 25. Households in the higher quartiles were using more inputs. In particular, those in quartile 95 were spending more on inputs than the other quartiles by a factor of 3 to 30 depending on the type of inputs.

Table 4: Loan sources and characteristics

Loan characteristics/Source	**Units**	**Formal sector**	**Semi-formal**	**Informal sector**	**F-Test**
Loan size	1000 dongs	29635 (49596)	10214 (6903)	19844 (28047)	2.27***
Interest rate	%/year	16 (7.211)	8.40 (2.003)	26.00 (31.941)	12.74***
Maturity	months	16 (12.778)	19 (17.904)	14 (9.712)	2.67**
Borrowers in sample	n	232	8	108	342
Percentage	%	68	2	30	100

Notes: Standard deviation in parentheses
*** significant at 1%, ** significant at 5%; * significant at 10%

Table 5: Household characteristics of household quartiles

Independent variable	Mean	SD	Q25	Q50	Q75	Q95
Rice production (tons)	32.634	35.869	11.760	23.899	42.000	86.220
Area with rice (ha)	6.453	7.886	2.970	4.680	7.500	17.520
Rice per ha (tons)	5.057	4.548	3.960	5.107	5.60	4.921
Expenditure (1000 dongs/ha)						
Seeds	2,106	3,972	523	1,165	2,361	6,490
Fertilizer	10,665	19,219	2,315	5,400	11,234	39,802
Pesticides	4,222	9,599	595	1,603	4,284	16,032
Hired labour	3,635	12,096	500	1,612	3,904	10,738
Machines hired	11,558	24,433	2,971	5,881	11,969	34,401
Age (years)	51.99	13.78	42	50	61	77
Education (years)	5.15	3.11	3	5	8	12
Family size (persons)	4.51	1.64	3	4	5	7
Farming experience (years)	24.18	11.63	15	23	33	43

Table 6 gives the results of the maximum likelihood estimates (MLE) of the pooled household model with dummy variables for the household who took formal and informal credit. The average technical efficiency of rice production was about 85%. This implies that farmers still had the possibility to improve their efficiency by an average of 15%. Similar results were found by Awotide and Adejobi (2006) and Nguyen (2003), although the calculated efficiency levels are relative to the frontier of the sampled households. In the Cobb-Douglas function, the coefficients of areas with rice and expenditure on pesticides were statistically significant. The model showed that technical inefficiency of rice production was associated with household characteristics (education level), technology (use of new farm technology), market orientation (distance from households' dwelling place to market centre), location (Can Tho province) and the access to formal or informal credit. This implies that rice efficiency was positively associated with better educated households using newer techniques, households from the Can Tho province and those further out from the market centre. Both formal and informal credit seem to increase farm efficiency. The coefficients of average age, family size, farming experience, Vietnamese ethnicity and gender of household head were not significant. The likelihood ratio tests of one-side generalized error exceeded the critical value (α=5 percent), suggesting that the null hypothesis of no technical inefficiency in rice production in the sample is rejected.

The distribution of technical efficiency of rural households in the Mekong Delta is presented in table 7. The technical efficiency levels of borrowers were higher than those of non-borrowers.

Table 6: Estimation of SFA and efficiency levels for rice production

Model		SFA model		
Production Coefficient	Units	Co-efficient	Standard Deviation	t-ratio
Dependent variable:				
Log(rice outcome) (tons)				
Independent variables (Log):				
Constant	β_0	1.2940***	0.1814	7.1352
Area rice (ha)	β_1	0.7405***	0.0623	11.8806
Seeds (1,000 dongs)	β_2	-0.0728	0.0501	-1.4521
Fertilizer (1,000 dongs)	β_3	-0.0329	0.0456	-0.7231
Pesticides (1,000 dongs)	β_4	0.0625**	0.0318	1.9654
Hired labour (1,000 dongs)	β_5	0.0325	0.0281	1.1552
Hired machines (1,000 dongs)	β_6	-0.0193	0.0425	-0.4537
δ^2		0.0478	0.0066	7.2593
Γ		0.0787	0.1536	0.5125
Log Likelihood		61.8561		
Inefficiency Effect Model				
Age (years)	δ_1	-0.0233	0.1139	-0.2041
Family-size (persons)	δ_2	-0.0076	0.0958	-0.0796
Experiences (years)	δ_3	0.0534	0.0699	0.7640
Education (years)	δ_4	-0.1088*	0.0612	-1.7787
Vietnamese ethnicity (yes=1)	δ_5	0.0554	0.0630	0.8793
Gender (male=1)	δ_6	0.0147	0.0411	0.3577
New technology (yes=1)	δ_7	-0.1289**	0.0468	-2.7566
Formal credit (yes=1)	δ_8	-0.4735**	0.1817	-2.6053
Informal credit (yes=1)	δ_9	-0.2995**	0.1146	-2.6128
Can Tho province (yes=1)	δ_{10}	-0.1904**	0.0761	-2.5009
Distance to market (1,000 m)	δ_{11}	0.1124*	0.0647	1.7384
δ_u^2		0.0038		
δ_v^2		0.0369		
TE		0.8505		
LR test of the one sided error		302.5701		

