

How to Cite:

Binh, N. D. (2022). Factors affecting the application of high technology in agriculture production of farmers in Ho Chi Minh City, Vietnam. *International Journal of Health Sciences*, 6(S1), 52-63. <https://doi.org/10.53730/ijhs.v6nS1.4756>

Factors Affecting the Application of High Technology in Agriculture Production of Farmers in Ho Chi Minh City, Vietnam

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Abstract--The article analyzes the factors affecting the decision to apply technology in agricultural production of farmers in Ho Chi Minh City. The logit model was used for the analysis. The results of the regression analysis showed that factors such as gender, education level, family labor, cultivated area, non-agricultural income, agricultural extension services, credit, farm training and economic efficiency from the application of high technology has a positive impact on the decision to apply technology in agricultural production of farmers in Ho Chi Minh City. While factors such as age, profit orientation, risk aversion, input costs, complexity of technology, and popularity of technology have a negative impact on the decision to apply technology of farmers.

Keywords---agricultural production, farmers, hi-tech agriculture, hi-tech application, Vietnam.

Introduction

Increasing labor productivity in order to contribute to increasing production and quality of goods to meet the increasing demand for food is very important. What to do to increase production and meet the demand for food security in the context that the land area is shrinking due to urbanization, desertification and saltwater intrusion is a big problem for countries. To solve that problem, countries have applied high technology to agricultural production, contributing to increasing productivity and quality of goods, meeting the demand for food security, and contributing to food security and sustainable development of the economic.

Ho Chi Minh City is the economic locomotive of Vietnam. However, in the process of development, the city's agricultural sector has not yet confirmed its role and position. In 2020, the agricultural sector contributes only 0.7% of the total GRDP, equivalent to 9.06 trillion VND (HCMC Statistics Office, 2020). In order for Ho Chi Minh City to become the economic and cultural center of the ASEAN region, the

International Journal of Health Sciences ISSN 2550-6978 E-ISSN 2550-696X © 2022.

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Manuscript submitted: 27 Nov 2021, Manuscript revised: 18 Feb 2022, Accepted for publication: 09 March 2022

city's agricultural sector must undergo a drastic transformation in order to actively contribute to socio-economic development goals. Therefore, the application of high technology to agricultural production is a fundamental way to increase productivity, promote socio-economic development, help increase sustainable food production. The development of hi-tech agriculture also creates favorable conditions for labor migration from the agricultural sector to the industrial and service sectors. [Jorgenson \(1961\)](#), considers technology to be a direct factor determining growth in the agricultural sector. Because of technical progress, the marginal product of agricultural labor is always greater than zero even though farmland is fixed. It can be seen that the application of technology in agricultural production is an urgent requirement of Ho Chi Minh City. Therefore, the analysis of factors affecting the decision to apply high technology in agricultural production of farmers plays a very important role in the process of policy making for the development of high-tech agriculture in the city. The remainder of the article is organized as follows. Section 2 presents the relevant literature review. Section 3 discusses the methodology applied. Section 4 presents result and discussion. The last section presents conclusions and policy implications.

Literature review

Theoretical foundations of high-tech agriculture

According to [Loevinsohn et al. \(2013\)](#), technology is the means and method of producing goods and services, including organizational methods as well as technical materials. Technology itself is aimed at improving a certain status quo to a more desirable level. It assists the worker to do his job more efficiently than he would in the absence of technology ([Bonabana-Wabbi, 2002](#)). Technology adoption is the integration of a new technology into an existing practice, carried out by a phase and some degree of adaptation ([Loevinsohn et al., 2013](#)). Technology adoption falls into two categories, the rate of application and the intensity of the application. The adoption rate is the relative rate at which farmers adopt the innovation over a given period of time. According to [Jain et al. \(2009\)](#), agricultural technology is understood to include all kinds of technical and implementation improvements that affect the growth of agricultural output.

