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Optimal Farm Size in Rice production of households Mekong Delta, Vietnam: case of Total Factor Productivity

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Abstract

The paper aims to examine the effect of farm size on the efficiency of production activities as a basis for determining the optimal farm size to maximize the efficiency of production activities. Primary data were from a ramdom sample of 498 households at three provinces of Mekong Delta, Vietnam. The analysis results show that the model is highly statistically significant and determines the inverted U-shaped nonlinear relationship between farm size and the efficiency of production activities through total factor productivity indicators (TFP). Hence, the optimal farm size of 9.7 ha will bring highest the efficiency of production activities. The paper proposed solutions to help use the farm size appropriately, improve production efficiency and improve household incomes.

1. Introduction

Manufacturers in all different fields pay attention to many factors from input to output, especially land, labor and capital because these are considered three important input factors that decide success in agricultural production. According to researchers, ***land*** is considered a scarce factor and an important factor of production (Adamopoulos and Restuccia, 2014). Besides**, *capital*** plays an important role and is an indispensable input because farmers need capital to buy materials, seeds, machinery, hire labor, etc. to ensure seasonality and minimize risks and capital can be obtained from many different sources (Modigliani and Miller, 1958). At the same time, according to Pfeffer and Jeffrey (1998), future sources of competitive advantage mainly come from the human resources of the production unit, which is ***labo***r because labor is considered the most abundant factor (Li et al., 2013). Besides those three main input factors, technical management capabilities and technological advances also play a very important role in determining the success of agricultural production in general and rice production in particular.

Agricultural land area in Asia accounts for 20% of the world's total agricultural land area, but the landholdings are very small (from 1-2 ha/household) compared to the world average (3.7 ha/household) and the trend of small-scale ownership is increasing (Pookpakdi, 1992). Vietnam's agricultural land area is 0.12 ha/person, only one sixth of the world average, equivalent to Belgium and the Netherlands, higher than the Philippines and India, but lower than China and Indonesia (OECD, 2015). Due to the industrialization that transfers agricultural resources (suchas labour and land) to the industrial sector, leaving less for agricultural production (Dinh Bao, 2014). In agricultural production, industry or services, producers are interested in many factors. One of the crucial factors determining the success of production is the efficiency of production activities (EPA), or to use optimally resources to improve EPA. In agricultural production, landis a scarce factor (Hoque, 1988), a vital factor of production (Adamopoulos and Restuccia,2014). Therefore, producers need to determine the optimal farm size threshold in order to maximize the efficiency of production activities. However, at different stages of the economy, thefarm size is different. In the 1960s, small scale was good and effective because of taking advantageof family resources (labor, land, production tools, …) but in the 1970s and 1980s due to the process of urbanization and specialization. In the process of industrialization, attracting a large number ofrural workers helps produce more efficiently on a large scale (Fan and Chan-Kang, 2005). According to these researchers, by the 1990s, the application of science and technology to production increased the land use intensity, thus negatively affecting the land resources and the environment leading to production not as effective as before (implied small farm was good).

In the order hand, to evaluate the efficiency of agricultural production activities, researchers use many different measurement indicators from land efficiency, labor efficiency, capital efficiency to technical efficiency, efficiency from technical improvements and crop management capabilities through many different methods. In order to help rice farmers in the Mekong Delta, Vietnam, have a more comprehensive assessment of the efficiency achieved through the rice cultivation process as well as have a solid basis for improving and enhancing production efficiency, especially management efficiency and technological advancement. Therefore, evaluating, measuring and improving total factor productivity (TFP) will contribute to reducing the scarcity of output products, improving product quality, improving technology and management techniques as well as expanding agricultural production activities, especially in the field of rice cultivation. At the same time, manufacturers must consider the possibility of influence as well as the level of contribution of these factors to agricultural growth and consider the level of influence of production factors on agricultural growth through agricultural growth through total factor productivity indicators and this is also the reason for forming this study.

Thus, the aim of this paper is to investigate the characteristics of the efficiency of production activities using multivariate regression methods. The main contributions of this article include three contents. First, it determined the efficiency of production activities due to total factor productivity. Second, this paper deeply analyzes the impact of farm size on the efficiency of production activities. Third, determine the optimal farm size to maximize the efficiency of production activities.

The rest of this paper's framework is organized as follows. Section 2 is a review of the available literature. Section 3 illustrates the methods and data used in this paper. In section 4 presents and discusses the empirical results. Conclusions and corresponding policy implications are provided in Section 5.

