Crop diversification, economic performance and household behaviour
Evidence from Vietnam

Huy Nguyen*

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* PhD student at Arndt-Corden Department of Economics, Crawford School of Public Policy, Australian National University. Email: huy.nguyen@anu.edu.au. I am grateful to participants at the PhD economic seminar, Arndt-Corden Department of Economics, ANU, for useful comments on earlier version of this paper.

Abstract

This study examines economic performance and household behaviour in multiple crop farming in Vietnam by measuring scale and scope economies, technical efficiency, and elasticities of substitution between inputs. The farming system in Vietnam is being transformed by integration between a set of cash crops and main food cropping operations. This transformation into diversified farming systems, where smallholders have a production base in rice, can affect the economies of scope, technical efficiency, and performance of farms. By using the approach of the input distance function, evidence is found of both scale and scope economies. These findings have important economic performance implications. Substantial technical inefficiency exists in multiple crop farming, which implies that by eliminating technical inefficiency crop, outputs could, in principle, be expanded by 20 per cent. Enhancing education and further land reforms are the main technical efficiency shifters. Evidence is also found for complementary between family labour and other inputs, except hired labour. The findings show further that the more adverse the farm production conditions, the more efficiently resources are allocated.

Key words: *crop diversification, input distance function, elasticity of substitution, stochastic frontier, technical efficiency, economies of scope, and economies of scale*

JEL code: O12, O13, O33

1. Introduction

The Vietnamese agricultural sector has been experiencing significant structural changes in recent years. Although agricultural systems are dominated by rice production, accounting for 65% of annual cropping land (Agricensus, 2006), a large number of rice farmers grow other annual crops in conjunction with rice to improve their livelihoods in the absence the land designation policy for higher economic profits (World Bank 2007; Dao & Lewis, 2013). Farm households in poor areas are converting some paddy land to other annual cropland so that they can earn higher incomes (Minot et al., 2006). FAO (2012) suggests that diversifying production to include horticulture and high value crops allows smallholders to broaden sources of food in local diets and to enter domestic markets for higher-value products. This is said to strengthen resilience to economic and climate risks.

The Strategy of Agriculture and Rural Development (2011-2020), issued by the Vietnamese government in 2009, set specific objectives for self-sufficiency in food grain production along with the increased production of other nutritious crops, as well as encouraging the exports of vegetables and other annual crops, keeping in view domestic consumption demand changes and nutritional requirements (DS, 2009). In this strategic plan, the government plans to reduce paddy land from 4.1 million hectares to 3.8 million hectares to promote crop diversification.[1] Such an emphasis at the policy level shows the importance of determining the merits of crop diversification at the farm level. Thus, the merits in terms of gains in economic performance of diversified crop farms are examined, so that an informed judgment may be drawn about the suitability of crop diversification as a desired strategy for promoting agricultural development.

It has long been recognised that the economic performance of diversified farm households is being increasingly influenced by output-input jointness (Paul and Nehring, 2005). As a result, economies of scope may exist when crop diversification leads to cost reduction associated with multi-output production processes (Baumol et al., 1982). Several empirical studies find evidence of economies of scope in farming (Chavas and Aliber 1993; Fernandez-Cornejo et al. 1992; Paul and Nehring 2005; Rahman 2010). While management expertise and technological advances tend to favour specialization, income uncertainty due to input and output price variability may favour diversification (Mafoua-Koukebene et al. 1996; Marsh et al., 2006; Chavas and Di Falco, 2012).

[1]The government also issued the Decision-1006 (2014) to restructure crop sectors in the period 2014-2020 with the priority to diversify crops (www.mard.gov.vn)

The objective of this paper is to examine the economic performance of crop-diversified farms in Vietnam. It tests whether the dynamic process of change in integrated farming sub-systems can affect the potential for productivity gains and technical efficiency. The economic performance of crop-diversified farms is also analysed by examining the response of households in adjusting output and input combinations in an environment of increasing cost stress, particularly in small farms. The substitutability between inputs can have an impact on the cost and efficiency of farm production (Paul et al., 2000). Understanding the economic performance of crop diversification is important in designing food security policies related to crop diversity.

Most existing studies focus only on rice instead of multi-output and multi-input patterns in Vietnam's agricultural production.[2] This study contributes to literature in several ways. Firstly, to the best of the author's knowledge, this research provides the first investigation of the economic performance of annual crop-diversified farms in Vietnam using parametric regression. The investigation of economic performance on rice-based diversified farm households should inform the Government's agricultural policy and provide a better understanding of household behaviour for annual crops. Secondly, it also provides the first evidence of the elasticity of substitution and complementarity between inputs, particularly the response of households to changes in other variables such as an increase in costs of fertilizer, pesticide and capital. Finally, understanding technical efficiency enables policy makers to uncover the factors that hinder productivity growth of annual crop farming in Vietnam. Kompas et al. (2012) provided evidence on the role of further land reform on improving technical efficiency in Vietnamese rice production. The determinants of technical efficiency in multi-crop environment, however, are an empirical question.

The paper is organized as follows. Section 2 introduces the research methodology including theoretical framework, empirical model and performance measures. Section 3 describes the dataset and the construction of variables. Section 4 reports and discusses the empirical results. The final section concludes and presents policy implications.

2. Research methodology

2.1. Theoretical framework

In order to investigate economies of diversification, technical efficiency and elasticity of substitution, a multiple output and input production technology is required. In this paper, an input-oriented stochastic distance function is analyzed instead of output oriented

[2] Papers that study the efficiency in rice production in Vietnam include Kompas et al. (2004, 2012); Vu (2012).

distance function. This is because inputs are scare and scattered, especially land, and rising costs of agricultural production due to high inflation over the past decade (World Bank 2011). Input expenditures accounted for 70 % in Vietnam's rice production in 2007 and 2008, which put more pressure on farmers' profits (FAO 2010, p. 229). Thus, it is logical to assume that the main concern is cost minimization or input orientation. In addition, the choice of a stochastic input distance function approach can allow separating the random noise from technical inefficiency effects.

In the study of stochastic frontier analysis, Kumbhakar and Lovell (2003) introduce the overview of input distance function. This function describes how much an input vector may be proportionally contracted with the output vector that is held fixed. This paper uses the theoretical framework introduced by Paul and Nehring (2005, p. 529). The input distance function *D(x,y)* is formally defined as:

$$D(x,y) = \max\left\{\lambda; \lambda > 0, x/\lambda \in L(y)\right\} \qquad (1)$$

$$L(y) = \left\{x \in R_{+}^{N} : x\right\}, x \text{ can produce } y \qquad (2)$$

Where x is a scalar, *L(y)* is the set of input requirement x, which is used to produce the output vector y. *D(x, y)* is non-decreasing, positively linearly homogenous and concave in x, and increasing in y. Paul and Nehring (2005) show that the input distance function can provide the measure of technical efficiency because it allows for deviation from the frontier. Finally, there is a dual relationship between input distance function and cost function, which allow us to relate the derivatives of the input distance function to the cost function (Färe and Primon, 1995).