Factors affecting the decision to apply technology in agriculture

Analyzing the factors affecting farmers' decision to apply high technology in agricultural production has been studied by many authors. [Akudugu et al. \(2012\)](#), grouped the determinants of agricultural technology adoption into three categories: economic, social, and institutional factors. Farmers' qualifications are found to have a positive influence on farmers' decisions to adopt high technology. The farmer's education increases his intellectual capacity; help him process and use information related to the application of new technology ([Mignouna et al., 2011](#)). A study by [Okunlola et al. \(2011\)](#), found that educational attainment has a positive and significant effect on technology adoption. Higher education influences farmers' decisions, making them more open to and able to analyze the benefits of new technologies ([Waller et al., 1998](#)).

Age is also believed to be a determining factor in new technology adoption. Older farmers are said to have gained knowledge and experience over time and are better able to assess technology and gain more information than younger farmers (Kariyasa & Dewi, 2013; Mignouna et al., 2011). Inversely, age was found to have a negative relationship with technology adoption. This relationship is explained by (Barrera et al., 2005), that as farmers get older, risk aversion increases and the return on long-term investment in the farm decreases. On the other hand, young farmers are often more risk-averse and willing to try new technologies.

Information available about technology affects people's adoption. It allows farmers to know a lot about the existence of new technology and the effectiveness of its adoption and this will facilitate technology adoption. Farmers only apply technology that they know or have heard about. Access to information reduces uncertainty about the performance of technology and thus can radically change individuals' subjective judgments over time (Uaiene et al., 2009).

Technology adoption by farmers will be higher when extension services are provided. Through extension services, farmers learn the benefits of new technology at extension agents. Enhancing actors act as a link between the creators (researchers) of the technology and the users of that technology. This reduces the transaction costs incurred when transferring information about new technologies to a large number of farmers (Genius et al., 2014). Many authors have reported a positive relationship between extension services and technology application in agriculture such as: Application of Imazapyr resistant maize (IRM) technology (Mignouna et al., 2011); improved maize adoption and land management in Uganda by (Sserunkuuma, 2005); application of modern agricultural technologies in Ghana (Akudugu et al., 2012).

A study conducted by Kinyangi (2014), has shown the factors affecting the application of high technology and agricultural production of smallholder farmers in the North of Kakamega district (Kenya) including: credit facilities; training human resources for agriculture; agricultural extension policy; market size; education level, gender and age. By using the logit model and the profit model, the authors have pointed out the factors that positively affect the application of high technology to rice cultivation by farmers in Nerica, Ghana such as: farm size, access to credit, farm training, ownership of machinery, equipment and labor by households. Meanwhile, factors such as age and profit orientation have a negative influence on the application of high technology in rice production in Nerica, Ghana (Udimal et al., 2017).

Farm size plays an important role in the adoption of new technology. Farm size affects farmers' technology adoption because some technologies are called scale dependent (Bonabana-Wabbi, 2002). Many studies have reported a positive relationship between farm size and agricultural technology adoption (Uaiene et al., 2009; Wiggins, 2009). Large-scale farmers are more likely to adopt a new technology because they can afford to dedicate a portion of their land to testing the new technology unlike smaller farms (Uaiene et al., 2009). Several studies have shown a negative effect of farm size on agricultural technology adoption. Small farm size can provide incentives for technology adoption, especially in the case of input-intensive innovations such as labor-intensive or land-saving technologies.

Smallholder farmers can adopt land-saving technologies such as greenhouse technology, no grazing as an alternative to increasing agricultural production (Yaron et al., 1992). A study by (Grieshop, Zalom, & Miyao, 1988; Samiee et al., 2009), concluded that farm size did not affect the adoption of integrated pest management (IPM) implying that dissemination IPM can take place regardless of the size of the farmer's operation. Household size is used simply as a measure of available labor. It determines the adoption process in that a larger household is able to reduce labor in the process of adopting new technology (Mignouna et al., 2011).

