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DETERMINANTS ON THE ADOPTION OF MODERN AGRICULTURAL TECHNOLOGY AT FARM HOUSEHOLD LEVEL: A CASE STUDY IN DONG ANH DISTRICT, HANOI CITY, VIETNAM

[a]Nguyen X. Dinh, [b]Nguyen M. Dung
[a] *Central Executive Committee of Vietnam Farmers' Union, Hanoi, Vietnam.*
[b] *Faculty of Economics and Rural Development, Vietnam National University of Agriculture, Hanoi, Vietnam.*

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ABSTRACT

This paper aims to identify the determinants on the adoption of modern agricultural technology at farm level in Dong Anh district, Hanoi city, Vietnam. A total of 300 farm households from Dong Anh district were randomly interviewed face to face for the necessary data collection. Logit regression model was used to explore the impact of different factors on the adoption of the modern agricultural technology. Findings indicated that the farmer' education, households' income, farm size, access to extension services and access to credit had statistically significant and positive impacts on the adoption. Meanwhile the number of land plot reflected the negative impact on the adoption. To foster the level of adoption, this study urges stimulating land accumulation for larger farm size and reduced number of land plots. In addition, demonstration models and more training courses for the farmers emphasizing on how to apply the modern agricultural technology and credit program providing loan with preferential interest rate should be provided for the farm households in the district.

Corresponding Author: Nguyen M. Dung
Email: maudung@vnua.edu.vn

INTRODUCTION

Agriculture in Vietnam is the commanding sector of the national economy, encompassing close to twenty percent of the GDP (GSO, 2020). At present around sixty percent of its total population is living in rural areas and dependent on agricultural production and associated activities. For its extremely important role, agricultural production has always been considered as the key sector in the national economy of Vietnam and the Vietnamese Government always commits to the view that the successful development of the country must be associated with the improved income and better life of its rural masses. However, the agricultural production in Vietnam has recently faced with many challenges of low productivity, food safety problems, decrease in agricultural land areas due to urbanization and industrialization, and severe impacts of climate changes (OECD, 2015). For overcoming these problems, the Vietnamese Government has made great efforts to promote the adoption of modern technology or high-technology such as new varieties, mechanization, information technology, etc. in agricultural production. Despite these efforts and economic viability of agricultural modern technology, the adoption rate of modern technology is various among the regions, and even various among the farm households in the same region. What factors do affect the adoptions of modern technology at farm households in Vietnam and at what

extents are interesting questions that need to be answered for the different decision of the adoption among the farm households.

There is a plenty of literature which deals with the modern agricultural technologies and the factors affecting the adoption of modern agricultural technologies by the small farms in developing countries (Franzel *et al.*, 2001; Place *et al.*, 2009; Tefera, 2013). According to Jain *et al.* (2009), agricultural technologies consist of all kinds of modern techniques and improved practices which will help improve the output and efficiency of agricultural production. As indicated by Challa and Tilahun (2014) modern agricultural technology tends to raise outputs and reduce average cost of production which in turn results in substantial gain in farm income. Technological innovation and its adoption therefore play a very crucial role in the agricultural development and has been considered a main factor which leads to the rapid development of agricultural industry in the last few decades in the world, especially in the developing countries where the agriculture is constituted by the majority of small farm households. According to Loevinsohn *et al.* (2013), agricultural technology adoption is an integration of a new technology into existing agricultural practices and is usually proceeded by a period of trying and some degree of adaptation. According to Doss (2003) it is also necessary to consider if adoption is a discrete status with binary response variables or not.

The decisions on the adoption of modern agricultural technology as well as the extent of the adoption by farmers are influenced by various factors. According to many scholars such as Katung and Akankwasa (2010), Akudugu *et al.* (2012), Loevinsohn *et al.* (2013), etc., those factors can be classified into three groups including economic, social and institutional groups. The farm size or the land holding of the farm households, the cost of technology adoption, the household income and the anticipated benefit from the technology adoption are included in the group of economic factors.

The social factor group consists of the age, education level and gender of farm householders, while the accessibility to extension services, accessibility to credit provision, and policy environment of state and local authorities are included in the institutional factor group (Akudugu *et al.*, 2012). However, those affecting factors on the agricultural technology adoption could also be classified into broad categories including the characteristics of farm householders, farm structure, institutional setting and managerial structure (McNamara *et al.*, 1991). Meanwhile other researchers categorize those factors into human capital, production and the environment of policies and natural resources (Wu and Babcock, 1998).

