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Determinants of Farmers' Agricultural Diversification: The Case of Cambodia

Kimty Seng
Graduate School of Asia-Pacific Studies, Waseda University, Japan

Abstract

A Heckman sample selection approach is employed with the data on Cambodia Socio-Economic Survey CSES-2007 to explore price and non-price factors determining farmers' crop diversification decision, and consequently affecting diversification intensity. The findings suggest that high relative price discourages farmers from diversifying crops. Irrigation, agricultural equipment ownership and farming expenditure have significantly positive effects on the decision, and sequentially increasing the intensity. Arable land size per household member, agricultural and transportation equipments have positive correlation with the diversification decision. Small scale of farming is a major hindrance to the decision, and consequently reducing the intensity. Land dispute, one of the main institutional matters in Cambodia, is found to have significantly negative marginal-effect on farmers' decision on crop diversification.

Keywords: Agricultural diversification, sample selection model, Cambodia

Introduction

In the process of economic development, agriculture serves as a food producer and factors-of-production supplier to industrial sector. It is also a major income generator for rural households in less developed economies. The well developing sector makes tremendous contribution to poverty and inequality reduction in out-of-the-way areas. Agricultural diversification has been considered one of the most likely avenues to promote the development of agriculture. The diversification is the adjustment of farming, which combines various and complimentary agricultural activities and moves agricultural resources from low to higher value (Meerta *et al.*, 2005; Joshi *et al.*, 2003; McCulloch and Ota, 2002; Delgado and Siamwalla, 1999). In sub-Saharan Africa, the movement of resources to high-value produce is the most likely way to better the agricultural productivity within a context of growing urbanization and global integration (IFPRI, 2007).

The importance of agriculture has attracted researchers' attention to the factors determining the agricultural production pattern. In Thailand, land title induces higher farming investment; famers with legally-titled land make more investment in farming, use more inputs, and produce more outputs (Feder *et al.*, 1988a; 1988b). Regarding crop diversification in Kanartaka, irrigation, fertilizers, physical infrastructure, markets structure and transportation are the main determinants (Saraswati *et al.*, 2011). In Kenya, agricultural assets, amount of hired labor, occupation of household head, contractual arrangements, farm size, and distance to output market are a major factor affecting the farmer's decision to diversify into horticulture (Mwangi *et al.*, 2013). Moreover, in Sudan the degree of crop diversification has positive correlation with the household size and income level (Abdalla *et al.*, 2013). Meanwhile, in India, Assam plains' diversification of agriculture

Corresponding author's
Email address: kim_sengty@yahoo.com

is a mechanism adopted to respond to ecological risk from flood (Mandal and Bezbaruah, 2013).

In Cambodia, more than 80 percent of the population lives in the countryside, earning their living by farming dependently upon rain-fed condition. The farming is dominated by rice production either for subsistence or small-scale commercial purpose. Over the past decades, the agricultural outputs have increased by 4.4 percent, driven mainly by rice, livestock and fisheries. Paddy covered around 2.63 million hectares during 2007-2011 (up to 90 percent of the cultivated land), and the production increased from 4 million tons in 2000 to 6 million tons in 2007 (MAFF, 2011; and MAFF & MWRM, 2010). However, the paddy yield remains relatively low vis-à-vis the neighboring countries'. The yield averaged around two tons per hectare in Cambodia, compared to 2.65 - 4.95 tons in the neighbors (EIC, 2006). The agricultural productivity is constrained by the shortage of capital investment for such inputs as seeds, fertilizers, and irrigation. Given price instability and relatively low productivity of agriculture, coupled with poor connection between rural economies and the rest of the economy, the rural population has not been much better off. However, a full employment of agricultural resources makes it more possible to shore up the rural struggling economies. But, only 0.9 percent of total land areas are now permanently-farmed (Hem, 2012). This reflects that the agricultural resources are not fully used, causing the agricultural output level to stay far below what it otherwise would be.

Transforming monoculture into diversified agriculture can not only promote the full employment of resources, but also bridge the market efficiency gap. The diversified agriculture has been equally considered a major strategy to conquer many challenges faced by farmers and to respond to opportunities. It improves farmers' nutrition; and more dynamic farmers can diversify agricultural products to meet changing consumption patterns as consumers become rich and urbanization develops rapidly. The diversification can also allow farmers to increase revenue by supplying products to potential export market. In Cambodia, the diversification of agriculture is, however, low and probably constrained by price factors and many non-price factors. Cambodian farmers' rice double-cropping is mainly determined by the water availability and cultivable land (Tong *et al.*, 2011). The unfamiliarity with and limited knowledge of non-rice crops, and unpredictable rainfall causes Cambodian famers to perceive that diversifying paddy field puts them at high stakes (ACIAR, 2011). Concerning land right issue, some of the farmers are landless or lost their land, as a result of the government's economic land concession, insecure land rights and tenure, limited access to information, and land grabbing. In 2008, 150, 000 Cambodians nationwide were intimidated into getting forcibly evicted (Amnesty International, 2008); and 21.1% of 2,235 households sampled were landless, and 26.3% held less than half a hectare of land (Chan, 2008).