2. Literature review

2.1. Total factor productivity (TFP)

TFP was defined and formed very early in experimental research in Germany by Tinbergen (1942). However, TFP is widely popular and used by many economists from Solow's (1957) definition. According to Solow, TFP is the level of technology or technological progress through the formula:

$$Y = A(t) \times F(L, K) \quad (1)$$

In which, Y is the achieved production output, K is the capital investment cost for input factors, L is the amount of labor involved in production and A(t) is the level of technology or total factor productivity and is a function of time.

According to Farrell (1957) the origin of TFP growth is due to changes in technical efficiency and advances in technology (Nishimizu and Page, 1982; Coelli et al., 2005). TFP is understood as growth through technological innovation, efficiency achieved from improving labor qualifications and capital management. Similarly, Li et al. (2013) believe that TFP is an indicator that comprehensively reflects the efficiency of the entire production process. Therefore, Li et al. (2013), Nkonde et al. (2015) used the Cobb-Douglas production function to calculate TFP adapted from Fan (1991), Zhang and Carter (1997) to form the formula:

$$Output_i = A_o \, e^{\eta t} K_i^{\alpha K} L_i^{\alpha L} FS_i^{\alpha FS} \exp(\varepsilon) \quad (2)$$

In which, Output is the rice output produced by the farmer household; K represents the value of capital (all production costs except family labor costs); L is the total number of working days (hired labor and family) and FS represents the area of land under cultivation of the farming household; αK, αL, αFS are the elasticity coefficients of capital, labor and land; i refers to the ith farmer and j refers to the jth crop;t is the time trend and η is the rate of technical progress. Taking logarithm (2) we get formula (3):

$$lnOutput_i = (lnA_0 + \eta t) + \alpha_K lnK_i + \alpha_L lnL_i + \alpha_{FS} lnFS_i + \varepsilon \quad (3)$$

Given that this production function is estimated with cross sectional data, the time trend variable is t=1 and thus the $\ln A_0 + \eta t$ term becomes the constant term. To get the TFP indicator, the research first compute the returns to scale (RTS) coefficient, which is the sum of factor output elasticities ($RTS = \alpha_K + \alpha_L + \alpha_{FS}$), then normalize each factor's output elasticity and obtain $\alpha'_K = \frac{\alpha_K}{RTS}$, $\alpha'_L = \frac{\alpha_L}{RTS}$, $\alpha'_{FS} = \frac{\alpha_{FS}}{RTS}$ and define TFP as:

$$TFP_i = \frac{Output_i}{K_i^{\alpha'_K} L_i^{\alpha'_L} FS_i^{\alpha'_{FS}}} \quad (4)$$

2.2. Factors affecting total factor productivity

Studies have used linear regression methods to analyze the effects of production factors on total factor productivity through equation (5):

$$TFP = \beta_0 + \beta_1 lnFarmsize + \varepsilon \quad (5)$$

If $\beta_1 < 0$ and is statistically significant, there exists an inverse relationship (Li et al., 2013; Nkonde et al., 2015) between cultivated land area and total factor productivity or cultivated land area. has a negative effect on TFP. However, formula (5) is often criticized for omitting other factors that affect TFP such as differences in residential areas (Byiringiro and Readon, 1996), labor participation (Heltberg, 1998) along with other factors. Therefore, Li et al. (2013) improved formula (5) by adding exogenous variables (including human resources and social capital such as education, technical training, personal experience, social networks and available resources), at the same time Nkonde et al. (2015) also added variables on crop management ability to control the impact of the above factors on total factor productivity of rice farmers using equation (6):

$$TFP = \beta_0 + \beta_1 Farmsize + \alpha' Z + \eta' X + \varepsilon \quad (6)$$

In which, Z is a vector of exogenous variables (household head characteristics, soil conditions and location fixed effects); X is a vector of crop management factors that affect yield; βi, α' and η' are the estimated coefficients of the model and ε is the random error.

3. Methods and data

3.1. Data resources

Considering the availability of the data and the statistical calibers, this paper selects data from three provinces in the Mekong Delta, Vietnam with the same characteristics of the land with large farm rice cultivation of AnGiang, DongThap and an average of CanTho. The study collected randomly 498 rice-producing households in the Autumn-Winter 2021, Winter-Spring 2021 and Summer-Autumn 2022 seasons to estimate for the whole year 2022, of which AnGiang (225 households), CanTho (90 households) and DongThap (183 households) based on the scale of each province in the survey area.