To empirically estimate the distance function, a functional form must be specified. This paper selects the translog functional form used by previous studies (Grosskopf et al., 1995; Paul et al., 2000; Irz and Thirtle, 2004; Paul and Nehring, 2005; Rasmussen, 2010; Rahman, 2010). The translog input distance function with M outputs, N inputs of the farm household i is given by:

$$\ln D_i = \beta_0 + \sum_{n=1}^{N}\beta_n \ln x_n + \frac{1}{2}\sum_{n=1}^{N}\sum_{k=1}^{N}\beta_{nk}\ln x_n \ln x_k + \sum_{m=1}^{M}\alpha_m \ln y_m + \frac{1}{2}\sum_{m=1}^{M}\sum_{l=1}^{M}\alpha_{ml}\ln y_m \ln y_l + \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{mn}\ln y_m \ln x_n \qquad (3)$$

Where D_i measures the radical distance from (x,y) to the production function and denotes the unobservable value of the distance function. As the input distance function is linear homogenous in inputs, the parameters in equation (3) must satisfy the following regulatory restrictions:

$$\sum_n \beta_n = 1, \sum_k \beta_{nk} = 0, \sum_n \gamma_{mn} = 0 (m = 1,...,M)$$

$$\beta_{nk} = \beta_{kn} (N, K = 1,...N); \alpha_{ml} = \alpha_{lm} (m, l = 1,....M)$$

We use the approach of Lovell et al. (1994) and Coelli and Perelman (1999) in imposing these restrictions by normalizing the function by one of the input. As a result, equation (3) is expressed as follows:

$$\ln(D_i / x_{1i}) = \beta_0 + \sum_{n=2}^{7} \beta_n \ln x_n^* + \frac{1}{2} \sum_{n=2}^{7} \sum_{k=2}^{7} \beta_{nk} \ln x_n^* \ln x_k^* + \sum_{m=1}^{4} \alpha_m \ln y_m + \frac{1}{2} \sum_{m=1}^{4} \sum_{l=1}^{4} \alpha_{ml} \ln y_m \ln y_n + \\ + \sum_{m=1}^{4} \sum_{n=2}^{7} \gamma_{mn} \ln y_m \ln x_n^* = \ln D(x^*, y) \quad (4)$$

Where $x_{ni}^* = x_{ni} / x_{1i} (\forall n, i)$ i.e. summing only *N-1* inputs are not used for normalization. Substituting *lnD* with *u* and adding an additional error term v to account for random noise result in a standard stochastic production frontier model including composed error structure as follows:

$$\ln(x_{1i}) = -(\beta_0 + \sum_{n=2}^{7} \beta_n \ln x_n^* + \frac{1}{2} \sum_{n=2}^{7} \sum_{k=2}^{7} \beta_{nk} \ln x_n^* \ln x_k^* + \sum_{m=1}^{4} \alpha_m \ln y_m + \frac{1}{2} \sum_{m=1}^{4} \sum_{l=1}^{4} \alpha_{ml} \ln y_m \ln y_n + \\ + \sum_{m=1}^{4} \sum_{n=2}^{7} \gamma_{mn} \ln y_m \ln x_n^*) - u_i + v_i \quad (5)$$

2.2. Econometric specification

The frontier estimation is different from typical econometric models in which adding a normal error term allows the functions to be fitted with the data. Furthermore, it implies that a one-sided error term (u_i) should be appended to the function. When the function captures stochastic errors, the model is transferred into a stochastic production frontier perspective, which was initially developed by Aigner, Lovell and Schmidt (1977) for production functions. The component of error terms is: the technical inefficiency error, and the irrelevant noise in the data such as measurement error and unobserved inputs v_i and independence to u_i. The term u_i is assumed to be a non-negative random variable independently distributed as truncation at zero of the normal distribution with unknown mean, M_i.

One of the issues arises for implementing the distance function estimation is which of the inputs might be used as a normalizing factor. As Collie and Perelman (2000) argue, any input can be chosen and this should not present econometric problems because the results are invariant to this choice. However, there could still be economic reasons for selecting x_1. Because this analysis mainly focus on rice-based annual crop farms, so all other inputs are represented relative to land as x_1 in this study.[3] The empirical model is derived as follows:

$$-\ln x_{1i} = \beta_0 + \sum_{n=2}^{7} \beta_n \ln x_n^* + \frac{1}{2}\sum_{n=2}^{7}\sum_{k=2}^{7} \beta_{nk} \ln x_n^* \ln x_k^* + \sum_{m=1}^{4} \alpha_m \ln y_m + \frac{1}{2}\sum_{m=1}^{4}\sum_{l=1}^{4} \alpha_{ml} \ln y_m \ln y_n + \sum_{m=1}^{4}\sum_{n=2}^{7} \gamma_{mn} \ln y_m \ln x_n^* + \sum_{k=1}^{8} \rho_k REG_k + v_i - u_i \quad (6)$$

And according to Battese and Coelli (1995), the parameter in the inefficiency distribution is expressed as $u_i = \eta_0 + \sum_{s=1}^{9} \eta_s M_{is} + \zeta_i^*$ (6a)

Where x_1 is land cultivated per farm as the normalizing input, v_i is the two-sided random error and u_i is the one-sided error in model (6), M in equation (6a) introduces variables that represent farm household characteristics. The model is added dummy variables that controls for regional differences, REG_k. The model (6) includes seven production inputs (X), four outputs (Y) and nine variables of M_{is} in the technical inefficiencies model. The estimates of parameters in the equations (6) and (6a) were implemented by using maximum likelihood estimation in a single state shown in Coelli and Perelman (2000). STATA 13 is used to estimate the model.