Because land title and land conflicts are a main issue in Cambodia, they may have significant effects on Cambodian farmers' diversification of agriculture. Moreover, price factors seem to be overlooked in the previous studies. Also, the impact of such institutional factors and price factors on the diversification has yet to be explored in the case of Cambodia in particular. The current study is, as a part of growing branch of literature on agricultural economics, conducted to bridge this gap and to offer further empirical evidence.

The attempt in this paper is therefore to provide new insights into a question of why the agricultural diversification is low in Cambodia, based on data on Cambodia Socio-Economic Survey 2007. In so doing, the paper has twin objectives: (i) to explore factors determining farmers' behavior towards agricultural diversification, with a focus on price factors and issues of rights to land, (ii) and consequently investigate their influences on the diversification intensity. The finding is crucial to the government's policies at micro and macro level in reducing poverty and inequality through rejuvenating

agricultural market favorable to the market-oriented diversification.

Analytical framework

The agricultural diversification is a production of additional crops to existing ones at farm level (Dorjee *et al.*, 2003). The agricultural activities are, with the availability of production technology, changed in response to the signals of markets. More specifically, it is a change in product (or enterprise) choice and input use decisions forced by market principle and profit maximization (Pingali and Rosegrant, 1995). At farm level, the diversification represents a change in the underlying characteristics of the farm system such that farming and products are more aligned with the social, environmental, and economic contexts (Barghouti *et al.*, 2004). Farmers make such a change in response to both opportunities (changing consumer demand and demographics, export potential, changing marketing opportunity, and improving nutrition) and threats (risk, external and domestic policy threats, and climate change).

To theoretically identify price and non-price factors affecting the farmers' decision, let assume that farmer *i* has, with the available agricultural resources, two strategic choices to produce commodities: either to diversify crop portfolio or produce a specific crop. He prefers any production strategy that can generate the highest profit. The model is solved as follow:

Crop diversification choice

As a producer, farmer *i* is to maximize the profit subject to the production technology constraint. The production technology is characterized by a combination of land K_i and other agricultural inputs X_i such as seeds, fertilizers…etc. Farmer *i*'s profit optimization problem can be written and solved as follow:

$$\underset{K_i,X_i}{\text{Max}}\ \pi = pQ_i - rK_i - p_X X_i$$
$$S.t:\ Q_i = Q(K_i, X_i; Z_q),$$
$$production\ technology\ constraint$$
$$Q_i, K_i, X_i \geq 0 \qquad \text{..... (1)}$$

Where Q, p, r and p_x are output of diversified crops, average price of output, cost of land renting and price of agricultural inputs respectively; and Z_q is production's characteristics, including access to irrigation and production techniques, shifting the production technology. The problem can be solved with the FOC for inputs as follow:

$$\frac{\partial \pi}{\partial K_i} = p\frac{\partial Q_i}{\partial X_i} - r = 0 \ \Rightarrow \frac{\partial Q_i}{\partial K_i} = \frac{r}{p}$$
$$\frac{\partial \pi}{\partial X_i} = p\frac{\partial Q_i}{\partial X_i} - p_X = 0 \Rightarrow \frac{\partial Q_i}{\partial X_i} = \frac{p_X}{p} \quad \text{... (2)}$$

From these equations, the optimal level of input *X* and the optimal land size to be used in the production, as well as the optimal output are obtained as follow:

$$K_i^* = K(p, r, p_x, Z_q)$$
$$X_i^* = X(p, r, p_x; Z_q) \qquad \text{..... (3)}$$
$$Q_i^* = Q(p, r, p_x; Z_q) \qquad \text{..... (4)}$$

The maximized profit from the diversification choice, called the indirect profit function, can be obtained:

$$\pi_D^* = pQ_i^* - rK_i^* - p_x X_i^* \ \ or\ \ \pi_D^* = \pi(p, r, p_x; Z_q) \qquad \text{..…….. (5)}$$

Crop specialization choice

Like the crop diversification choice, but here farmer *i* produces a specific crop with the available agricultural resources. The production technology is characterized by a combination of land K_i and input X_i'. The farmer maximizes the profit subject to the production technology constraint. Farmer *i*'s profit maximization problem can be written as follow:

$$\underset{K_i,X_i}{\text{Max}}\ \pi = p_s Q_{si} - rK_i - p_{x'} X_i'$$
$$S.t:\ Q_{si} = Q(K_i, X_i'; Z_q),$$
$$Q_{si}, K_i, X_i' \geq 0 \qquad \text{..... (6)}$$

Where Q_s, p_s and $p_{x'}$ are output of specialized crop, specialized crop output price and price of input X' respectively.