3.2. Estimation model of farm size impacts on the efficiency of rice production activities

FarmSize is the farm size of rice cultivation on the largest field (hectares), *FarmSizesq* is the square of farm size of the household (Mahmood & Nadeem-uh-haque, 1981; Byiringiro & Reardon, 1996; Heltberg, 1998; Dorward, 1999; Van Hung et al., 2007; Barrett et al., 2010, Ali & Deininger, 2015; Nkonde et al., 2015). Our hypothesis is ambiguous as to its effect. On the one hand, we expect that the large farm, TFP will continuously increase because then the households can easily manage production activities and control the motivation of working of the workers (mainly family labor), appropriate selection and quality assurance of inputs (fertilizers and agricultural medicines) due to low demand. In addition, households will also be able to apply advanced farming techniques to increase productivity and contribute to improving profitability for farmers.However, as the farm size grows and exceeds the optimal farm size, TFP will decrease, because family labor cannot guarantee all farming activities, so they have to hire more local labor that is difficult to control their working motive, there are difficulties in management, the amount of investment capital is insufficient so they have to borrow from different sources with high costs.

NumLabor is the number of working-age members of the family involved in rice production (number of employees). This is a good resource and contributes to high efficiency in production (Heltberg, 1998; Barrett et al., 2010; Gaurav & Mishra, 2015).

Dummy variables including, *Female* is the dummy variable representing the gender of the head of household (= 1 if the head of household is female and = 0 otherwise) (Dhungana et al., 2004; Carletto et al., 2013; Li et al., 2013). *Training* dummy variable showed the head of the household participated in training courses in the last 3 years (Li et al., 2013; Gaurav & Mishra, 2015). Dummy variables indicate difference in residence are *AG, DT* (Byiringiro & Readon, 1996).

Exper is the number of years of rice cultivation by the housholds head. It has positively effected on the total factor production (Byiringiro & Readon, 1996; Li *et al*., 2013).

TCapital is total cost invest for input factors. Our hypothesis is ambiguous as to its effect. On the one hand, we expect that households invest more capital then production cost increase and TFP will reduction (Feder et al., 1990). On the other hand, households invest flexibly inputs then TFP will increase (Gaurav & Mishra, 2015; Rios & Shively, 2016). TCapital is the total cost of investment for inputs from land preparation to harvest and it also is an indispensable input because households need capital to buy materials, seeds, machines, hire labor,... to ensure seasonality and reduce risks and capital that can be obtained from various sources (Modigliani & Miller, 1958). The capital also helps farmers invest in developing irrigation systems, applying new techniques to diversify production types to avoid having to sell products at low prices. Hence, it increased TFP with the expectation of positive or negative value depending on farm size at the economic stage by scale or non-economic scale.

NumPlot are the number of rice plots of the household, reflects farm fragmentation (Byiringiro & Readon, 1996; Van Hung et al., 2007). Distance is the distance from the household to the largest field (Byiringiro & Readon, 1996; Ali & Deininger, 2015). We expect that the more plots the farm has, and the more distant they are from the residence, the less productive is the farm operation.

DIncome is the household's non-rice income such as raising animals, growing fruit trees, aquaculture, so on. This is the capital that households use to invest in their production or save to reinvest (Bravo-Ureta và Pinheiro, 1997). Therefore, it will increase TFP with expectation of positive value.

LaborHired is the total labor days hired to work in rice fields (days/hectares) and *LaborFamily* is the total number of family labor days working on rice fields (days/crop) (Heltberg, 1998;Dhungana et al., 2004; Van Hung et al., 2007; Carletto et al., 2013; Gaurav & Mishra, 2015). Therefore, they will increase TFP with expectation of positive value.

Besides, *Edu* is the educational level of the head of household (number of classes). Education of the household head is also a factor to consider when analyzing the efficiency of rice production in particular and agricultural production in general, because highly educated household heads will quickly acquire and apply production techniques new, information about changes in the market and the natural environment, ... in order to make reasonable use of inputs to ensure rice yield and product quality (Heltberg, 1998; Dhungana et al., 2004; Rios & Shively, 2005; Carletto et al. ., 2013; Li et al., 2013; Ali & Deininger, 2015) with positive expectations.

On the basis of the theory presented, formulate the following experimental model:

$$\begin{aligned} TFP_{ik} = \beta_0 + \beta_1 FarmSize_i + \beta_2 FarmSize_i^2 + \beta_3 NumLabor_i + \beta_4 Gender_i + \beta_5 Edu_i \\ + \beta_6 DIncome_i + \beta_7 NumPlot_i + \beta_8 LaborHired_i + \beta_9 LaborFamily_i + \beta_{10} AG_i \\ + \beta_{11} DT_i + \beta_{12} TCapital_i + \beta_{13} Exper_i + \beta_{14} Distance_i + \beta_{15} Training_i \\ + \varepsilon_i \quad (7) \end{aligned}$$

3.3. Data analysis

The study used descriptive statistics and two-stage regression methods.