2.3 Performance measures

2.3.1. Scale and scope economies

Willig (1979) finds that with economies of scope, joint production of two goods by one firm is less costly than combined costs of production of two firms. Moreover, economies of scope arise from the presence of public inputs (Baumol et al., 1982). Based on the above ideas, scale and scope economies can be derived in farming production. Färe and Primont (1995) and Paul and Nehring (2005) find that the combination of the first-order input elasticities representing scale economies shows the positive correlation between productivity and input growth. Moreover, these studies conclude that the relationship between input and output scale economy is defined as the sum of individual input elasticities and reflects how much overall input use must increase to support a 1% increase in all outputs. Based on the development in Paul and Nehring (2005), the

[3]Using land as a normalizing variable in the input distance function has been widely applied in many studies in agricultural economics (Irz and Thirle, 2004; Paul and Nehring, 2005; Rahman, 2010; Rasmussen, 2010). This choice is consistent with the typical agricultural economics approach to production modelling in terms of yields, and inputs per acre.

individual input elasticity summarizing the input expansion that is required for a 1% increase in Y_m is expressed as follows:

$$-\varepsilon_{D,y_m} = -\frac{\partial \ln D}{\partial \ln y_m} = \frac{\partial \ln x_1}{\partial \ln y_m} = \frac{\partial x_1}{\partial y_m}\frac{y_m}{x_1} = \varepsilon_{x,y_m} \qquad (7)$$

The measure in the equation (7) can be considered as an “input share” of y_m that is relative to x_1. It is expected to be negative for all desirable outputs. Summarizing all elasticities in equation (12) results in a measurement of scale economies shown by:

$$-\varepsilon_{D,y} = -\sum_m \frac{\partial \ln D}{\partial \ln y_m} = \sum_m \frac{\partial \ln x_1}{\partial \ln y_m} = \varepsilon_{x,y_m} = \varepsilon_{x,y} \qquad (7a)$$

Paul and Nehring (2005) indicate that the extent of scale economies (for proportional changes in all inputs) is implied by the shortfall of $\varepsilon_{x,y}$ from 1. $\varepsilon_{x,y} < 1$ implies increasing return to scale. In addition, we can decompose the first-order elasticities $\varepsilon_{x,ym}$ and $\varepsilon_{x,y}$ into the second-order effects capturing the changes in output composition as scale expands. This decomposition is implied by technological bias measures showing how the y_m input elasticity or the share $\varepsilon_{x,ym}$ reflects to a change in another output. Thus, these measures provide insights about the output jointness of the agricultural production system. The increase in y_m as y_l increases can be represented by $\varepsilon_{y_m,y_l} = \partial \varepsilon_{x,y_m} / \partial \ln y_l$. If $\varepsilon_{y_m,y_l} < 0$, output jointness or complementarity is implied. As a result, there is an existence of economies of scope in farm production. With economies of scopes, the cost of adding the production of y_l to the production of y_m is smaller than the production of y_l alone. As a result, this elasticity is represented by the cross-output coefficient estimate α_{ml}, $\varepsilon_{y_m,y_l} = \alpha_{ml} = \varepsilon_{y_l,y_m}$. If the complementarity between outputs is satisfied, an increase in one output expands the contribution of other outputs and thus performance and cost savings.

2.3.2 Elasticity of substitution

In this paper, the estimated parameters of the input distance function are used to calculate the Morishima elasticity of substitution (MES). The familiar Allen-Uzawa elasticity of substitution (AES) is also calculated and compared with the MES. In the two input case, the MES and AES provide the same result. However, they yield different results if there are more than two inputs (Grosskopf et al., 1995, p. 282). This paper mainly focuses on the computation applied in several studies (Grosskopf et al., 1995 for MES and AES; Kumar, 2006 for MES and AES; Rahman, 2010 for MES and AES).

Grosskopf et al. (1995, p. 281) claim that due to the complete description of the production technology, the parameters of the input distance function may be used to describe the characteristics of the frontier technology, including curvature, which captures the degree of substitutability along the surface technology. Hence, the indirect MES as denoted by Blackorby and Russel (1989) can be calculated as:

$$MES_{x,nk} = -\frac{d\ln[D_n(x,y)/D_k(x,y)]}{d\ln[x_n/x_k]} = x_n\left(\frac{D_{nk}(x,y)}{D_k(x,y)}\right) - x_n\left(\frac{D_{kk}(x,y)}{D_n(x,y)}\right) \quad (8)$$

Where the subscripts in the input distance function indicates partial derivatives with respect to inputs, e.g. $D_{nn}(x,y)$ represents the second order derivative of the distance function with respect to x_n. Kumar (2006) notes that the first derivatives of the input distance function with respect to inputs obtain the normalized shadow price of that input due to the dual property between cost function and the input distance function. The first component of the definition, thus, can be considered as the ratio of percentage change in the shadow prices resulted from 1% change in the ratio of inputs. This represents the change in relative marginal products and input prices needed to affect substitution under cost minimization. Grosskopf et al. (1995) suggest a simplified method to calculate the indirect MES as follow:

$$MES_{x,nk} = \varepsilon_{x,nk}(x,y) - \varepsilon_{x,nn}(x,y) \quad (9)$$

Where $\varepsilon_{x,nk}(x,y)$ and $\varepsilon_{x,nn}(x,y)$ are the constant output cross and own elasticity of shadow prices with respect to input. The first term gives information on whether pairs of inputs are net substitutes or net complements, and the second term is the own price elasticity of demand for the inputs. In addition, Kumar (2006) further adds that if $\varepsilon_{x,nk}(x,y)$ is greater than zero, net complements are implied. If $\varepsilon_{x,nk}(x,y)$ is less than zero, net substitutes are indicated. In the case of indirect MES, if more input x_n were used for a given level of x_k, a higher value of MES suggests lower substitutability and the relative shadow price of x_n to x_k would increase substantially. In this way, the indirect MES give information as to the feasibility of substitution. In addition, MES is not symmetric. Using the parameters from the translog estimating equation (6), $\varepsilon_{x,nk}(x,y)$ and $\varepsilon_{x,nn}(x,y)$ are obtained as follows:

$$\varepsilon_{x,nk}(x,y) = [\beta_{nk} + S_n S_k]/S_k \text{ if } n \neq k \text{ and } \varepsilon_{x,nn}(x,y) = [\beta_{nn} + S_n(S_n - 1)]/S_n \text{ if } n{=}n \quad (10)$$

Where S_n is the first order derivative of the translog input distance function with respect to x_n as: $S_n = \partial \ln D / \partial \ln x_n = -\partial \ln x_1 / \partial \ln x_n^*$ (11)

As regards the AES, Grosskopf et al. (1995) suggest a method to derive the AES from the input distance function as follows:

$$AES_{x,nk} = \left[D(x,y)D_{nk}(x,y)/D_n(x,y)D_k(x,y)\right] \quad (12)$$

From the parameters of the equation (6), the AES can be estimated as:

$$AES_{x,nk} = \frac{\beta_{nk}}{(x_n x_k) D_n D_k} \text{ Where } D_n = (1/x_n)[\hat{\beta}_n + \sum_n \hat{\beta}_{nk} \ln x_k^* + \sum_m \hat{\gamma}_{mn} \ln y_m + \hat{\theta} \ln P_i] \quad (12a)$$

It should be noted that all elasticities of substitution (MES and AES) are evaluated at the mean of the data using parameter estimates of equation (6).