Solving the profit maximizing problem gives the optimal profit from crop specialization expressed in functional form as:

$$= p_s Q_{si}^* - rK_i^* - p_x X_i^* \quad or \quad \pi_s^* = \pi\left(p_s, r, p_{x'}; Z_q\right) \quad \text{..... (7)}$$

Finally, let consider the farmer's choice between the crop diversification and specialization, by comparing the optimal profit from the crop diversification choice with the optimal profit from the crop specialization choice. There are three choices as follow:

$$\begin{cases} \text{if } D = \pi_D^* - \pi_s^* > 0, \text{farmer } i \text{ chooses crop diversification} \\ \text{if } D = \pi_D^* - \pi_s^* < 0, \text{farmer } i \text{ chooses crop specialization} \\ \text{if } D = \pi_D^* - \pi_s^* = 0, \text{farmer } i \text{ is indifferent} \end{cases}$$

If the diversified profit is higher than the specialized profit, then the farmer is induced to diversify crops, and vice versa. The farmer is indifferent, if the profits are equal. The optimization solution also implies that the farmer's decision on crop production pattern is a function of the average price of the diversified outputs (p), the price of the specialized output (p_s), the land renting cost (r), the input prices (p_x, and $p_{x'}$), the characteristics of the production (Z_q). However, to make it easier to predict price effects, a relative price (the ratio between p_s and p) is taken into account. If the relative price of crop A in terms of other crops goes up, it is more likely the farmer has tendency to increase the production of that crop, and vice versa. At the indifferent point, apart from the above factors, new market opportunity also serves as a main incentive for the choice between the crop diversification and specialization.

To empirically analyze Cambodian farmers' diversification of crops, factors determining farmer's behavior towards the diversification are established, based on the above theoretical framework and the previous studies (e.g. Feder *et al.*, 1988a, b; Saraswati *et al.*, 2011; Mwangi *et al.*, 2013; Abdalla *et al.*, 2013; Tong *et al.*, 2011). The factors assumed to determine the diversification are divided into: price factors, farmer's characteristics, farmer's endowments, production risk and characteristics, and institutional factors. The empirical analysis is conducted within a two-stage framework starting with the farmers' choice between the crop diversification and specialization and ending with the diversification intensity. It is hypothesized that price factors and secured land rights determine the farmers' decision on crop diversification, and consequently affecting the level of diversified-farming.

Empirical methodology

Econometric approach

The study of diversification is, in this paper, conducted in relation to the determination of the factors affecting farmers' decision on crop diversification, and sequentially the intensity of diversification. Such a study is assumed to follow the selectivity models (Key *et al.*, 2000; Omiti *et al.*, 2009). First, a peasant decides discretely whether or not to diversify. Second, the peasant decides on the level of diversified-farming conditional on the diversification decision. Tobit model, double-hurdle model and Heckman model are broadly employed to analyze such a sequential decision. The Tobit approach is, however, inappropriate for the current study because it contains mixed information on both direct and partial effects of the independent variables on the dependent ones. The double-hurdle approach suffers from selectivity bias, and then not suitable to this study (Greene, 2002). Some of the factors affecting the farmer's diversification decision would likely affect the diversification intensity. This may cause an overstatement of the estimators in a linear dummy variable regression (Greene, 2002). Hence, to estimate the famers' diversification and intensification decision needs to control for self-selection bias.

Heckman sample selection approach can be employed to deal with the selectivity bias resulted from non-random subsets of diversified farmers selected from all sampled farmers and Tobit model's problem. Another reason for using the approach is that farmers may prefer crop diversification, because of such unobserved effects as risk-aversion,

their skills and soil quality. Practically, the Heckman sample selection model can be explained in two steps. The first step addresses determinants of the diversification decision. The dependent variable is a binary choice, the probability of being diversified or otherwise. The second step deals with factors affecting the diversification intensity, conditional upon diversification decision. Farmer *i*'s diversification decision is expressed as follow:

$$Y_{1i} = Z_i\gamma + u_i$$

$$Y_{1i}^{*} = \begin{cases} 1, if\ farmer\ decides\ to\ diversify\ crops \\ 0, \ otherwise \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Y_{1i} is a latent endogenous variable, measuring the probability of diversifying crop; Z_i is factors determining the diversification probability; and γ is estimators. The outcome equation, representing the diversification intensity, is given by:

$$Y_{2i} = X_i\beta + \varepsilon_i;\ observed\ iff\ Y_{1i} = 1 \ldots (2)$$

Where Y_{2i} is the diversification intensity, observed if only if farmer decides to diversify crops or Y_{1i} = 1; X_i is factors determining the intensity; and β is estimators. u_i and ε_i are error terms of the regression equations. In the model, there is also the assumption about the distribution of and the correlation between u_i andε_i. The assumption is that the errors have bivariate normal distribution with $\sigma = 0$ and correlationρ, and are independent of explanatory variables. That is, the error terms in the selection and outcome equation are:

$$u_i \sim N(0,1)$$
$$\varepsilon_i \sim N(0, \sigma^2)$$
$$corr(u_i, \varepsilon_i) = \rho$$