Characteristics of farmers such as education level, age, gender is assumed to have some effects on the adoptions of agricultural technologies. High education level of farmers could possibly increase their knowledge and ability, then make them more reasonable and open in mind, and better evaluate the gains of the improved farm technology. As the result, farmers' education level usually places the positive impacts on their decision on adoption of the new agricultural technologies (Okunlola *et al.*, 2011; Uematsu and Mishra, 2010). Age of farmers is however often uncovered to place a negative effect on new technology adoption or younger farm householders have a tendency to adopt more than the older. The main reason is that younger householders are usually less risk-averse and they are typically more eager to strive new technologies (Sezgin and Kaya, 2011). Gender issue has also been investigated in many studies related to agricultural technology adoption and different results on the role of men and women has been found (Bonabana-Wabbi, 2002). However, in the study of the adoption of new maize varieties in Ghana by Doss and Morris (2000) the relationship between gender and the adoption were found to be not statistically significant or gender had no significant effects on the adoption.

Farm structure includes the farm size, labor force and household income. In many studies, farm size or land holding of farm households is considered as the important determinants of the adoption of new agricultural technology. However, the influence of the land holdings on the adoption was found quite various across the studies. The impact of this factor on the adoption could be positive, negative and even neutral (Yaron *et al.*, 1992; Kasenge, 1998). The availability of agricultural labor force within households may facilitate application of technology due to liquidity constraints majority of farming households cannot easily acquire hired labour (Carletto *et al.*, 2007). The effect of the farm household income on the adoption of agricultural technologies has also been investigated and it is usually reported that the farm with higher income tend adopt new agricultural technology more (Reardon *et al.*, 2007; Sezgin and Kaya, 2011).

Institutional factors including the accessibility to credit provision, accessibility to extension services and the setting of local and national policies could also place the impacts on the adoptions. Thanks to extension services provided such as training course, demonstrations, or extension staff's visits and advices, farmers will certainly understand well how to practice with new technology and they will also recognize the benefits of modern agricultural technology more clearly. Many researchers have therefore found a positive interaction between extension services availability and new technology adoption. Similarly, it is also reported by many researchers that better accessibility to credit would encourage farm households to adopt new agricultural technologies since the credit accessibility could help small farm households to overcome budget constraints for the adoption (Mohamed and Temu, 2008; Simtowe and Zeller, 2006). The national and local policies such as subsidizing agricultural inputs or outputs for adopted farmers could also stimulate the adoption rate.

There are only a few studies on adoption of agricultural technologies in Vietnam. Van Thanh and Yapwattanaphun (2015) studied on banana farmers' adoption of sustainable agricultural practices in Quang Tri province (North Central Region of Vietnam). Hoang (2020) conducted a study on adoption of good agricultural practices by cattle farmers in Binh Dinh province (the South of Vietnam). For the rice production, Dung *et al.* (2018) studied on the determinants of rice farmers' adoption of sustainable agricultural technologies in the Mekong delta in Vietnam meanwhile Le *et al.* (2020) examined the information acquisition and the adoption of a new rice variety in rural villages in Central Vietnam. This study however focuses on the determinants on the farmers' adoption of modern agricultural technology in the red river delta of Vietnam. This will contribute to enrich the understandings of the impacts of farmers' characteristics, farm structures and institutional factors on the adoption of modern agricultural technologies, especially in the red river delta of Vietnam.

METHODOLOGY

Study site description

This study is conducted in Dong Anh district - a suburban area of Hanoi city. Dong Anh district is located in the Red river delta – the second largest rice bowl of Vietnam (after the Mekong delta). The district has an agricultural land area of 10,540 ha (57.8% of total natural area) and the total population of 415 thousand people in 100,4 thousand households. It is estimated in 2020 that the farm households accounted for around 85% of total households in the district. The main crop in the district was rice as it accounted for 68% of total planted areas (Hanoi Statistics Office, 2020). Since 2018, the local authority has encouraged farm households to adopt the new rice variety with high quality using the modern technology in fertilizing and pesticide management for improving their income. For this purpose, the local government subsidize 50% of new variety cost for farm households and the training courses on the farming techniques are provided for farmers in the district. However, up to 2020, the area of new rice variety accounted for around 25% of the total rice cultivated areas.