2.3.3 Technical efficiency

Technical efficiency (*TE*) refers to the ability to minimize input use in the production of a given output vector, or the ability to obtain maximum output from a given input vector (Kumbhakar and Lovell, 2003). In general, $0<TE<1$, where $TE = 1$ reflects that farms are producing on the production frontier and are said to be technically efficient. Alternatively, $TE<1$ implies that farms are technically inefficient, which means that ($1-TE$) captures the proportional reduction in inputs, x that can be gained to produce output, y.

Equation (6a) estimates the determinants of technical inefficiency in annual crop farms. From the one-sided error term u_i in equation (6), the levels of technical efficiency can be estimated. According to Kumbhakar and Lovel (2003), variance term is defined as $\delta^2 = \delta^2_v + \delta^2_u$ and $\gamma = \delta^2_u / (\delta^2_v + \delta^2_u)$. Using the approach of Coelli and Perelman (1999), the input distances are predicted as $D=E[exp(u)/e]$, where $e=v-u$. The technical scores of each farm are derived from the inverse of these input distances D.

3. Data

The paper uses the Vietnam Household Living Standard Survey (VHLSS) in 2006 for empirical analysis. This survey is nationally representative, and consists of questionnaires at both household and communal levels. There were 9,189 households surveyed in VHLSS 2006. This empirical analysis focuses on rice-based farms that mainly grow rice, starchy crops, vegetables and industrial annual crops. It should be noted that there are 4,824 farm households representing 52.49 % of total households in VHLSS 2006. Rice-based annual cropping farms are selected to study (3,059 rice farms accounting for an average 63.94% of farms in the sample).

To concentrate on household behaviour of rural households in adjusting output and input combination and measures of economies of scope, particularly small farms, from the full sample, we follow the approach of Jolliffe (2004) by selecting farm households with at least one member who describes the main jobs as farming. In addition, farm households producing at least one annual crop are selected. The sample used in this paper thus includes pure tenant households, and land rental households. This selection criterion results in a sample of 1,970 farm households.

Table 1. Definitions, units of measurement and summary statistics for all variables in the empirical analysis

Variable	Unit	Obs.	Mean	Std. Dev.
Output variables				
Rice (y_1)	Kg	1970	1876.68	2713.83
Vegetables (y_2)	Kg	1970 (1550)	410.06	1152.29
Starchy crops (y_3)	Kg	1970 (1445)	1025.48	4110.27
Annual industrial crops (y_4)	Kg	1970 (751)	71.62	310.94
Input variables				
Land area cultivated (x_1)	Ha	1970	0.41	0.54
Family labour (x_2)	Hours	1970	2293.65	1616.68
Fertilizers (x_3)	kg	1970	525.93	717.59
Pesticides (x_4)	1000 VND	1970	359.74	1071.03
Labour hired (x_5)	1000 VND	1970	340.02	1184.20
Capital hired (x_6)	1000 VND	1970	546.40	968.83
Seeds (x_7)	1000 VND	1970	415.07	597.48
Farm specific variables				
Age of the household head	Years	1970	47.72	11.13
Mean education of working age men	Years	1970	4.08	2.17
Mean education of working age women	Years	1970	3.99	2.16
Household members, from 15 to 60	Persons	1970	3.02	1.20
Dependency ratio (%)	%	1970	0.31	0.22
Days of illness	Days	1970	21.25	43.03
Number of plots	Plots	1970	6.32	4.26
Hours of nonfarm wage participation	Hours	1970	988.77	1519.42
Ratio of land with land use right certificates	%	1970	0.63	0.40

Table 1 describes the summary of statistics on the variables. In the inefficiency model, there are a number of variables representing farms' characteristics that may affect technical efficiency. The age of the farm household head is included to control for demographic differences between farms. In this paper, the impact of education is decomposed between male and female education. Women education are playing more important role in farm production (Rahman, 2010). The family size is also added in the model to test whether it affects technical efficiency. It is defined as a subsistence pressure variable, which is used by some studies (Rahman, 2010; Wang et al. 1996).

As regards land policies, there are two key variables including land fragmentation and land certificate title. The first is land fragmentation measured by the number of plots. The paper test whether land consolidation results in improving technical efficiency. The latter is the ratio of land under title to total land areas of farms. The final variable in the inefficiency model is hours of participation into nonfarm activities. Farms with a higher nonfarm hours may operate at lower level of technical efficiency (Wang et al., 1996).

It should be noted that the average farm size of multiple crop-growing households is small (0.41 hectare per farm), in which 95% of farmers have land areas less than 1 hectare. In light of high land fragmentation in rural Vietnam (average 6.32 plots per farm in VHLSS 2006), diversification can be a solution to reduce risk for small farms when income from rice production is low. Chavas and Di Falco (2012) found that small-scale farms tend to diversify to stabilize the returns of different crops and reduce risk.

4 Results and discussion

4.1. Tests of hypotheses for model selection

Table 2 provides the results of hypothesis tests. It provides the results of the likelihood ratio tests. There are five hypothesis tests that are summarized in Table 2. Firstly, testing the selection of a right functional form, the log likelihood specification test rejects the Cobb-Douglas specification in favor of a translog production function. Secondly, it tests whether the inefficiency term *u* is non-stochastic and equal to zero. The log likelihood ratio test at 5% significant level rejects the null hypothesis. As a result, this indicates that significant technical inefficiencies exist in Vietnam's agriculture.

Table 2. Tests of hypotheses

Name of tests	Null hypothesis	Likelihood ratio ($\chi^{2\text{-calculated}}$)	$\chi^{2\text{-critical}}_{(0.95)}$	Decision
1. Functional form (Translog vs Cobb-Douglass)	H_0: $\beta_{nk}=\alpha_{ml}=\gamma_{mn}=0$ for all n, k, m and l	1092.71	73.31	Reject H_0
2. No inefficiency effect	H_0: $\gamma=\eta_0=\eta_1=\eta_2=\eta_3=\eta_4=\eta_5=\eta_6=\eta_7=\eta_8=\eta_9=0$	41.39	3.84	Reject H_0
3. Farm specific effects do not affect technical inefficiencies	H_0: $\eta_0=\eta_1=\eta_2=\eta_3=\eta_4=\eta_5=\eta_6=\eta_7=0$	76.48	15.51	Reject H_0
4. Input-output separability	H_0: all $\gamma_{mn}=0$ for all m and n	97.36	36.42	Reject H_0
5. Returns to scale (scale economy if $\varepsilon_{x,y}<1$)	H_0: $(\Sigma\alpha_m)=1$ for all m	11.39	3.84	Reject H_0

Next, the paper tests whether the variables in the technical inefficiency model are statistically significant. The null hypothesis is rejected at 5% level, implying that the distribution of inefficiencies is not the same across individual household and is subject to the variable of vector M_i in equation (6a). Then, the hypothesis of input-output separability is also tested. The hypothesis test is defined mathematically by equating all cross-terms between outputs and inputs (γ_{mn}) to zero. The null hypothesis is strongly rejected, which indicates that it is impossible to aggregate consistently the two outputs into a single index. As the same time, this result shows why the input distance function is more appropriate than a stochastic frontier production function, which requires the aggregation of all outputs before estimation. The final test introduced is the presence of returns to scale in the context of multi-output technology. The summary of all regulatory restrictions of all α_m that equal to 1 is tested. The null hypothesis is also rejected in favor of the existence of scale economy.