First, the study uses a two-stage regression method. Step 1, the study uses the least squares estimation method to estimate the production function. This regression result will be the basis for determining the corresponding total factor productivity for each farmer household. Step 2, the study uses the TFP just calculated in step 1 as the dependent variable in the model to estimate factors affecting TFP and is also estimated through the OLS method.

Finally, descriptive statistical methods (mean, maximum, minimum, standard deviation, ...) are used to describe the current status of rice production of Mekong Delta farmers, the current status of land use in rice production of Mekong Delta farmers and determine the optimal land size threshold. Besides, the author uses the least squares estimation method to estimate the production function to calculate TFP and estimate the factors affecting TFP as presented in the theoretical basis section.

Finally, study use necessary conditions and calculation formula of Greene (2003), Wickramaarachchi & Weerahewa (2018):

$$\frac{\partial EPA(FarmSize)}{\partial FarmSize} = 0 => FarmSize = \frac{\beta_1}{2\beta_2} \ (8)$$

4. Empirical results and discussion

4.1. Overview of farming households

Demographic characteristics of rice farming households are summarized in Table 1. The average number of household members is 4 and the average number of members of working age is 3 per household but there are about 2 participants rice. This is the reserve labor force that is ready to serve the family's rice farming activities and is easy to mobilize when it comes to harvest.

Table 1. Basic indicators of the Mekong Delta rice households

Criteria	Unit	Average	Max	Min	Std.Dev
Number of household members	People	4.38	11.00	1.00	1.43
Number of family workers	People	3.28	9.00	1.00	1.34
Number of family workers working in rice fields	People	1.70	5.00	1.00	0.90
Age of head of household	Year	52.28	85.00	24.00	10.96
Farm size of rice cultivation	Hectares	1.71	17.00	0.10	1.77
Educational of the household head	Year	5.97	15.00	0.00	3.51
Living time in the locality	Year	47.44	85.00	6.00	13.81
Experience in rice cultivation	Year	30.07	60.00	6.00	10.98

Source: Summary results of self-survey data in 2022

Farmers' educational is still relatively low, average of 6 years with standard error of 3.5 years, which is a big obstacle for farmers in acquiring knowledge and applying advanced technology progress of the world into the family’s production. The average living time in the locality is 47 years and the average rice farming experience is 30 years, that is a long time for them to accumulate experience in rice cultivation, contributing to increase the efficiency production for households.

In addition, the average rice farm size of the surveyed households is 1.71 hectares with a standard deviation of 1.77 hectares. There are households with very small scale (0.1 hectares), this is a huge limitation in the application of mechanization to production, which increasing costs and reducing production efficiency for farmers.

4.2. Total factor productivity (TFP)

Table 2 presents statistical results describing the variables in the model (3). Most of the variables in the model do not vary much between rice farmers in the same crop as well as between crops in the year. is shown in quite detail through the standard deviation values of the variables which are very small compared to the average value.

Table 2: Quantitative variables in the model (3)

Criteria	Average	Max	Min	Std.Dev
LnFS	0.14	2.83	-2.30	0.90
LnL				
- Autumn-Winter	3.17	4.92	2.16	0.43
- Winter-Spring	3.11	3.30	2.16	0.44
- Summer-Autumn	3.08	4.28	2.16	0.47
LnK				
- Autumn-Winter	3.06	3.58	2.54	0.17
- Winter-Spring	3.08	3.74	2.57	0.17
- Summer-Autumn	3.08	3.59	2.57	0.16

SOURCE: SUMMARY RESULTS OF SELF-SURVEY DATA IN 2022

The results of model estimation (3) using the OLS method are shown in Table 2 after performing tests related to the model and finding that the model does not violate the assumptions of the linear regression model. (like multicollinearity, heteroskedasticity, ...).

The production function estimation results in Table 3 show that the model has a high statistical significance of 1% and the coefficient of determination R^2 in the models is also quite high at about 95%, showing that the factors in The model has good control over fluctuations in production output.

The variable FS has a positive coefficient at a high significance level of 1% in all 3 rice cultivation seasons of the year, implying that as the scale of cultivated land expands, production output increases. Variable K has a positive coefficient with a high significance level of 1% in the Autumn-Winter and Summer-Autumn crops but is insignificant in the Winter-Spring crop, implying that in the Winter-Spring crop, productivity does not depend much on capital but in the Autumn-Winter and Summer and Autumn depends heavily oncapital. Similarly, variable L also has a positive coefficient at a low significance level of 10% in farming seasons (except the Autumn-Winter crop). The estimation results also show that the contribution of capital and labor is very small, but the opposite is true for the land factor (ieland contributes largely to the household's production productivity). This implies that the farming level of the farmers surveyed in the study area is advanced, and the contribution of capital is greater than labor and the level of land use in rice cultivation of farmers in the study area. research area.