Notes: *** significant at 1%, ** significant at 5%; * significant at 10%

Table 7: Distribution technical efficiencies of households

	Borrowers				Non-borrowers	
	Formal borrowers		Informal borrowers			
Range	n	%	n	%	n	%
<70%	0	0	0	0	157	50
70-80%	0	0	0	0	128	41
80-90%	0	0	5	5	27	9
90-100%	233	100	99	95	0	0
Total	233	100	104	100	312	100

Table 8 gives the results of the quantile analysis. The rice yields of all quantiles are significantly positively affected by the area with rice, expenditure on pesticides (except quantile 95), education level of the household head (except quantile 95) and use of new farming technology. Furthermore, for all quantiles, access to credit, both formal and informal, contributed significantly to production. The rice yield of quantile 50 was positively affected by age of the household head, Vietnamese ethnicity, higher expenditure on hired labour and location in Can Tho province. The coefficients of the dummy variables for access to formal and informal credit confirm that borrowers were more likely to have higher rice production outcomes than non-borrowers. The coefficients of formal credit uptake were larger than those for informal credit access in functions of quantile 25 and 95, and smaller in functions of quantile 50 and 75, but the differences were not large.

The possible explanations for the model results are as follows. First, the coefficients of access to credit were negatively significant in technical inefficiency regression and positively significant in the quantile regression, implying that access to credit is likely to increase the technical efficiency of rice farmers. In fact, the financial constraints in farming are likely to be relieved through credit, which allows the purchase of more inputs, which in turn increases revenues and profit (Hyuha et al., 2007). Additional funds from credit markets can be used to invest in rice paddy production, principally by adopting new technologies (Nuryartono. et al., 2005). Nuryartono (2005) also found that access to financial markets facilitated the adoption of technology such as fertilizer and pesticides. In the inefficiency model, the coefficient of access to formal credit is larger than that of informal credit, suggesting that access to formal credit had a larger effect on rice production efficiency. The findings are consistent with Kebede (2001); Nwaru (2001); Ajibefund and Aderinola (2003); Nguyen (2003); Ogundari (2008).

A second possible explanation is that the coefficients for education and use of new technique were negative and highly significant in the technical inefficiency model and positively significant in quantile regression (except in the largest quantile). Education may enhance the acquisition and utilization of information on improved technology as well as their entrepreneurship (Coelli and Battese, 1996; Dey et al., 2000; Effiong, 2005; Onyenweaku et al., 2005; Idiong, 2006). The importance of the introduction of new technologies on production is also confirmed.

Third, the signs in both models of the coefficient of distance from household dwelling to the market suggest that households in remote areas were more likely to have lower technical efficiency levels and rice yields. Poor communication and transportation facilities may lead to lower efficiency levels of households further away from market centres. This finding is consistent with those in studies by Lanzona and Evenson (1997); DeSilva et al. (2006); Larson and Plessmann (2009).

Furthermore, farmers in Can Tho province had higher production and efficiency levels than those in the other provinces. Rice farming in this province benefits not only from the natural fertilization provided by the Tien and Hau Rivers, but also from the support of the two largest agricultural science centres of the Mekong Delta, namely Can Tho University and Cuu Long Delta Rice Research Institute.