In this paper, the monotonicity condition is tested, which shows that the input distance function is non-decreasing in inputs (i.e. $\partial \ln D / \partial x_n \geq 0$) and non-increasing in outputs (i.e. $\partial \ln D / \partial y_m \leq 0$) (Hailu and Veeman, 2000). The fulfilling curvature property in accordance with production theory can be checked by examining the Hessian matrix of the second-order partial differentials of the distance function with respect to outputs and inputs. Monotonicity conditions are not violated if the elasticities of inputs are positive and elasticities of outputs are negative. Table 3 below provides the monotonicity condition check. The signs of the coefficients on the first order terms of inputs and output are consistent with theory.

Table 3. Monotonicity condition check

Inputs $\{(\partial \ln D / \partial x_n) \geq 0\}$ for every input	Value	Outcome	Outputs $\{(\partial \ln D / \partial y_m) \leq 0\}$ for every output	Value	Outcome
Family labor	0.019	Fulfilled	Rice	-0.078	Fulfilled
Fertilizer	0.029	Fulfilled	Vegetables	-0.007	Fulfilled
Pesticide	0.011	Fulfilled	Starchy crops	-0.037	Fulfilled
Labor hired	0.009	Fulfilled	Annual industrial crops	-0.062	Fulfilled
Capital hired	0.005	Fulfilled			
Seeds	0.021	Fulfilled			

4.2. Measures of economic performance

The evidence of scale economies also presented in Table 4. The measures show significant scale economies ($\varepsilon_{x,y}$=0.898) for input-oriented specification. This evidence is the same as other studies used the approach of input distance function in crop farms (Paul and Nehring, 2005, $\varepsilon_{x,y}$=0.653 for the US; Rahman, 2010, $\varepsilon_{x,y}$=0.45 for Bangladesh; Rasmussen, 2010, $\varepsilon_{x,y}$=0.723 for Denmark). Ogundari and Brümmer (2010) also found the evidence of increasing returns to scale in cassava production in Nigeria using the output distance function. Chavas and Aliber (1993) had the same evidence in small farms using the US farm data.

Table 4. Elasticities of input distance function at sample means (First order components)

Variables	Symbol	Value[a]	*t*-ratio
Output elasticities			
Scale economy	$\varepsilon_{x,y}$	0.898	
Rice	$\varepsilon_{x, y1}$	0.591	21.86
Vegetables	$\varepsilon_{x, y2}$	0.030	3.85
Starchy crops	$\varepsilon_{x, y3}$	0.172	4.31
Annual industrial crops	$\varepsilon_{x, y4}$	0.105	1.88
Input elasticities			
Family labour	$\varepsilon_{x, x2}$	-0.165	-7.42
Fertilizer	$\varepsilon_{x, x3}$	-0.204	-6.19
Pesticides	$\varepsilon_{x, x4}$	-0.068	-3.19
Labour hired	$\varepsilon_{x, x5}$	-0.030	-4.77
Capital hired	$\varepsilon_{x, x6}$	-0.028	-3.25
Seeds	$\varepsilon_{x, x7}$	-0.146	-5.05
Land	$\varepsilon_{x, x1}$	-0.360	
Output jointness			
Rice and vegetables	$\varepsilon_{x,y12}$	-0.011	-2.84
Rice and starchy crops	$\varepsilon_{x,y13}$	-0.019	-6.05
Rice and annual industrial crops	$\varepsilon_{x,y14}$	-0.023	-5.34
Vegetables and starchy crops	$\varepsilon_{x,y23}$	-0.003	-2.49
Vegetables and annual industrial crops	$\varepsilon_{x,y23}$	-0.0003	-0.24
Starchy crops and annual industrial crops	$\varepsilon_{x,y34}$	-0.0004	-0.34

Notes: [a] evaluated at the means of the data using the parameters estimates of equation (6).

Similarly, the first order conditions of the input distance function with respect to inputs are equal to cost shares and imply the importance of inputs in annual crop production. As can be seen in Table 4, all elasticities are statistically significant at 1% level. Land has the largest elasticity with the value of 0.36, which means that the cost of land represents 36% of total cost at the sample mean.[4] The costs of pesticides, fertilizer and seeds represent 42.2% of the total costs in VHLSS 2006. FAO (2010) shows that the costs of fertilizer, pesticides and seeds represented 43% of total cash costs during the 2008 winter-spring rice crop in Vietnam. The family labour cost accounts for 16.5% of total production costs, reflecting the importance of family labour in the production process. It should be noted that the markets for land and labour in developing countries are not sufficiently developed.[5] As a result, there is a lack of information on land prices or family labour input in the household data surveys, which cannot provide the information on the cost shares of land and family labour.

To further investigate the implications of the estimated parameters of output jointness, ε_{x,y_m,y_l} is estimated. In the estimated input distance function, ε_{x,y_m,y_l} is represented by the cross-parameter (α_{ml}) in equation (6). As can be seen in Table 4, there is a complementarity between rice and other crop, which implies that the input uses expanding other annual crops do not have to increase as much. For instance, estimated coefficient between rice and starchy crop is 0.019, which implies that a 1% increase in rice output will reduce the marginal utilization of inputs for producing starchy outputs by 0.019%. Among output jointness coefficients, the economic gain of diversification is 0.023, which is the highest in combining the production of rice and annual industrial crops. There is no evidence of economies of diversification across the combinations of vegetables and annual industrial crops or starchy crops and annual industrial crops. There may be potential clashes with resource allocation requirements, such as land and labour. This finding indicates that significant scope economies exist in crop diversification. Similar results are found in Rahman (2010) for Bangladesh and Ogundari and Brümmer (2011) for Nigeria.