Table 3: Production function estimation results to calculate TFP

The dependent variable is LnSL (logarithm of output).

Criteria	Autumn-Winter	Winter-Spring	Summer-Autumn
$\ln A_0 + \eta t$	0.894***	1.743***	0.921***

α_K	0.304***	0.052	0.279***
α_L	0.021	0.037*	0.038*
α_{FS}	0.989***	1.017***	0.982***
RTS = $\alpha_K + \alpha_L + \alpha_{FS}$	1.315	1.106	1.299
α'_K	0.231	0.047	0.215
α'_L	0.016	0.033	0.029
α'_{FS}	0.753	0.920	0.756
R^2	0.9578	0.9544	0.9596

Notes: (*) Significant at 10%, (**) significant at 5%, (***) significant at 1%.

SOURCE: ESTIMATED RESULTS OF SELF-SURVEY DATA IN 2022

4.3. Effects of factors on total factor productivity

THE DISSERTATION USES A GROUP OF EXPLANATORY VARIABLES TO ESTIMATE THE EFFECTS OF THESE VARIABLES ON FIVE MEASURES OF TFP OR THERE ARE FIVE MODELS TO ESTIMATE THE EFFECTS OF FARM SIZE ON TFP (INCLUDING LAND PRODUCTIVITY, LABOR PRODUCTIVITY, CAPITAL EFFICIENCY, EE AND TFP). THUS, THE DESCRIPTION OF QUANTITATIVE VARIABLES (TABLE 4) AND QUALITATIVE (TABLE 5) IS MADE BEFORE GOING INTO THE ANALYSIS OF THE ESTIMATED RESULTS. HOWEVER, VARIABLES ABOUT FARMSIZE, EDU, EXPER, NUMLABOR HAVE SHOWED IN TABLE 1.

TABLE 4. QUANTITATIVE VARIABLES IN THE MODEL (7)

Criteria	Unit	Mean	Max	Min	Std. Dev
FarmSize	Ha	1.71	17.00	0.10	1.77
NumLabor	Person	1.70	5.00	1.00	0.90
Edu	Classes	5.97	15.00	0.00	3.51
DIncome	Million VND/year	21.33	100.00	0.00	21.79
NumPlot	Plots	1.08	3.00	1.00	0.31
LaborHired	Days/hectares	34.56	156.25	1.88	22.60
LaborFamily	Days/hectares	40.87	211.67	0.94	26.72
TCapital	Million VND/hectares	65.65	104.11	43.30	9.17
Exper	Years	30.07	60.00	6.00	10.98
Distance	Km	4.86	75.00	0.01	10.77

SOURCE: SUMMARY RESULTS OF SELF-SURVEY DATA IN 2022

The average number of rice plots of the household is 1 plot, this is a typical farming characteristic of Mekong Delta farmers because they do not have the habit of dividing the farming scale into many different plots so it will face many difficulties in the management as well as the use of modern equipment and machinery in production. The distance from home to the largest rice field about 5 km, some households live away from the field to 75 km, which also makes it difficult to manage the family's rice field.

Besides, the income from rice cultivation, the household also has other sources of income about 21.33 million VND per year, in which the main focus such as income from workers - officials, income from trading - service and income from raising. The variable TCapital is the total amount of money that farmers invest in all stages of rice cultivation from preparing land, seed, fertilizer, medicine, and so on to harvesting, transportation with about 66 million VND per ha.

The total number of family workdays involved in managing and tending rice fields is about 75 days per ha, of which the number of family labor days invested in rice fields is higher than that of hired laborers.

Most of the interviewed households, the head of the household is male and only 51 female-headed households because of our country's perceptions and practices in general and the Mekong Delta in particular, especially in rural areas (Table 5).

Table 5: Quanlitative variables in the model (7)

Criteria	**Gender**		**Training**	
	Number of household	**(%)**	**Number of household**	**(%)**
Yes	51	10.24	297	59.64
No	447	89.76	201	40.36
Total	**498**	**100.00**	**498**	**100.00**

SOURCE: SUMMARY RESULTS OF SELF-SURVEY DATA IN2022

The majority of rice households who participated in the training courses in the past 3 years accounted for 59.64% with an average of 4.15 times and the highest number of participants in the 3 last year was 20 times. The knowledge that households received from the training courses is 45.75% of the knowledge using inputs; 44.98% of rice cultivation techniques; 36.62% of market information on output; 34.74% of credit information; and 0.76% for other information.