Data collection

The secondary data including the number of farm households and agricultural area in the district were mainly gathered from the department of Agriculture and Rural Development in Dong Anh district. The primary data on adoption of modern agricultural technology were collected from farm survey using the questionnaire set. The number of survey farm households was calculated based on the formula for identifying the sample size as follows (Cochran, 1963).

$$n = \frac{z^2\, pq}{e^2}$$

where, n stands for estimated number of survey farm households or the sample size, z is confident level, e is the maximum allowable error. P stand for population proportion of adopted farm. Taking the maximum allowable error e of 5%, and p =0.25%, the value of z is 1.96 at confident level at 95% then the number of farm households for the survey or the sample size is acquired to be 296. However, for better securing the confident level, a total of 300 rice farm households in the district were chosen for the survey.

The random sample method was applied for selecting the farm household for the survey. At first, three representative communes for rice production were selected (out of 24 communes in total in Dong Anh district) through the group discussions with the local district staff. Then the list of all rice farm households in those three communes was produced and 300 farm households were randomly selected from the list with the similar range (similar range with the household

number on the list). The face-to-face interviews with the householders of those 300 selected farm households were conducted in 2020 for gathering the necessary data on the adoption of modern agricultural technology and the related factors in the farm households (such as characteristics of the farm householders, farm structures and the famers' access to credit and to extension services).

The models

Both logit and probit models could be used particularly for predicting the relationship between the binary response probability (the dependent variable) and explanatory factors (independent variables) and they give almost identical results. Both models provide a measure of how appropriate an explanatory variable (coefficient size) is, and its tendency of the relationship (positive or negative). However, the logit model carrier's fewer assumption than the probit model. Moreover, logit model is very flexible and easy to use from mathematical viewpoint (Hosmer & Lemeshow, 1991); Greene, 2008). Therefore, we choose the logit model for determining the factors affecting the decision of modern agricultural technology adoption of the farm households in this study. A random utility model was constructed to estimate the probability that a farm households would adopt modern agricultural technology. A random utility model is written as follows (Ben-Akiva and Lerman, 1985):

$U_{in} = V_{in} + \varepsilon_{in}$, i =1,....,I and n = 1,....,N (1)

Where;

U_{in} is expected utility of the nth farmer if he or she chooses alternative i. Vin is the deterministic portion of the utility (to be maximized), and ε_{in} is random error. The probability that farmer n decides to take alternative i is:

$Pn(i) = Pr(U_{in} \geq U_{jn}) = Pr\ (V_{in} + \varepsilon_{in} \geq V_{jn} + \varepsilon_{in}) = Pr(\varepsilon_{jn} - \varepsilon_{in} \leq V_{in} - V_{jn})$ ……..(2)

for all i, j ϵ Cn where Cn is the choice set for farm n

It is assumed that the stochastic component εin in Equation (1) has a distribution that is independent and identical across the alternatives and individuals. εjn - εin in equation (2) is logistically distributed. Then the probability of farmer n that decides to choose alternative i is given as follows:

$$P_n(i) = \frac{e^{\mu V_{in}}}{\sum_{j \epsilon Cn} e^{\mu V_{jn}}}$$

Where μ > 0 is the scale parameter, assumed equal to one since it is unidentifiable within any particular data set and cannot be distinguished from the overall scale of the estimated coefficients of the linear parameter βs. With two choices (i = 1 and i = 0), a logit model gives the probability of choosing 1 alternative is as (Ben-Akiva and Lerman, 1985).

$$P_n(i=1) = \frac{e^{\mu V_{in}}}{e^{\mu V_{in}} + e^{\mu V_{jn}}} = \frac{1}{1+e^{-\mu(V_{in}-V_{jn})}} = \emptyset(V) = \emptyset(\beta' x),$$

It means that Prob (Adoption) = ϕ(β'x) where β'x is the vector of parameters to be estimated and x is the vector of observations. The reduced form of logit models in this study is given as follows

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_k X_k$

In this study, the binary variable in the model is the state of adoption by the survey farm households (taking value of 1 if farm adopted modern agricultural technology and 0 if farm did not adopt). The explanatory variables include the farmers' characteristics (age, gender, education), farm structure (farm size, household income, agricultural labor in the farm, number of rice plot), and institutional factors (accessibility to extension services and accessibility to credit).