The conditional mean in the model has to do with the selectivity problem, obtained by taking the expectation of Eq. 2 conditional on $Z_i\gamma + u_i > \bar{Y}$ ($\bar{Y}$ is diversification threshold).

$$E[Y_{2i}/Y_{1i} > \bar{Y}] = E[Y_{2i}/Z_i\gamma + u_i > \bar{Y}]$$
$$= E[X_i\beta + \varepsilon_i/Z_i\gamma + u_i > \bar{Y}]$$
$$= X_i\beta + E[\varepsilon_i/u_i > \bar{Y} - Z_i\gamma] \quad \ldots\ldots\ldots\ldots\ldots (3)$$

If u_i and ε_i are uncorrelated, $E[\varepsilon_i/u_i > \bar{Y} - Z_i\gamma] = 0$, and then the parameters estimated by the OLS regression of Eq. 2 are consistent. With the assumption of there being a correlation between these error terms, the selection problem needs to be taken into account by estimating $E[\varepsilon_i/u_i > \bar{Y} - Z_i\gamma]$. Under the assumption that u_i and ε_i are jointly normally-distributed, the conditional mean of diversification intensity in the Heckman model is:

$$E[Y_{2i}/Y_{1i} > \bar{Y}] = X_i\beta + \rho\sigma_\varepsilon\lambda_i(\alpha_u)$$

$$= X_i\beta + \beta_\lambda\lambda_i(\alpha_u) + v_i \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

And, the marginal effects would be expressed as

$$\frac{\partial E[Y_{2i}/Y_{1i} > \bar{Y}]}{\partial X_i} = \beta - \theta(\frac{\rho\sigma_\varepsilon}{\sigma_u})\delta_i(\alpha_u)$$

.

Eq. 4 shows that the only OLS of outcome equation with X_i can, because of omit $\lambda_i(\alpha_u)$ which is sometimes called inverse Mills ratio bring about the biased and inconsistent estimates. With the above assumptions, the Heckman model is practically estimated by using maximum likelihood procedure that jointly estimates the parameters of both diversification decision and intensity equation. The parameters can be interpreted as the marginal effects of a unit change in explanatory variables, which consist of two components. There are the direct effects of explanatory variables on the mean of diversification intensity captured by β and the indirect effects caused by a change in explanatory variables that appear both in the outcome and selection equation. This is

[2] See also Johnson and Dinardo, 1997. *Econometric Methods*. 4th Edition, pp. 447-449

[3] See also Greene, 2003. Econometric Analysis. New Jersey: Prentice Hall, pp. 780-784

because a change in some X_i affects not only the mean of intensity, but also the probability of diversifying crops; that is, it affects Y_{2i} through $\lambda_i(\alpha_u)$. If independent variable is binary, the marginal effects are interpreted as a result of the discrete change of the variable from zero to one.

Model specification

Paddies are the main farming of the majority of Cambodian rural people. However, people settling alongside Mekong River plant other crops than rice, such as soybean, maize, tobacco…etc. Some plant only a specific crop a year, engaging for the rest of the year in non-agricultural activities. Then, any farmer who grows more than one specific crop is considered to diversify the crops. This is used as diversification threshold. The crop diversification intensity is usually computed by using Herfindalh Index (HI) who's the value ranges between zero and one. But, Transformed Herfindalh Index (THI) is preferred to the HI, because the later measures the concentration; and the former is also suitable to Cambodia's available data. The THI is calculated by subtracting Herfindalh Index (HI) from one. Then, the THI is bounded by zero and one; the higher the value, the higher the diversification intensity. The index is calculated with the following formula: $THI = 1 - HI \; or \; THI = 1 - \sum_{j=1}^{n} p_j^2$, $and \;\; p_j = \frac{A_j}{\sum_j^n A_j}$, where p_j is proportion of j^{th} crop; A_j is area under j^{th} crop; and $\sum A_j$ is total cultivated land.

A set of independent variables include variables theoretically expected to determine the decision on whether or not to diversify crops, and possibly to affect the degree of diversification. In the theoretical model, the decision on crop production strategy is a function of the relative price, the input price, and the farmers' and production's characteristics.

Given the dominance of paddy in Cambodian farming, paddy relative price is used to capture the price impact on the diversification decision, expected to have negative effects on the diversification. The relative price is a ratio between the paddy price and a weighted average price of multiple crops individual farmers grow. Per-square expenditure on farming includes a pay for planting materials, chemical fertilizers, hired labor and gasoline…etc. To maximize the use of such inputs, the farmers may increase the diversified crop production.

Land per household member and ownership of agricultural equipments represent the farmer's endowments, expected to have positive effects on the production and market regime decision. Access to irrigation and yield loss caused by rot, eaten by birds/other insets, rodents, over-rainfall, and flood are used as proxies for the production's characteristics and ecological risk. Access to irrigation, crucial to the farming, increases farming productivity, and then being expected to positively affect the diversification. To adapt to the ecological condition, the farmers may opt crop diversification strategy. But the ecological risk such as unpredictable rain-fed water may constrain the farmers from diversifying their farming as documented by ACIAR (2011).