4.3. Elasticity of substitution and complementarity

In this paper, the approach of Rahman (2010) is extended by introducing further information on the output cross and own elasticity of shadow prices with respect to inputs. Among the cross elasticity between inputs, family labour appears to be complement to all other inputs, except hired labour (Table 5). Hired labour can be a substitute for family

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[4]Due to regulatory restrictions, $\sum_n \beta_n = 1$ in the equation (6), the elasticity of land is computed by taking the difference between 1 and summary of the coefficients of all other inputs. Thus, the significant level cannot be reported in Table 4.

[5]Many studies find that perfect labour and land markets are rarely found in developing countries (Benjamin, 1992; Urdy, 1996; Jolliffe, 2004). Le (2010) also rejected the perfect market assumptions. World Bank (2006) has the same conclusion for land market in Vietnam when the government controls land prices and ownership.

labour. The complementarity between family labour and fertilizer, pesticides, capitals and seeds implies that if the shadow prices of fertilizers, pesticides, seeds and capital increase, there is a reduction of family labour supply. Therefore, the increasing burden of high costs results in increasing inefficiency in crop production. Consequently household members seek off-farm opportunities to smooth income and consumption in light of the uncertainties of farm incomes (Reardon et al. 2001).

Table 5. Mean of output cross and own indirect elasticity of shadow prices with respect to inputs (ε_{ij})

	Labour	Fertilizer	Pesticide	Hired labour	Capital	Seeds
Labour	-1.112 (-16.17)	0.288 (4.02)	0.120 (0.95)	-0.312 (-3.05)	0.471 (4.03)	0.230 (2.68)
Fertilizer	0.352 (3.97)	-0.901 (-8.02)	0.337 (1.74)	0.362 (2.52)	0.014 (0.09)	-0.009 (-0.07)
Pesticide	0.051 (0.95)	0.116 (1.74)	-0.589 (-3.55)	-0.348 (-3.60)	0.004 (0.05)	0.221 (2.68)
Hired labour	-0.057 (-3.05)	0.053 (2.52)	-0.149 (-3.60)	-0.217 (-1.67)	0.066 (1.89)	-0.073 (-2.74)
Capital	0.079 (4.03)	0.002 (0.09)	0.002 (0.05)	0.061 (1.89)	-1.438 (-12.07)	0.048 (1.61)
Seeds	0.204 (2.68)	-0.004 (-0.05)	0.462 (2.68)	-0.355 (-2.74)	0.250 (1.61)	-0.848 (-6.53)

Notes: t-values are in parentheses; evaluated at the means of the data using parameters estimates of equation (6).

The elasticity of substitution between family labour and hired labour is also of interest in this paper. In the light of rising landlessness in Vietnam, the substitutability between family labour and hired labour can provide policy implications. In 2004, landlessness rate was 13.55%, which led to increasing social stratification in rural areas. More farm households hired labour for farming activities and participated in off-farm jobs Vietnam (Akram-Lodhi, 2005; Ravallion and van de Walle, 2006). As the shadow price of hired labour rises, households increase labour supply. Conversely, households reduce family labour required for farming activities. If more family labour participates into off-farm jobs, the shadow price of hired labour will go down. As the degree of substitutability between family and hired labour increases, farm operators can more easily hire replacement workers on the farm. The family labour can then allocate more hours to off-farm activities or migrate to urban areas (D'Antoni et al. 2014). This can result in increasing inequality and social stratification within rural areas as shown by Akram-Lodhi (2005).

Table 6. The indirect Morishima elasticity of substitution

	Labour	Fertilizer	Pesticide	Hired labour	Capital	Seeds
Labour		1.189 (7.58)	0.709 (3.43)	-0.251 (-1.29)	1.909 (11.36)	1.078 (6.30)
Fertilizer	1.465 (11.63)		0.926 (2.85)	0.579 (3.48)	1.452 (6.71)	0.841 (4.16)
Pesticide	1.163 (13.14)	1.016 (6.25)		-0.131 (-0.87)	1.443 (8.33)	1.069 (6.37)
Hired labour	-1.180 (-15.10)	0.954 (8.16)	0.439 (2.47)		1.504 (11.81)	0.775 (5.71)
Capital	1.192 (17.28)	0.903 (8.00)	0.591 (3.28)	0.279 (2.15)		0.896 (6.94)
Seeds	1.316 (11.57)	0.896 (5.45)	1.051 (3.95)	-0.138 (-0.82)	1.689 (8.09)	

Table 7. The indirect Allen-Uzawa elasticity of substitution

	Labour	Fertilizer	Pesticide	Hired labour	Capital	Seeds
Labour						
Fertilizer	0.012 (1.72)					
Pesticide	-0.005 (-0.35)	0.015 (0.69)				
Hired labour	-0.095 (-4.66)	0.034 (1.10)	-0.294 (-4.32)			
Capital	0.038 (2.62)	-0.022 (-1.17)	-0.025 (-0.62)	0.060 (1.03)		
Seeds	0.007 (0.76)	-0.021 (-1.66)	0.051 (1.84)	-0.144 (-3.86)	0.019 (0.67)	

Notes: t-values are in parentheses; evaluated at the means of the data using parameters estimates of equation (6).

The indirect Morishima and Allen elasticities of substitution are computed from the input distance function and are presented in Tables 6 and 7, respectively.[6] These results are consistent with Table 5. There is a complementarity between family labour and other inputs, except hired labour. Households are sensitive to input price changes. This implies that an increase in shadow prices of fertilizer, pesticides and capital to family labour would increase substantially, mitigating the cost savings of such a substitution. Hence, in this case, the Morishima elasticity of substitution provides this paper with information on the feasibility of substitutions. In the relationship between family labour and hired labour, the Morishima elasticity of substitution suggests substitutability and the relative shadow price of hired labor to family labour would increase, not mitigating the cost savings of such

[6] See further procedures about how to calculate elasticities in Grosskopf et al. (1995, p. 293).

substitutions. Overall, the estimated elasticities indicate that family labor can be relatively easily substituted for hired labour.

6.5. Technical efficiency

The mean technical efficiency is 0.80, which implies that the average farm households could, in principle, reduce further 20% of inputs to produce given crops or increase outputs by 20% at given inputs. This also indicates that opportunity may exist to expand crop outputs without using more inputs or the application of improved production technology. There is a wide range of production inefficiency of farm households ranging from 16% to 96% in multiple crops farming (Figure 1). The mean technical efficiency of multiple crop farming is higher than other estimates of studies focusing only on rice. Kompas et al. (2012) and Vu (2012) estimated the mean technical efficiency to be 0.77 and 0.78 respectively. This finding indicates that technical efficiency is higher in crop diversity than single rice production.