As the farm households in the district take the same policy environment and the similar input and output market, the variable of policy and market access are not considered in the model. The detail of explanatory variables is given in Table 1.

RESULTS AND DISCUSSION

Characteristics of survey farm households

The results from direct interviews with the farm households reveal that 181 farm households (out of 300 selected ones) had adopted the modern technology for their rice production while the rest of 119 households had not adopted, yet. In the average, the household head was 45.6 years old (ranging from 25 to 67). There was not statistically difference in the age between adopter and non-adopter group (table 2). Around 65% of household heads were male and significant difference was statistically (at 0.05 level) found between adopter and non-adopter group. While 69% of the adopters were male, the figure for non-adopter was 58%, respectively.

The respondents had spent 7.64 years in schools for the formal education. The adopters were found to have more year in schools (0.98 year) or higher education level than the non-adopters. This disparity was significant at

0.01 statistical level. In the average, one survey farm households have the income of 52.56 mil VND/year (or around 2250 USD).

The adopted households also had significantly higher income (12.65 mil. VND) than non-adopted ones. The farm households had 2.4 agricultural labors within family and there was no significant difference between two groups. Generally, the farm households in the district have quite small agricultural land areas. Each survey farm households had just 3173m2 for the cultivation. Adopted farms were found to have larger farm size, but fewer number of plots than non-adopted ones. These differences have a significance at 0.01 level by statistical test.

Table 1. Explanatory variables used in the household adoption model.

Variable name	Description	Values
Age	Age of householders	Years
Gender	Gender of householders	1 for male, 0 for female
Education level	Education level of householders	Years in school
Income	Household income	1000 thousand VND
Agri-labor	Agri-laborers of a household	No. of agri-laborers in farm households
No. of plot	Land plots of a household	Number of plots
Farm size	Rice planted areas	m2
Access to extension	Extension services is provided to farmers	1 for being provided, 0 for otherwise
Access to credit	Loan access of farm household	1 for borrowing loan, 0 for otherwise

Source: Household survey by the research team

Table 2. Characteristics of survey farm households.

Variable name	All (n=300)	Adopters (n=181)	Non-adopters (119)	Difference	P-value
Age (year)	45.60	46.00	45.18	0.82	0.2620
Gender (dummy)	0.65	0.69	0.58	0.11**	0.0295
Education (year)	7.64	8.03	7.05	0.98***	0.0012
Income (mil. Vnd)	52.56	57.57	44.92	12.65**	0.0217
Agri-labor (person)	2.40	2.41	2.39	0.02	0.4302
No. of plot (number of plot)	3.10	2.95	3.32	-0.37***	0.0001
Farm size (m2)	3173.3	3840.1	2159.2	1680.9***	0.0001
Accessibility to extension services (dummy)	0.52	0.58	0.41	0.17***	0.0016
Accessibility to credit (dummy)	0.37	0.44	0.26	0.18***	0.0009

***,**statistically significant at 0.01and 0.05 level respectively.

Source: Household survey by the research team

Data indicates that 52% of the farm households accessed extension services though the training courses on modern technology and also through the extension staffs' visit to farm households. Around 37% of farm households borrowed the loan, mainly from the agricultural banks for farm production. The proportions of adopted farm households that accessed extension services and credits were found significantly higher at 0.01 level than the figures of non-adopted farms.

Factors affecting the adoption of modern agricultural technology

The logit regression model is used for identifying the factors affecting the adoption of modern agricultural technology at farm level in Dong Anh district. The results of the logit model are presented in Table 3. Since the chi-square test statistics for the estimated model is 132.98 and the Prob > chi^2 is 0.0000, it means that empirical logit model is highly significant (at 0.001 level) in explaining the decision to adopt the modern agricultural

technology by farm households in the district. The coefficient of the independent variables including farmer' education level, household income, number of land plots, access to extension services, access to credit is statistically significant. This implies that those variables significantly affect the probability of a farm household to adopt the modern agricultural technology. Meanwhile the other explanatory variables such as age and gender of the householders, number of agricultural labors within the farm households are not statistically significant in explaining the adoption decision of survey farm households.