A study by Melesse B (2018), in Ethiopia has shown that the application of high technology in agricultural production of the people is influenced by three main factors: (1) Demographic factors including factors such as: female-headed or male-headed families have differences in technology adoption; Older people with a lot of experience in traditional agricultural production and young people also have differences in the process of applying new technology to production. (2) Factors on socio-economic situation include Education level of farmers; availability of agricultural land and access to properties; availability of labor resources; farm size. (3) Institutional factors include services for agricultural development such as: financial services; insurance; information; the infrastructure; market access; agricultural extension policies. Meanwhile, the application of high technology to the Chinese people's lychee growing process is assessed by Li et al. (2019), as dependent on factors such as: Scale of lychee production of people; people's accumulated knowledge about litchi; experience in growing litchi; intellectual level; people's attitude towards positive assessment of new technology.

The decisive factor in the adoption of new technology is the net profit that farmers gain from adopting the technology, including all costs of using the new technology (Foster & Rosenzweig, 1995). Previous studies on the determinants of technology adoption have reported that high technology costs are an obstacle to farmers' technology adoption. Research conducted by (Makokha et al., 2001), reported high labor and other input costs, packaging and on-time delivery as the main obstacles to with fertilizer use. The cost of hired labor is also reported by (Ouma et al., 2002), as one of the other factors hindering the application of fertilizers and hybrid seeds in Embu County Kenya. Research by Wekesa et al., (2003), when analyzing the determinants of improved maize adoption in the coastal lowlands of Kenya, found that the cost was high and not Seed availability is one of the factors causing low technology adoption rates.

Off - farm income is also reported to have a positive impact on technology adoption. Off -farm income serves as an important strategy to overcome credit constraints for rural households in many developing countries (Reardon et al., 2007). According to (Diirro, 2013), non-farm income helps farmers replace working capital to increase inputs such as improved seeds and fertilizers. However, not all technologies show a positive relationship between nonfarm income and its adoption. According to Goodwin & Mishra (2004), the pursuit of off-farm income may undermine their adoption of modern technology by reducing their interest in agriculture.

Inheriting domestic and international studies, on the basis of socio-economic reality, the author believes that the application of high technology in agricultural

production is influenced by five groups of factors: group of factors related to institutions (credit policy, agricultural extension, training); group of factors related to producers (gender, age, education level, profit orientation, family labor, risk aversion, non-agricultural income); group of factors related to the socio-economic situation (infrastructure, input costs, technology development); group of factors related to characteristics and performance of technology (complexity of technology, popularity of technology, economic efficiency from technology adoption) and group of factors related to natural conditions natural – geographical (land characteristics, climatic conditions).

Research Methods

Research model

The model explains the binary dependent variable (1/0) based on whether the respondents accepted ($Y = 1$) or did not accept ($Y = 0$). Regression model is used to measure the factors affecting the decision to apply high technology in agricultural production of Ho Chi Minh City. There are quite a few theoretical models for studying variables with nominal scales. In this topic, the author uses Logit model with Maximum Likelihood method to estimate regression coefficients. Logit models come in two forms:

$$P\left(Y = \frac{1}{X}\right) = \frac{e^{(\beta X)}}{1 + e^{(\beta X)}} \quad \text{or} \quad P\left(Y = \frac{1}{X}\right) = G(X\beta) \quad (1)$$

Where: $P\left(Y = \frac{1}{X}\right)$ is the conditional probability on X so that $Y = 1$; $G(X\beta)$ is the cumulative distribution function of X . After transforming the Logit regression function to

$$\ln\left(\frac{P(Y=1)}{P(Y=0)}\right) = \beta_1 + \beta_2 X_{2i} + \dots + \beta_n X_{ni} + e_i \quad (2)$$

Put $P(Y=1) = P_0$; $P(Y=0) = 1 - P_0$, the above equation can be rewritten as follows:

$$Y = \ln\left(\frac{P_0}{1-P_0}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \dots + \beta_{19} X_{19} + e_i \quad (3)$$