As regards the determinants of technical inefficiency in multiple crops farming, Table 8 provides the effects of farm characteristics on technical inefficiency. Education plays a vital role in reducing technical inefficiency, particularly women education. The level of impact on the reduction of technical inefficiency of female education is two times higher than that of male education. This also reflects the role of women in improving technical efficiency and farm production. In light of more opportunities in off-farm jobs and men's migration to cities, women in rural areas have become a key labor force (GSO, 2009). This result is consistent with the finding of Rahman (2010), who emphasizes the role of women in Bangladesh agriculture. In addition, household size at working ages also significantly improves technical efficiency. Mafoua-Koukebe et al. (1996) indicates that when production is labour intensive, farms tend to be more diversified. More supply of family labour at working age, thus, reduces technical inefficiency in crop production.

The effect of land fragmentation on agricultural efficiency is captured in the technical inefficiency model. The number of plots is used instead of the Simpson index. This result is consistent with the conclusions of previous studies (Hung et al. 2007; Kompas et al. 2012). It means that the reduction of land fragmentation improve technical efficiency. One of interesting finding here is the effect of land use right certificate on technical efficiency. If farms have titled land, more incentives to invest and provide a source of collateral for loans. The empirical result shows that farm households with higher and proper the ratio of land with land use right certificates are more efficient. This result is also consistent with recent findings of Kompas et al. (2012) and Vu (2012)

Figure 1. Distribution of technical efficiency indices

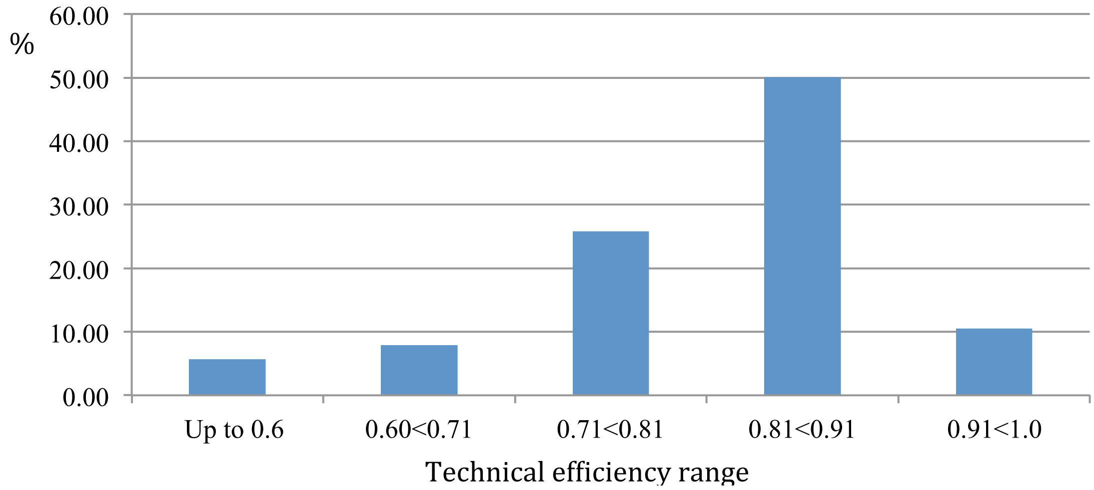

Table 8. Technical inefficiency model

	Parameters	Coefficients	*t value*
Age of the household head	η_1	0.0009	0.20
Mean education of working age men	η_2	-0.070	-2.67
Mean education of working age women	η_3	-0.141	-5.42
Household members, from 15 to 60 years old	η_4	0.398	6.63
Dependency ratio (%)	η_5	0.643	2.22
Days of illness	η_6	0.005	0.51
Number of plots	η_7	0.021	1.96
Hours of nonfarm wages	η_8	-0.0002	-4.19
Ratio of land with land use right certificates	η_9	-0.203	-1.66
Constant	η_0	-3.107	-7.20
Number of observations		1970	

7. Conclusion and policy implications

Scale and scope economies were found in multiple crop production. The finding reveals that increasing returns to scale are evident in Vietnamese multiple crop production, which means that 1% increases in total output, inputs increase by 0.89%. The increase in rice production will reduce the marginal utilization of inputs for producing other crops. Moreover, the crop combination results in cost savings in the production process. Results also show that households with smallholder production substantially respond to cost stress in multiple crop environment. Family labour and other inputs such as fertilizers, pesticides and capitals are complement, which means that farm labour use will fall when the prices of these inputs increase. This finding contributes to the literature on the push factors of labour allocation in smallholder farms. Due to the small scale of annual crop production, farms are sensitive to the costs of inputs. Policies that lead to more incentives to invest in crop faming activities should focus on the reduction of input costs.

The Vietnamese government should change the approach of designing food security policies. The reduction of costs of production such as fertilizer, pesticides, seeds and hired capitals also plays a vital role in creating more incentives for farmers to stay and invest in agricultural production. In addition, increasing cost stress contributes to reallocating the resources of households by reducing the investment in agriculture. However, the adjustment of cost structure also impacts on rural labour market when more farmers have worked for farm wages (Akram-Lodhi, 2005). The result shows that there is a substitute between family labour and hired labour. With the increasing participation in off-farm activities of smallholders, the reliance on hired labour is more important for producers. The farm household can allocate more hours to off-farm works by easily hiring replacement workers on the farm.

Another finding is that there is an existence of substantial technical inefficiency in multiple-crop farming, which implies that there may be opportunities to expand crop outputs by 20% without resort to greater uses of inputs or improved technologies in farm production. There were seven variables, which significantly affect technical inefficiency. The improvement of education, particularly for women and reduction of the dependency ratio contribute to improving technical efficiency. Furthermore, land reforms toward the reduction of land fragmentation and proper land rights should be strengthened to improve efficiency.

The policy implication of this research emphasizes the design of policies to promote crop diversification for small farms, which is found to improve productivity through scope economies and technical efficiency improvement. The Vietnamese government seems to give priority to rice self-sufficient policies rather than the income of farmers. Kompas et al. (2012) also conclude that the mandate to grow rice in all provinces, at least in terms of defined efficiency criteria, is not appropriate. The recent thrust of the Vietnamese government to promote diversification in the Strategy of Agriculture and Rural Development (2011-2020) is a step in a right direction. Therefore, crop diversity should be expanded to improve incomes of farm households.