Household head's age, sex, ethnicity, education level, household member's non-agricultural paid-job, and other languages than Khmer, and farming scale are used to capture the farmer's characteristics. The farming scale is captured by whether the farmer owns or cultivates arable lands of one hectare or less. Because the majority of the farmers cultivate crops on small plot of land (Table 2), they are expected to have tendency to reduce crop diversification. In other words, cultivable land size of one hectare or less discourages the farmers from diversifying their farming. The age can be also a proxy for the farmer's experiences in farming. Squared age is also included as an independent variable to control for the aging affect on the diversification decision. The ethnicity can equally capture mutual trust and common belief; it may then influence the decision on the market-oriented diversification of crops. This is because the ethnicity can facilitate the sharing of information amongst farmers. In the context

[4] Ratio of village paddy price to village weighted average price of multiple crops.

of Cambodia's economy, it can, moreover capture the effects of rural in-labor-force population migration to the capital and to other regional countries. The mass migration may engender a shortfall in labor forces available for agriculture, and then affecting the agricultural production. Household member's non-agricultural paid-job captures the impact of off-farm jobs on the household's agricultural decision, so too does it capture the information effects. Family members having other off-farm jobs can get more access to information on agriculture, since they have more social networks. Moreover, a highly educated household head can generally gain more easily access to information than does the low educated head. Then, the education level can have positive effect on the diversification decision.

Land title and land dispute representing farmer's property rights and land insecurity are used to capture the institutional effects on Cambodian farmers' crop diversification. The farmer with titled land can find it easier to have access to credit than does the farmer with untitled land, and more apparently being motivated to invest more in diversified farming. By contrast, land conflict may discourage them from investing in production of diversified crops. Moreover, transaction costs, also a main institutional factor, are taken into account in the diversification regression. The transaction costs are typically categorized into variable transaction cost (VTC) which is proportional to quantity of goods trades and fixed transaction cost (FTC) which is related to information-on-market cost (Key *et al.*, 2000, Heltberg and Tarp, 2002, and Goetz, 1992). However, it is difficult to empirically measure the transaction costs, because the latter are not easily recorded in a survey (Key *et al.*, 2000). Based on previous studies, especially a study conducted by Heltberg and Tarp (2002), transportation equipment ownership is used as a proxy for the VTC, while information equipments such as radio, TV and telephone are proxied for the FTC. An increase in transportation costs and time of travelling is expected to have negative impacts on the market-oriented diversification of crops. Therefore, any household possessing the transportation equipments can reduce the transportation costs, and then being induced to diversify crops for commercial purpose. Access to information and social networks can reduce the FTC. Then, the information equipments such as radio, TV and telephone can facilitate the information on markets, encouraging the farmers to diversify their crop portfolio and participate in the markets.

Data and descriptive statistics

The data on Cambodia Socio-Economic Survey *CSES-2007* are used for the regression analysis. The survey was conducted by the National Institute of Statistics of Cambodia, with the sample size of 360 villages or 3,600 households in 11 provinces, which is the subsample of *CSES-2004*. It gathered necessary information on the population's living standards. In the *CSES*, there are various modules, including households' demographic characteristics, production and cash income, consumption and nutrition, education, health, access to social and community services, transport and communication, housing, assets such as land and other equipments, and rights to land.

On average, farm household in the observed households possesses arable land of 1.50 hectares, with the majority of household head being male and 45 years old and having educational level of 5 years and half. The descriptive statistics in Table 2 shows that only 31.17% of the observed households diversified crop cultivation, with the paddy crops covering up to 72.87%. The majority of households were smallholder farmers, with 56% of the observed farmers owning arable of 1 hectare or less. 98% of the observed households are Khmer; and only 42% has access to irrigation. Only 59.54% of the observed households cultivated titled land, showing that almost 50% of the households did insecure land.