Thus, the decision to apply high technology in agricultural production of farmers in Ho Chi Minh City is established in the form:

$$Y = \beta_0 + \beta_1 * Sex + \beta_2 * Age + \beta_3 * Education + \beta_4 * Profit\ orientation * + \beta_5 * Family\ labor + \beta_6 * Risk\ aversion + \beta_7 * Farm\ size + \beta_8 * Off-farm\ income + \beta_9 * Credit\ access * + \beta_{10} * On-farm\ demonstration + \beta_{11} * Agricultural\ extension\ service + \beta_{12} * Input\ cost + \beta_{13} * The\ complexity\ of\ the\ technology + \beta_{14} * Popularity\ of\ technology + \beta_{15} * Economic\ efficiency\ from\ applying\ technology + \beta_{16} * The\ development\ of\ technology + \beta_{17} * The\ infrastructure + \beta_{18} * Characteristics\ of\ the\ land + \beta_{19} * Weather\ condition + e_i$$

Data

The study was conducted on 05 suburban districts of Ho Chi Minh City, including Cu Chi, Binh Chanh, Nha Be, Hoc Mon, and Can Gio. This area was chosen because it is the main agricultural development locality of the city, especially Cu Chi is the place where the Hi-tech Agricultural Park is located according to Decision No. 3534/QD-UB dated July 14, 2004 of Ho Chi Minh city people's Commission, with an area of 88.17 hectares.

The author interviewed directly by questionnaire to receive feedback from farmers. The farmers who have lived and have been in agricultural production for a long time were purposefully selected to limit interviews with people who were not engaged in agricultural production, who did not have adequate knowledge of how agriculture was produced. Sampling technique is performed multistage. First, each district selects 02 communes, then each commune selects 02 hamlets and finally, using a random sample, a number of farmers in each hamlet will be asked to answer the question. On the basis of the population of each hamlet, the determination of the sample size was determined by the formula of Taro Yamane (minimum sample size was the largest with $p = q = 0.5$).

$$n_1 = 0,5 \times (1 - 0,5) \left(\frac{z}{\varepsilon} \right)^2 = 0,25 \times \left(\frac{z}{\varepsilon} \right)^2$$

z = distribution value corresponding to selected confidence (if 95% confidence level, z value is 1,96)

$$= 0,25 \left(\frac{1,96}{0,05} \right)^2 = 384$$

The response rate is assumed to be 96% and the final sample size (n_2) is calculated as follows: $n_2 = 384/0.96 = 400$. Thus, the number of samples to be investigated will be 400, the number of samples to be included in the analysis is 384. The field survey started in November 2021 and ended in February 2022.

Table 1
Variable with their definitions and a prior expectation

Variables Definitions Expected signs	Variables Definitions Expected signs	Variables Definitions Expected signs
Sex	1 if the farmer are male; 0 otherwise	+/-
Age	Number of year	+/-
Education	Years of formal education by the farmer	+
Profit orientation	1 if the farmer treats rice farming as a business enterprise; 0 otherwise	+
Family labor	Number of family members providing labor	+
Risk aversion	1 if the farmer practices crop diversification; 0 otherwise	+/-

Farm size	Number of hectares used for agriculture	+
Off farm income	Total income from sources other than agriculture farming in Cu Chi district, HCM city.	+
Credit access	1 if the farmer has access to credit; 0 otherwise	+
On-farm demonstration	1 if the farmer participated in any on-farm demonstrations; 0 otherwise	+
Agricultural extension service	1 if the farmer Agricultural extension service; 0 otherwise.	+
Input cost	1 if costs are burdensome for farmers; 0 otherwise.	-
The complexity of the technology	Levels from 1 (less complex) to 5 (very complex)	-
Popularity of technology	Percentage of locals applying high technology to production.	+
Economic efficiency from applying technology	What percentage increase in economic value when applying high technology to production	+
The development of technology	1 if the technology is development; 0 otherwise.	+
The infrastructure	1 if the infrastructure is development, 0 otherwise.	+
Characteristics of the land	if it is convenient for the application of technology; 0 otherwise.	+
Weather condition	if it is convenient for the application of technology; 0 otherwise.	+

Source: Authors' calculation.