Table 6: Total factor productivity in rice cultivation of farmers

Unit: %

Criteria	**Mean**	**Max**	**Min**	**Std. Dev**
Autumn-Winter season	3.34	7.42	1.58	0.97
Winter-Spring season	6.09	10.52	3.59	1.33
Summer-Autumn season	3.37	6.44	1.66	0.95
Whole year	12.79	24.04	7.29	2.92

SOURCE: SUMMARY RESULTS OF SELF-SURVEY DATA IN 2022

Total factor productivity is a very important indicator that shows the technological level and management ability of farming households, and is an indicator that measures comprehensive production efficiency in land use. labor and capital. Any production activity on a large or small scale requires a high level of technology and good management ability to bring about increased efficiency in production. The highest TFP is in the winter-spring crop with an average of 6 and a standard deviation of 1.33. The crop with the lowest TFP target of the year is the autumn- winter crop of 3.34.

Testing for violation of the assumptions of the linear regression model is performed when estimating the model (7). The model only violates the heteroscedasticity phenomenon, so the estimation results presented in Table 7 are the results after correcting the heteroskedasticity phenomenon.

Table 7: Factors affecting the farm size to TFP of rice households

Dependent variable: TFP – Total factor productivity (%)

Variables	**Autumn-Winter**	**Winter-Spring**	**Summer-Autumn**	**Whole year**
FarmSize	0,6536***	0,4504***	0,6165***	1,7196***
	(0,0432)	(0,0589)	(0,0423)	(0,1224)
$FarmSize^2$	-0,0350***	-0,0231***	-0,0308***	-0,0889***
	(0,0048)	(0,0043)	(0,0045)	(0,0116)
NumLabor	0,0193	-0,0158	0,0287	0,0274
	(0,0378)	(0,0656)	(0,0373)	(0,1261)
Female	0,1107	0,1849	0,1906**	0,4794
	(0,1062)	(0,1716)	(0,0961)	(0,3433)
Edu	-0,0008	0,0051	0,0032	0,0062
	(0,0083)	(0,0150)	(0,0085)	(0,0270)
DIncome	0,0010	-0,0002	-0,0008	0,0000
	(0,0013)	(0,0025)	(0,0013)	(0,0042)
NumPlot	0,1717*	-0,1196	-0,0102	0,0690
	(0,0883)	(0,1717)	(0,0912)	(0,3183)
LaborHires	-0,0034*	-0,0025	-0,0046	-0,0044
	(0,0019)	(0,0053)	(0,0041)	(0,0046)
LaborFamily	-0,0014	0,0043	0,0058*	0,0049
	(0,0025)	(0,0054)	(0,0033)	(0,0041)
AnGiang	0,2598**	0,9682***	0,2799***	1,4695***

	(0,1113)	(0,1717)	(0,1064)	(0,3502)
DongThap	0,2727***	0,8484***	0,2119**	1,2979***
	(0,0941)	(0,1524)	(0,0916)	(0,3055)
TCapital	0,0121	0,0114	0,0162*	0,0242**
	(0,0085)	(0,0128)	(0,0086)	(0,0113)
Exper	-0,0095***	-0,0160***	-0,0089***	-0,0348***
	(0,0028)	(0,0051)	(0,0027)	(0,0091)
Distance	0,0005	-0,0086**	-0,0013	-0,0100
	(0,0022)	(0,0037)	(0,0025)	(0,0073)
Training	0,0566	-0,0296	-0,0514	-0,0119
	(0,0612)	(0,1055)	(0,0591)	(0,1910)
Cons	1,9870***	5,0518***	2,1235***	8,3258***
	(0,2648)	(0,4478)	(0,2548)	(0,9927)
Number of obs	498	498	498	498
R-squared	0,5552	0,2763	0,5622	0,5088
Prob > F	0,0000	0,0000	0,0000	0,0000

Notes: - Each variables, first row is estimated coefficient β_i and second row is standard deviation.

- (*) Significant at 10%, (**) significant at 5%, (***) significant at 1%.

SOURCE: ESTIMATED RESULTS OF SELF-SURVEY DATA IN 2022

The estimation results show that the models have high statistical significance and have shown a nonlinear relationship of the form ∩ between farm size and production efficiency expressed through a measure of total factor productivity. Synthetic factors in three rice cultivation seasons and the whole year. However, the R^2 in the models is relatively good (27.63% -56.22%) showing that these factors can only control 28% - 56% of the variation in total factor productivity, in when unobservable factors largely determine total factor productivity.