Education level significantly affects the farmers' decision of the adoption. Famers with higher education level has higher probability of the adoption as the expected. The coefficient of 0.1075 for education variable means that if the farmers get one more year in school, the probability of the adoption will increase by 0.1075 or 10.75% (if other variables remain constant). This finding is similar to study results of Challa and Tilahun (2014), Salasya *et al.* (2007), Beshir *et al.* (2012) who also concluded that existed the positive and significant interaction between the farmers' education level and their decision on the new technology adoption.

Table 3. Effects of explanatory variables on farmers' adoption of modern agricultural technology through binary logistic regression.

Variables	Coeff.	Z	P > |z|
Age of householders	0.00747	0.51	0.610
Gender of householders	0.34734	1.06	0.287
Education level	0.10754*	1.79	0.074
Household Income	0.06480*	1.82	0.068
Agricultural labor	0.18901	1.15	0.251
Number of plots	-0.61057***	-3.22	0.001
Farm size	0.00122***	7.04	0.000
Accessibility to extension services	0.74179**	2.40	0.016
Accessibility to credit	0.83268**	2.44	0.015
Constant	-3.8362***	-3.05	0.002
Log likelihood		-135.00	
LR Chi^2		132.98	
Prob> Chi^2		0.0000	
Pseudo R^2		0.330	

Note: ***,**, * stand for statistically significant at 0.01, 0.05 and 0.1 level, respectively.

The household income was also found to significantly and positively affect the adoption of the farm households at 0.1 statistical level. This is consistent with the results of many studies such as Sezgin and Kaya (2011), Challa and Tilahun (2014). When the household income increases by 1 million VND, the households in Dong Anh district would adopt the modern technology at higher probability of around 6.48%. The farm size also places the positive and very significant effect on the adoption of modern technology at 0.01 level. It is possible that the farmer with larger rice land area wants to apply the technology in large amount for high efficiency. This finding is similar to the study results by Sharma *et al.* (2010), Akudugu *et al.* (2012), Idrisa *et al.* (2012), etc. The number of rice land plot is however found to place the negative effect on the adoption of the survey farm households at 0.01 statistical significance level. The farmer with more rice land plots would adopt the modern technology at lower probability. It is possibly because when farmers have more plots it means their rice land is more scattered. In this case, the management cost for adoption of modern technology would be higher, thus hindering the farmer's adoption.

The model results show that the farm households' access to credit provision and access to extension services have positive impacts on the adoption of new agricultural technology at statistical level of less than 0.05. Farm households who adopt the modern agricultural technology need more budgets for buying the necessary inputs such as the varieties and fertilizers. The access to

credit provision thus plays the crucial role in helping farm households to overcome the budget limitations for the adoption. This is consistent with the findings of many researchers such as Beshir *et al.* (2012), Salasya *et al.* (2007). The farm households in the district with the accessibility to the extension services also have higher probability of the adoption. It is because when farmers participated in the training courses or visited to the demonstrations, they would be provided with full guidance by extension agents on how to adopt the modern technology and explained in detail what the benefits they could get from the adoptions, how they could overcome the problems or difficulties when they face with for adopting the technology. It is similar with the results from Le *et al.* (2020) in the study on the adoption of new rice variety in central Vietnam, and from Kinyangi (2014) in studying factors affecting the adoption of new farming technology at small farm households in Kenya.

CONCLUSION AND RECOMMENDATIONS

The adoption of the modern agricultural technology at farm level in Dong Anh district is influenced by characteristics of farmers, farm structures and institutional factors. Farmers' education level, household income, farm size, access to extension services and access to credit were found to have positive impacts on the adoption with statistical significance. The number of land plot, however place the negative impact on the adoption with statistical significance. Meanwhile age and gender of householders, number of agricultural labors within the households are not of statistical significance in explaining adoption decision of survey farm households.

Based on these findings, we recommend that stimulating land accumulation for larger farm size and reduced number of land plots within the farm households should be done for enhancing the adoption of modern agricultural technology by farm households. It is also highly important to improve the extension services in the district since farmers' education and extension services both have the positive effects on the adoption. More training courses for farmers on how to apply the modern agricultural technology should be provided. In addition, the demonstrations should be built so that the farmers can visit and learn how to apply viably. Credit program providing loan with preferential interest rate should also be attached to the adoption promotion program in the district.

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