Results and Discussions

After excluding variables that are not statistically significant, such as: infrastructure, technology development, soil characteristics and climate conditions (Sig value > 5%). The model is analyzed on 15 factors affecting the decision to apply high technology in agricultural production of farmers. The results of Binary Logistics regression analysis give the value $-2 \text{ Log likelihood} = 104,013a$ and Nagelkerke R Square = 0.891, showing the reliability of the model, which proves the explanation of the independent variables for the decision high technology application in agricultural production of farmers in Ho Chi Minh City is possible, the model predicts the correct probability of 97.9%. Binary Logistics regression equation on factors affecting the decision to apply high technology in agricultural production of households in Ho Chi Minh City is written in the form.

$$\ln(\text{odds}) = -460.667 + 2,295 * \text{Sex} - 25,429 * \text{Age} + 7,803 * \text{Education} - 139.385 * \text{Profit orientation} + 80,813 * \text{Family labor} - 144,502 * \text{Risk aversion} + 67,481 * \text{Farm size} + 50,841 * \text{Off-farm income} + 15,004 * \text{Credit access} + 114,970 * \text{On-farm demonstration} + 93,725 * \text{Agricultural extension service} - 0,588 * \text{Input cost} - 4,111 * \text{The complexity of the technology} - 1,019 * \text{Popularity of technology} + 120,095 * \text{Economic efficiency from applying technology} + ei$$

The results of marginal effects in the table 2 show that, when the household size is large, as shown in the large number of laborers in the family, the probability of applying high technology in agricultural production increases to 90% compared to families with few workers. This result is quite similar to the results of the study (Mignouna et al., 2011). Farm size has a positive effect on technology applicability. As the farming area of farmers increases, the opportunity to apply high technology in Ho Chi Minh City also increases to 90%. This is true of the research results of (Uaiene et al., 2009), the larger the area, the more people are willing to spend a part of their land to test new technologies. Off farm income has a strong impact on the ability of farmers to apply high technology, when the off-farm income of households increases, the probability of applying high technology to agricultural production in Ho Chi Minh City will increase 90%. This result is quite consistent with research (Reardon et al., 2007), that suggests that off-farm income acts as an important strategy to overcome credit constraints for households rural areas in many developing countries and (Diirro, 2013), off-farm income helps farmers substitute working capital to increase inputs such as improved seeds and fertilizers.

Farmers who have the opportunity to access training programs and seminars are more likely to apply high technology to agricultural production than those who do not. The results of the marginal effects in table 2 show that the farmers who have access to the training sessions, the probability of applying high technology in agricultural production will increase to 90%. The results from this study are quite consistent with those of (Udimal et al., 2017).

Agricultural extension services have a positive impact on farmers' ability to apply technology. Extension services contribute to strengthening the actors working to link between creators and users of technology. The results of marginal effects in table 2 show that farmers who have access to agricultural extension services, the probability of applying high technology to agricultural production will be 90% higher than those who do not have the opportunity to access agricultural extension services. This result is quite similar to the study of (Genius et al., 2014) that extension services help reduce transaction costs incurred when transferring information about new technology to a large number of farmers.

Economic efficiency from the application of high technology is the goal that every manufacturer. The results of marginal effects in table 2 show that, when farmers can determine the economic benefits brought from the application of high technology, the opportunity to apply high technology in production is also higher than 90%. This result is consistent with the study of (Foster & Rosenzweig, 1995).

Table 2
The degree of impact of factors on the decision to apply high technology in agricultural production of farmers in Ho Chi Minh City

Nub	Factors	B	Exp(B)	dy/dx
1	Sex	2.295	9.928	0.424514
2	Age	-25.429	0	-0.1
3	Education	7.803	2447.723	0.896337

4	Profit orientation	-139.385	0	-0.1
5	Family labor	80.813	1.25E+35	0.9
6	Risk aversion	-144.502	0	-0.1
7	Farm size	67.481	2.03E+29	0.9
8	Off farm income	50.841	1.2E+22	0.9
9	Credit access	15.004	3280889	0.899997
10	On-farm demonstration	114.970	8.53E+49	0.9
11	Agricultural extension service	93.725	5.06E+40	0.9
12	Input cost	-.588	0.555	-0.04192
13	The complexity of the technology	-4.111	0.016	-0.09823
14	Popularity of technology	-1.019	0.361	-0.06144
15	Economic efficiency from applying technology	120.095	1.43E+52	0.9
<i>Constant</i>		-460.667	1.43E+52	0.9

Source: Authors' calculation.