If we only analyze a simple model with only two factors: land size and total factor productivity, all three rice cultivation seasons show a nonlinear relationship of the form ∩ between farm size and total factor productivity with a high significance level of 1%. This shows that, as the scale of farming expands, it becomes easier for farming households to access information on input use as well as the ability to access credit (Khan and Maki, 1979), and specialized labor. With high skills, the ability to apply technology and management is higher. However, whenthe land size is too large to exceed the optimal threshold, each additional farm size will createan additional burden for the household because production costs increase faster than the increase in production efficiency (management ability) due to the low education level of farmers (only about 6th grade, limited capital, lack of specialized labor, ...) leading to a decline in TFP.

The estimation results also show that the variables that affect and have statistical significance on total factor productivity in all three production seasons are different. This proves that farmers have different investments in rice crops during the year, along with differences in input prices as well as changes in natural conditions.

When adding variables indicating household characteristics as well as management ability intoa complete model, the results show that the estimated coefficients of important observed variables remain relatively stable, meaning that in addition to the Farm size variable, Variables Female (only Summer-Autumn crop), NumPlot (only Autumn-Winter crop), TCapital (only Summer-Autumn crop), LaborFamily (only Summer-Autumn crop), AnGiang, DongThap affect TFP and LaborHires variable in the same direction (only in the Autumn-Winter crop), Distance (only in the Winter-Spring crop), Exper negatively affected total factor productivity in all three rice cultivation seasons.

Variables AnGiang and DongThap both have positive coefficients and are quite statistically significant in all three rice cultivation seasons. This implies that farming households residing in An Giang and Dong Thap have the ability to manage and apply technology more effectively than households living in CanTho, so households living in the two areas will be more effective. This table will have higher total factor productivity than households living in Can Tho. The variable LaborFamily has a positive coefficient at the 10% significance level only in the Summer-Autumn crop, implying that an increase of 1 day in the number of working days inthe rice fields of family labor will increase total factor productivity by 0.006 times. .

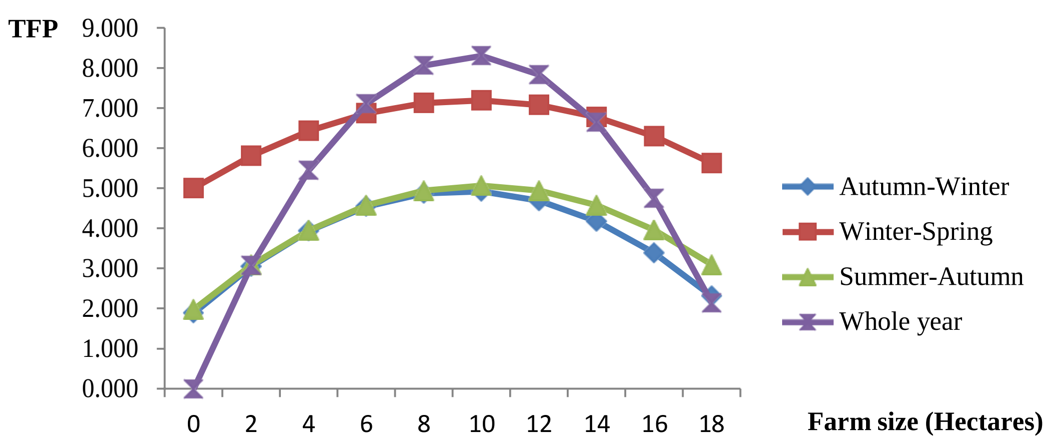
The variable TCapital has a positive coefficient at the 10% significance level in the Summer-Autumn crop but is insignificant in the Autumn-Winter and Winter-Spring crops, implying that when the amount of investment in the stages from input to output of the farming process is Rice cultivation will increase TFP by 0.016 times. The variable NumPlot also has a positive coefficient at the 10% significance level in the Autumn-Winter crop, implying that the more rice fields a farmer has, the more total factor productivity increases. Specifically, it will increase by 0.18 times when there is one more piece of cultivated field.

Among the factors of management ability, the Female variable has a positive effect on total factor productivity at the 5% significance level in the Summer-Autumn crop but is not significant in the remaining 2 crops of the year; This implies that if the household head is female, the ability to manage and apply technology to the family's rice farming activities will be better and 0.19 times higher than if the household head is male. The variable Exper has a high statistical significance of 1% in all three rice cultivation seasons and has a negative effect on total factor productivity because rice cultivation requires flexible application of experience and knowledge about natural environment and technological advances. The variable Distance has a negative coefficient at the 5% significance level in the Winter-Spring crop, implying that the closer the distance from the farmer's house to the largest plot of land, the higher the ability to manage and apply technology. Similarly, the variable LaborHires also has a negative coefficient at the 10% significance level only in the Autumn-Winter season and is insignificantin the Winter-Spring and Summer-Autumn seasons, implying that when the number of hired labor days working in rice fields increases, increases, TFP decreases due to the inability to control the motivation and working capacity of hired workers.