Table 1: Summary of variables

Variables	Proxy & Measurement	Ex. Sign
Dependent		
Dummy for Diversification Decision	Diversify = 1, Otherwise = 0	
THI	Measurement of crop diversification intensity	
Independent		
Log Relative Price	Natural log of Paddy Relative Price	+
Log Expenditure on Agriculture	Natural log of per-square expenditure on farming	+
Farmer's characteristics		
- Log HHH's Age	Natural log of household head's age	+/-
- Log HHH's Age Squared	Square of natural log of household head's age	
- Log HHH's Schooling Years	Natural log of household head's schooling years	+
- Dummy for Ethnicity	Dummy for household head's ethnicity (Khmer = 1, Otherwise = 0)	+/-
- Dummy for Non-agricultural Paid Job	Dummy for any household member's non-agricultural paid jobs (Paid jobs = 1, Otherwise = 0)	+
- Dummy for HHH's Sex	Dummy for household head's gender (Male = 1, Otherwise = 0)	+/-
- Dummy for Land Area of 1 Hectare or less	Dummy for farmer possessing arable land of 1 hectare or less, considered smallholder farmer (Smallholder = 1, Otherwise =0)	-
- Dummy for Language	Dummy for any household head who can use other language than Khmer (Yes = 1, Otherwise = 0)	+/-
Farmer's endowments		
- Log Arable Land Size per Household Member	Natural log of arable land size per household member who can work (square meters)	+
- Dummy for Agricultural Equipment Ownership	Dummy for household's agricultural equipments such as cart, tractor, plough, threshing machine, harrow/rake/spade, hand tractor, rice mill and water pump (Equipment Ownership = 1, Otherwise = 0)	+
Risk and production's characteristics		
- Dummy for Yield Loss	Dummy for yield loss. Yield loss is caused by rot, eaten by birds/other insets, rodents, and over-rainfall, flood…etc. it captures ecological conditions (Loss = 1, Otherwise = 0)	+/-
- Dummy for Access to Irrigation	Dummy for any household that can have access to irrigation for cultivation (Access to Irrigation = 1, Otherwise = 0)	+
Institutional factors		
- Dummy for Land Dispute	Dummy for any household that experiences land dispute (Land Dispute = 1, Otherwise = 0)	-
- Dummy for Land Title	Dummy for any household whose the land is titled (Land title = 1, Otherwise = 0)	+
- Dummy for Transportation Equipment Ownership	Dummy for any household that owns transportation equipments such as car, Van/Jeep, motorcycle, bicycle (Equipment Ownership = 1, Otherwise = 0)	+
- Dummy for Info. Equip. Ownership	Dummy for any household that owns informative equipments such as radio, telephone and TV (Equipment Ownership = 1, Otherwise = 0)	+

Table 2: Main characteristics in the whole sample

Characteristics	Percentage
Paddy crops	72.87%
Non-Paddy crops	27.13%
Khmer Ethnicity	97.92%
Household head (Male)	80.30%
Farmers with titled land	59.54%
Access to Irrigation	42.30%
Transportation equipment ownership	86.74%
Informational equipment ownership	73.04%
Agricultural equipment ownership	97.43%
With arable land $\leq$ 1 Hectare	55.66%
Crop diversification	31.17%

Source: Author's calculation from CSES-2007

Table 3 suggests that land size cultivated by diversified farmers is statistically significant bigger than that cultivated by the specialized farmers, reflecting that the land size may affect the crop diversification decision. The difference in access to irrigation between the diversified farmers and the specialized farmers is very significant, showing the importance of the irrigation to the diversified farmers. About 67 % of diversified farmers hold land title, while only around 56% of specialized farmers hold the title. The ownership of agricultural and transportation equipments are significant different between the diversified farmers and specialized ones. The percentage of diversified farmers with such equipments is significantly higher than that of specialized ones. This can show that those who own such equipments would be likely to diversify crop production.

Table 3: Main differences between diversified and specialized farmers' characteristics

Variables	Diversified (D)	Specialized (S)	Difference (S) – (D)	p-value (Two-Tailed)
Average arable land size in ha	1.784	1.369	-0.415	0.006***
Spending on farming per m^2 (Riel)	128.793	100.106	-28.687	0.223
Access to Irrigation	0.483	0.396	-0.087	0.000***
Household head's age	45.023	45.170	0.147	0.822
Household head's sex	0.815	0.797	-0.018	0.348
Household head's schooling years	5.565	5.460	-0.105	0.467
Land title	0.666	0.563	-0.103	0.000***
Informational ownership	0.753	0.720	-0.033	0.118
Agricultural equipment ownership	0.989	0.968	-0.021	0.005***
Transport equipment ownership	0.904	0.851	-0.053	0.001***
Land dispute	0.005	0.010	0.005	0.227
Off-Farm jobs	0.397	0.381	-0.016	0.498

Note: *** means the difference is statistically significant at 1% level.
Source: Author's Calculation from CSES-2007

The descriptive statistics of the variables used in the regression are summarized in Table 4 as follow.

Table 4: Summary of descriptive statistics of variables

Variables	Mean	Max	Min	Std. Dev.	Obs.
THI	0.119	0.998	0	0.208	2066
Dummy for diversification decision	0.312	1	0	0.463	2066
Log relative price	-0.011	1.437	-1.822	0.184	1847
Log expenditure on agriculture	3.793	9.622	-2.08	1.116	2028
Log HHH's age	3.762	4.511	2.944	0.312	2066
Log HHH's age square	14.250	20.348	8.670	2.333	2066
Dummy for ethnicity	0.979	1	0	0.143	2065
Dummy for land of 1 Hectare or less	0.557	1	0	0.497	2066
Dummy for Non-agricultural paid job	0.386	1	0	0.487	2049