Table 8: Quantile regressions of rice production

	Units	Quantile (25)	Quantile (50)	Quantile (75)	Quantile (95)
Dependent variable: Log(rice outcome) (tons)					
Independent variables (Log):					
Constants	β_0	0.221	0.280	1.027***	1.048*
		(0.97)	(1.12)	(3.44)	(1.73)
Area rice (ha)	β_1	0.760***	0.698***	0.718***	0.803***
		(12.83)	(11.30)	(10.35)	(5.65)
Seeds (1,000 dongs)	β_2	-0.058	-0.025	-0.042	-0.146
		(-1.20)	(-0.46)	(-0.66)	(-1.17)
Fertilizer (1,000 dongs)	β_3	-0.009	0.060	-0.036	-0.095
		(-0.19)	(1.21)	(-0.65)	(-1.02)
Pesticides (1,000 dongs)	β_4	0.128***	0.103***	0.080**	-0.020
		(4.34)	(3.10)	(2.03)	(-0.24)
Hired labour (1,000 dongs)	β_5	0.009	-0.001	0.029	0.029
		(0.37)	(-0.00)	(0.84)	(0.41)
Hired machines (1,000 dongs)	β_6	-0.027	-0.079*	-0.091	0.052
		(-0.71)	(-1.71)	(-1.64)	(0.41)
Age (years)	δ_1	0.131*	0.173*	0.104	0.186
		(1.81)	(2.01)	(0.98)	(0.71)
Family-size (persons)	δ_2	-0.0249	-0.064	-0.071	-0.033
		(-0.47)	(-1.18)	(-1.13)	(-0.24)
Experience (years)	δ_3	-0.049	-0.018	-0.038	-0.028
		(-1.40)	(-0.47)	(-0.84)	(-0.30)
Education (years)	δ_4	0.099***	0.106**	0.157***	0.141
		(3.51)	(3.17)	(3.40)	(1.25)
Vietnamese ethnicity (yes=1)	δ_5	0.048	0.056*	-0.085*	-0.057
		(1.58)	(1.68)	(-2.22)	(-0.73)
Gender (male=1)	δ_6	0.016	0.004	-0.038	-0.034
		(0.74)	(0.16)	(-1.31)	(-0.60)
New technology (yes=1)	δ_7	0.101***	0.092***	0.086*	0.200***
		(3.66)	(3.07)	(2.24)	(3.29)
Formal credit (yes=1)	δ_8	0.111***	0.189***	0.249***	0.334***
		(3.94)	(6.23)	(6.69)	(7.01)
Informal credit (yes=1)	δ_9	0.097**	0.223***	0.319***	0.274***
		(2.99)	(6.44)	(7.73)	(4.34)
Can Tho province (yes=1)	δ_{10}	0.079*	0.076*	0.0807	0.025
		(1.85)	(1.66)	(1.45)	(0.21)
Distance to market (1,000 m)	δ_{11}	0.014	0.067	0.068	0.019
		(0.32)	(1.41)	(1.24)	(0.16)
N		654	654	654	654
Pseudo R-square		0.605	0.526	0.481	0.473
Min sum of deviations		78.972	105.675	87.031	28.463

t statistics in parentheses

Notes: *** significant at 1%, ** significant at 5%; * significant at 10%

5. Conclusion and implications

This paper investigates the technical efficiencies and yields of rice farmers in the Mekong Delta of Vietnam by using SFA and quantile regressions. The determinants of the stochastic production frontier tested included the land area used for rice and expenditure on seeds, hired labour, fertilizer, pesticides and hired machines. Coefficients of area with rice and of expenditure on pesticides had the expected signs (as they did in studies by Coelli and Battese (1996); Kyi and Oppen (1999); Wadud and White (2000); Jaforullah and Premachandra (2003); Nguyen (2003); Ogundari (2008)). Technical efficiency and rice yields were positively influenced by access to credit, household characteristics (educational level of household head), location of households (location in Can Tho province and proximity to the nearest market centre), farm technology (use of new farm technology and expenditure on pesticides) and area with rice. In addition, borrowers are relatively wealthier than non-borrowers, although the quantile regression confirmed that credit positively contributes to production among the smaller producers as well.

The results of this study have a number of implications, especially for credit accessibility. They have shown that access to formal credit had a larger effect on rice production efficiency than the uptake of informal credit. Formal credit is regulated while the informal credit is not and is easier to access. A further expansion of rural credit systems could enhance and contribute to increased rice production and efficiency in the Mekong Delta. Given the limited extent of governmental credit programmes in the Mekong Delta, accessibility to credit by rural households could be improved by establishing more branches of agricultural and community banks in the rural areas, providing innovative credit schemes that overcome problems of smallholder farmers who lack collateral and by reducing the currently long processing times of loan applications and other requirements. In addition, access to credit could be made easier for farmers without the specific commodity requirements. Furthermore, credit should meet the needs of the farmers, in particular for investment in farm activities.

Credit awareness and the establishment of strong and viable farmer organisations (such as cooperatives or credit associations) which can play a leading role in increasing farmers' access to credit are important. Similarly, savings mobilization programmes should be developed and promoted in the survey area, which will inspire participation and provide encouragement to farmers to save and reinvest. Savings programmes also reduce the costs of monitoring lenders.

Many rural clients of the formal credit programmes have a lack of skills and training, and limited access to markets and technology. As a result, when these households have access to credit to invest in an existing business or to start-up a new one, the sustainability of their activities may become problematic. Therefore, it is very important for the financial institutions to facilitate or directly involve themselves in "credit plus" services that may include skill development/training, marketing facilities and business development services for their customers to help them sustain the economic activities supported by their financial schemes. To a more general extent, education is needed to improve efficiency levels. This could also increase the use of new farming technology, which plays a significant role in rice production. A future research project should focus on the impact of external services intervention on rice farming by panel data.

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