4.3. Optimal farm size of rice production households Mekong Delta

The estimated coefficient of the variable Farm size has a positive value at a high significance level of 1% in the Autumn-Winter, Winter-Spring, Summer-Autumn crops and the whole year and the variable Farm sizesq has a negative value with the same high significance level of 1% in all three seasons. Rice cultivation is the same all year as just described. This shows a nonlinear relationship of the form ∩ between farm size and production efficiency expressed through a measure of total factor productivity in rice cultivation in 2016 - 2017. From this result, to find the optimal farm size threshold (Debertin, 2002; Hassanpour, 2002; Greene, 2003; Hosseinzad et al., 2009; Hassanpour, 2013) for rice cultivation for each crop and whole year by differential method. The implication is that this is the optimal farm size threshold that helps farmers maximize production efficiency through a measure of total factor productivity because if production exceeds this optimal farm size threshold, the ability to manage and technology application by households will be ineffective due to (i) Difficulty controlling the working motivation of hired workers, (ii) Limited capital resources and (iii) Low management capacity of farming households due to education level. level is about 6th grade. Therefore, to bring about the highest efficiency in rice production, farmers should invest in a reasonable land scale for each crop (ranging from 9 hectares - 10 hectares). and the optimal farm size threshold for the whole year is 9.67 hectares.

The results of this study are quite similar to many studies such as: Hoque (1988) with the optimal farm size from 7 - 12 hectares; Nkonde et al (2015) with optimal farm size at 11.75 hectares; Wickramaarachchi and Weerahewa (2018) with the optimal farm size at 9.03 acres, farmers will achieve the highest production efficiency when farming at this optimal scale.



Source: Summary results of self-survey data in 2022

Figure 1. Optimal farm size in rice cultivation of Mekong Delta households

5. Conclusions and policy implications

This paper conducts an analysis of the relationship between farm size and TFP as a basis for determining the optimal farm size to maximize the efficiency of production activities. The analysis results show that the model is highly statistically significant and determines the inverted U-shaped nonlinear relationship between farm size and the efficiency of production activities as measured by total factor productivity in the whole year. Hence, the optimal farm size of 9.7 ha will bring highest the efficiency of production activities.

Besides, the main factor is farm size, TFP is also affected by other factors. The factors having positively effect on the TFP including total investment costs for inputs, the area of residence in AnGiang and DongThap. At the same time, the factor are years of experience having negative effect on the efficiency of production activities.

Based on the estimation results combined with the results of analyzing the reality of rice production of households in the Mekong Delta. The research proposed solutions to help use the farm size appropriately, improve production efficiency and improve household incomes.

Firstly, households with farm size smaller than the optimal farm size. On the one hand, households with good conditions and strong financial resources should rent or pledge the land of adjacent farming households to take advantage of economies of scale; collaborate with neighboring small farm rice households to expand production scale with groups, rice cultivation groups or cooperatives; can participate in a large model field to take advantage of the farm size and government's support policies; and need to link up to establish "large sample fields" and establish specialized farming areas associated with VietGAP standards. On the other hand, for households with limited financial resources should rent or mortgage land to neighboring households wishing to expand their farming; boldly transforming industries (especially non-agricultural occupations) through state support (vocational training, assistance in accessing capital, policies to attract investment and development of cottage industries and handicrafts); boldly transfer land to neighboring farmers in a suitable form when rice cultivation is not possible (ie exits to join the labor market); and the government should speed up the transfer of land use rights and voluntary labor contracts (Li et al., 2013).

Secondly, households whose farming size is greater than the optimal farm size should narrow the farming size to take advantage of internal resources as well as apply economic principles to increase the efficiency of production activities by dividing rice fields into two fields for household heads and children. Each person who manages and exploits a field will achieve maximum the efficiency of production activities. Additionally, developed in the direction of establishing a joint stock company because of its advantages compared to single production or group or cooperative, which is a clear division of labor and specialization according to each strength field, the company has workshops - storage warehouses - processing plants - stable output markets and reputable in the market. This issue help them maximize resources, increase their percentage of shares and profits received based on their farming size.

COMPETING INTERESTS

The author has no competing interests to declare.

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