Dummy for HHH's Sex	0.803	1	0	0.398	2066
Dummy for language	0.076	1	0	0.266	2066
Log land per household member	-1.75	2.931	-7.06	1.247	2066
Dummy for Agri. Equipment ownership	0.975	1	0	0.157	2066
Dummy for yield loss	0.644	1	0	0.479	2066
Dummy for access to irrigation	0.423	1	0	0.494	2066
Dummy for land dispute	0.008	1	0	0.09	2066
Dummy for land title	0.595	1	0	0.491	2066
Dummy for Transport. Equip. Ownership	0.867	1	0	0.339	2066
Dummy for Info. Equip. Ownership	0.73	1	0	0.444	2066
Log HHH's schooling years	1.579	2.773	0	0.527	1576

Source: Author's calculation from CSES-2007

Results and discussion

Table 5 presents the estimated results of Heckman selection model, marginal effects of independent variables on crop diversification decision and conditional marginal effects on the diversification intensity. The first column presents the estimated results of outcome equation, the second the estimated results of diversification selection, the third the marginal effects on diversification selection and the fourth the result of conditional marginal effects. The likelihood-ratio test of independent equations at the bottom of the table suggests that the null hypothesis of uncorrelated errors for the outcome and selection regression can be rejected at 10 percent. That is, there is the presence of sample selection bias in the second stage, and then using sample-selection model is justified for the regression analysis.

The estimated results suggest that the coefficients of the paddy relative price are significantly negative for the diversification selection, as expected. Also, the relative price has significantly negative marginal effect on the degree of diversification. This can reflect that higher price of paddy theoretically induces the farmers to increase rice production for commercial purpose. That is, the farmers' market-oriented diversification of crops is more sensitive to a change in paddy price.

The coefficients of spending on farming are very significantly positive for both the outcome and selection regression. Moreover, the marginal effect results indicate the very significant impact of spending on the diversification intensity. The spending, in particular on planting materials and chemical fertilizers, encourages the farmers to maximize the uses of agricultural resources by diversifying crops. The availability of such inputs is very crucial to the farmers' crop production.

Arable land size per household member has, in spite of the insignificant impact on the diversification intensity and of there being no marginal effect on the intensity, significantly positive effect on the crop diversification decision. Farmer with bigger arable land size may be more intent upon engaging in the diversified farming. This finding seems to support the government's policy on social land concession (SLC)[5], suggesting that the policy can help improve the rural farmers' lives, through promoting the crop diversification. The result is consistent with the findings by Mwangi, *et al.* (2013) in the case of Kenya, by Ashfaq, *et al.* (2008) in the case of Pakistan and by Tong *et al.* (2011) in the case of Cambodia. The finding is seemingly more optimistic about the SLC in terms of economic development than the arguments by Neef *et al.* (2013) that the SLC is just the ruling political elites' strategy to use international aid agencies as a tool to formalize the displacement and distributional injustices.

[5] The social land concession is a legal mechanism to allocate private state land to landless and land-poor households or communities for social purposes, especially for residential and farming use, according to Article 2 of Cambodia's Sub-Decree on Land Concession, 2003.

The results also suggest that the ownership of agricultural equipments has significantly positive correlation with the diversification decision and the intensity at 1 and 10 percent level respectively. It has very significantly positive marginal effect on the diversification degree. This result is also consistent with the findings by Mwangi *et al*. (2013) and Ashfaq *et al.* (2008). In Cambodia, the majority of farmers, especially smallholders, use primitive equipments for their farming. Then, based on this finding, modern or sufficient agricultural equipments more likely induce the farmers to diversify crops, more apparently for commercial purpose.

The access to irrigation is found to have significantly positive effect on both the diversification decision and diversification intensity, and also significantly highly-positive marginal-effect on the intensity. The irrigation improves the farming productivity and induces the farmers to diversify crops. Yet, the access to irrigation is still limited due to the insufficient development. This result is consistent with the findings by Tong *et al.* (2011), indicating the importance of production technology extension through developing adequate irrigation for the farmers. As for the ecological condition, it is not found to have significant influence on the diversification decision and its intensity.

The land title, one of the main institutional variables, is not found to have significant impact on the farmers' decision. However, the estimated results of the marginal effects suggest that land dispute wreaks significantly havoc on the diversification decision. The results reflect the negative implication of land dispute for the farmers' agricultural production, especially smallholder farmers', on which their lives are mainly dependent. Then, urgently solving the land conflict may encourage the peasants to diversify crops, and then bettering their living standards.

The results also show that the transportation equipments have statistically significant positive impact on the crop diversification decision. This reflects that the transportation costs affect the agricultural production pattern. The low costs, resulting in the low VTCs, provide incentive for the farmers to diversify crop portfolio which is more possibly for the purpose of selling in the market.