Credit policy is a factor that strongly affects the ability to apply high technology to agricultural production of farmers in Ho Chi Minh City. The results of marginal effects in table 2 show that, when credit policies are favorable, farmers easily access credit, the probability of technology application will be 89.9% higher than those without credit access. This result is quite consistent with the study of [Udimal et al. \(2017\)](#). The level of education of farmers positively affects the ability of farmers to apply technology. When the education level of farmers increases by one grade, the probability of farmers applying high technology is higher than 89.6%. According to [Mignouna et al. \(2011\)](#), a farmer's level of education increases his intellectual capacity; help him process and use information related to the application of new technology. Gender also positively affects farmers' ability to apply technology to agricultural production. The results of the marginal effects in table 2 show that, when men are head of the household, the probability of applying technology is 42.5% higher than that of female-headed households. This result is consistent with the study of [Udimal et al. \(2017\)](#). Meanwhile, factors such as age, profit orientation, risk aversion, input costs when applying technology, complexity of technology and technology's popularity have a negative influence on the ability to Technology application ability of farmers in Ho Chi Minh City. The results of marginal effects in Table 2 show that these variables are all negative.

Conclusions and Recommendations

The results of the regression analysis from the logit model are quite consistent with the empirical studies in the world. The application of high technology to agricultural production by farmers in Ho Chi Minh City is influenced by groups of factors such as institutions, personal characteristics, socio-economic situation, technology characteristics and performance. Factors such as gender, education level, family labor, cultivated area, non-agricultural income, agricultural extension services, credit, farm training and economic efficiency from high technology application has a positive impact on the ability to apply technology to agricultural production of farmers in Ho Chi Minh City. Other factors such as: age, profit orientation, risk aversion, input costs, complexity of technology, popularity of technology have a negative impact on the decision to apply technology of the company. farmer

household. Based on these findings, the paper proposes some recommendations as follows:

- *Firstly*, Ho Chi Minh City should promote training programs and seminars to create conditions for farmers to access new technologies, gradually transfer technology to farmers through public application projects. technology into the production of vegetables, ornamental flowers, ornamental fish, shrimp farming, dairy cow raising. At the same time, promote trade promotion activities to gradually expand the consumption market to meet the output demand for high-tech agricultural products.
- *Second*, Ho Chi Minh City should strengthen preferential credit policies for farmers applying high technology, creating favorable conditions for farmers access to capital with preferential interest rates, helping them invest in modern equipment, new varieties of plants and animals.
- *Third*, the city should implement agricultural extension policies well to help farmers know the benefits of new technologies, and through agricultural extension services to increase contact between scientists and farmers, helping people solve questions and concerns about the complexity of technology, reduce risk aversion and confidently apply technology in production.
- *Fourth*, the city should regularly organize visits to effective technology application models at home and abroad to help farmers know the economic efficiency from the application of technology in agricultural production. On the other hand, it is necessary to strengthen the organization of agricultural fairs to create opportunities for farmers to participate and learn experiences in production and consumption of high-tech agricultural products.
- *Fifth*, the probability of high technology application depends quite a lot on the scale of production land. Therefore, in order to stimulate farmers to apply high technology, Ho Chi Minh City should have solutions to develop the agricultural cooperative model and encourage businesses with capital and technology potential invest in high-tech agricultural.

In summary, this study uses a logit model to determine the factors affecting the decision to apply technology in agricultural production of farmers in Ho Chi Minh City. However, the article just stopped at one city, not the whole country. Therefore, broader studies should be continued to contribute to proposing policy implications to promote the development of high-tech agriculture nationwide.

Acknowledgement

The research is funds by University of Economics and Law (VNU-HCMC) under grant number: CS/2021-01

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