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Appendix. Parameter estimates of the stochastic input distance function including inefficiency effects

Variables	Parameters	Coefficients	SE	*t value*
Production variables				
ln(labor/land)	β_2	-0.235	0.142	-1.66
ln(fertilizer/land)	β_3	0.253	0.193	1.31
ln(pesticide/land)	β_4	-0.427	0.128	-3.33
ln(hired labor/land)	β_5	0.034	0.045	0.77
ln(capital/land	β_6	-0.126	0.049	-2.59
ln(seeds/land)	β_7	-0.074	0.189	-0.39
1/2 ln(labor/land)2	β_{22}	-0.046	0.011	-4.03
1/2 ln(fertilizer/land)2	β_{33}	-0.021	0.023	-0.93
1/2 ln(pesticide/land)2	β_{44}	0.024	0.012	2.06
1/2 ln(hired labor/land)2	β_{55}	0.036	0.004	9.1
1/2 ln(capital/land)2	β_{66}	-0.013	0.003	-3.91
1/2 ln(seeds/land)2	β_{77}	0.001	0.019	0.05
ln(labor/land)*ln(fertilizer/land)	β_{23}	0.025	0.015	1.72
ln(labor/land)*ln(pesticide/land)	β_{24}	-0.003	0.009	-0.35
ln(labor/land)* ln(hired_labor/land)	β_{25}	-0.014	0.003	-4.66

ln(labor/land)* ln(capital/land)	β_{26}	0.009	0.003	2.62
ln(labor/land)* ln(seeds/land)	β_{27}	0.010	0.013	0.76
ln(fertilizer/land)* ln(prsticide/land)	β_{34}	0.009	0.014	0.69
ln(fertilizer/land)* ln(hired labor/land)	β_{35}	0.005	0.004	1.1
ln(fertilizer/land)* ln(capital/land)	β_{36}	-0.005	0.005	-1.17
ln(fertilizer/land)* ln(seeds/land)	β_{37}	-0.031	0.019	-1.66
ln(pesticide/land)* ln(hired labor/land)	β_{45}	-0.013	0.003	-4.32
ln(pesticide/land)* ln(capital/land)	β_{46}	-0.002	0.003	-0.62
ln(pesticide/land)* ln(seeds/land)	β_{47}	0.022	0.012	1.84
ln(hired labor/land)* ln(capital/land)	β_{56}	0.001	0.001	1.03
ln(hired labor/land)* ln(seeds/land)	β_{57}	-0.015	0.004	-3.86
ln(capital/land)* ln(seeds/land)	β_{67}	0.003	0.004	0.67
ln(labor/land) * ln(rice output)	γ_{21}	0.037	0.011	3.46
ln(labor/land)* ln(vegetables)	γ_{22}	0.001	0.003	0.33
ln(labor/land)*ln(starchy output)	γ_{23}	-0.005	0.003	-1.91
ln(labor/land)* ln(annual industrial output)	γ_{24}	-0.010	0.004	-2.87
ln(fertilizer/land)* ln(rice output)	γ_{31}	-0.046	0.018	-2.56
ln(fertilizer/land)* ln(vegetables)	γ_{32}	0.002	0.005	0.44
ln(fertilizer/land)*ln(starchy output)	γ_{33}	-0.003	0.004	-0.74
ln(fertilizer.land)*ln(annual industrial output)	γ_{34}	-0.004	0.005	-0.73
ln(pesticide/land) * ln(rice output)	γ_{41}	0.009	0.010	0.85
ln(pesticide/land) * ln(vegetables)	γ_{42}	0.005	0.003	1.57
ln(pesticide/land)*ln(starchy output)	γ_{43}	-0.003	0.003	-1.09
ln(pesticide/land)*ln(annual industrial output)	γ_{44}	0.000	0.003	0.1
ln(hired labor/land)* ln(rice output)	γ_{51}	0.008	0.004	2.15
ln(hired labor/land)* ln(vegetables)	γ_{52}	0.001	0.001	0.68
ln(hired labor/land)*ln(starchy output)	γ_{53}	0.002	0.001	3.14
ln(hired labor/land)*ln(annual industrial output)	γ_{54}	-0.002	0.001	-1.71
ln(capital/land)* ln(rice output)	γ_{61}	0.016	0.004	3.94
ln(capital/land)* ln(vegetables)	γ_{62}	-0.001	0.001	-0.56
ln(capital/land)*ln(starchy output)	γ_{63}	0.001	0.001	1.13
ln(capital/land)*ln(annual industrial output)	γ_{64}	-0.001	0.001	-0.79
ln(seeds/land) * ln(rice output)	γ_{71}	-0.002	0.015	-0.14
ln(seeds/land) * ln(vegetables)	γ_{72}	-0.005	0.004	-1.16
ln(seeds/land)*ln(starchy output)	γ_{73}	-0.004	0.004	-1.15
ln(seeds/land)*ln(annual industrial output)	γ_{74}	0.007	0.005	1.37
ln(rice output)	α_1	-0.191	0.189	-1.01
ln(vegetables)	α_2	0.025	0.049	0.5
ln(starchy output)	α_3	0.218	0.041	5.35

ln(annual industrial output)	α_4	0.196	0.056	3.47
1/2 ln(rice output)2	α_{11}	0.105	0.017	6.1
1/2 ln(vegetables)2	α_{22}	0.019	0.002	7.65
1/2 ln(starchy output)2	α_{33}	0.019	0.002	9.23
1/2 ln(annual industrial output)2	α_{44}	0.040	0.005	8.79
ln(rice output)* ln(vegetables)	α_{12}	-0.011	0.004	-2.84
ln(rice output)*ln(starchy output)	α_{13}	-0.019	0.003	-6.05
ln(rice output)*ln(annual industrial output)	α_{14}	-0.023	0.004	-5.34
ln(vegetables)*ln(starchy output)	α_{23}	-0.003	0.001	-2.49
ln(vegetables)*ln(annual industrial output)	α_{24}	0.000	0.001	-0.24
ln(starchy output)*ln(annual industrial output)	α_{34}	0.000	0.001	-0.34
Region				
North East	ρ_1	0.058	0.018	3.18
North West	ρ_2	0.021	0.031	0.66
North Central Coast	ρ_3	0.113	0.019	5.96
South Central Coast	ρ_4	-0.016	0.026	-0.61
Central Highlands	ρ_5	0.345	0.042	8.15
South East	ρ_6	0.445	0.053	8.45
Mekong River Delta	ρ_7	0.138	0.040	3.48
Constant	β_0	0.306	1.344	0.23
Inefficiency effects function				
Age of the household head	η_1	0.001	0.005	0.2
Mean education of working age men	η_2	-0.070	0.026	-2.67
Mean education of working age women	η_3	-0.141	0.026	-5.42
Household members, from 15 to 60 years old	η_4	0.398	0.060	6.63
Dependency ratio (%)	η_5	0.643	0.290	2.22
Days of illness	η_6	0.001	0.001	0.51
Number of plots	η_7	0.021	0.011	1.96
Hours of nonfarm wages	η_8	0.000	0.000	-4.19
Ratio of land with land use right certificates	η_9	-0.203	0.122	-1.66
Constant	η_0	-3.107	0.432	-7.2
N		1970		