The ethnicity is found to have, although it has insignificant effect on the diversification decision, significantly negative impact on the diversification intensity. This more seemingly has something to do with rural labor forces. In Cambodia, the largest ethnicity is Khmer (up to 98 percent); and the agricultural activities are still primitive. According to the Ministry of Planning (2012), 90 percent of rural villages have seen a decline in population, owing to the rural migration to Phnom Penh and other regional countries, especially to Thailand, for jobs. This suggests that Khmer farmers have faced the deficiency of labor forces, resulted from the mass migration of rural working-age population, and then inducing them to reduce the crop diversification degree. Interestingly, the farmers owning plot of land of 1 hectare or less are found to decide to reduce crop diversification as expected, spelling out the fact that their diversification of crops is constrained by the small scale of farming. Foreign language of household members has significantly negative effect on the crop diversification decision. In Cambodia, especially in urban areas, English is the first popular foreign language. Those who can use English well can easily find jobs in urban areas, and normally remit a share of their income to their families. Then, their families may have tendency to reduce agricultural production, or crop diversification in particular, due to the lack of labor forces and dependency on the remittance.

Table 5: Estimated results (Heckman sample selection and marginal effects, dependent variable: THI)

Independent variables	THI	Selection	ME on selection	Conditional ME
Log paddy relative price	-0.043	-0.553	-0.193	-0.061
	(0.291)	(0.003)***	(0.003)***	(0.013)**
Log expenditure on agriculture	0.052	0.194	0.068	0.0324
	(0.000)***	(0.000)***	(0.000)***	(0.000)***
Log Land per household member	0.002	0.113	0.039	0.01
	(0.893)	(0.022)**	(0.022)**	(0.167)
Dummy for agri. Equip. Ownership	0.237	1.033	0.247	0.096
	(0.094)*	(0.004)***	(0.000)***	(0.000)***
Dummy for access to Irrigation	0.075	0.14	0.049	0.035
	(0.001)***	(0.067)**	(0.068)**	(0.002)***
Dummy for yield loss	0.005	0.009	0.003	-0.002
	(0.813)	(0.904)	(0.904)	(0.834)
Log HHH's age	0.23	3.463	1.209	0.367
	(0.764)	(0.181)	(0.181)	(0.344)
Log HHH's age squared	-0.018	-0.451	-0.157	-0.044
	(0.861)	(0.195)	(0.195)	(0.396)
Dummy for ethnicity	-0.218	0.288	0.092	-0.021
	(0.085)*	(0.429)	(0.383)	(0.76)
Dummy for HHH's sex	0.036	0.014	0.005	0.012
	(0.251)	(0.900)	(0.900)	(0.434)
Dummy for land area $\leq$ 1 Hectare	-0.073	-0.482	-0.169	-0.064
	(0.029)**	(0.000)***	(0.000)***	(0.000)***
Dummy for language	-0.062	-0.276	-0.090	-0.038
	(0.222)	(0.090)*	(0.066)*	(0.051)*
Dummy for land title	-0.032	-0.014	-0.005	-0.011
	(0.141)	(0.854)	(0.854)	(0.338)
Dummy for Tran. Equip. Ownership	0.002	0.229	0.076	0.02
	(0.967)	(0.062)*	(0.049)**	(0.230)
Dummy for Info. Equip. Ownership	-0.031	-0.079	-0.028	-0.016
	(0.221)	(0.363)	(0.367)	(0.221)
Log HHH's schooling years	-0.008	0.102	0.036	0.007
	(0.719)	(0.161)	(0.161)	(0.542)
Dummy for land dispute	0.115	-0.72	-0.195	-0.047
	(0.568)	(0.215)	(0.073)*	(0.479)
Dummy for non-agri. Job	0.019	0.101	0.036	0.014
	(0.400)	(0.181)	(0.183)	(0.203)
Constant	-0.645	-9.089		
	(0.653)	(0.059)*		
Observations		1389	1389	1389
Rho	0.758			
Sigma	0.246			
Lambda	0.187			
LR test of indep. Eqns. (rho = 0)	Prob > chi2 = 0.077			

Note: (1) P-values are in parentheses. (2) *, **, and *** are significant at 10%, 5% and 1% level respectively.
Source: Author's Estimation

Conclusion

A Heckman selection model is applied with the data on Cambodia Socio-Economic Survey *CSES-2007* to scrutinize the price and non-price impacts on Cambodian farmers' behavior towards crop diversification. In general, the relative price between paddy price and weighted average price of all crops has negative impact on the crop diversification decision. Irrigation and farming expenditure have positively significant effects on farmers' crop diversification, and consequently increasing the intensity. Farmer possessing adequate agricultural equipments has high tendency to diversify crops. Land dispute, one of the main institutional matters in Cambodia, is found to have significantly negative marginal-effect on farmers' decision on crop diversification. The significance of land size is also found, suggesting that the appropriate land distribution policy such as social land concession is very crucial.

The current paper provides an analysis of exogenously-presumed price and non-price factors determining the farmers' behavior towards crop diversification. For further research, the analysis will be further extended to the farmers' behavior towards the market-oriented diversification of crops, with a main focus on price and institutional effects.

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