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Full Length Research Paper

Assessment of the premium on rice yield and rice income from adoption of organic rice farming for Cambodian farmers: An application of endogenous switching regression

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Cambodia has the potential to engage in organic rice farming since many rice farmers never fully embraced the excessive use of external farm input. Hence, this article intended to identify factors influencing farmers' decision in adoption of organic rice farming as well as to assess the premium of rice yield and rice income of farmers from adopting organic rice. Endogenous switching regression was employed to control for farmers' observable and unobservable characteristics. Data were collected through face-to-face interview using structured questionnaire. Out of 221 respondents, 84 farmers were organic farmers, and 137 farmers were randomly selected conventional farmers. Result indicated that variables such as: *age, education, selling, other farm activities, number of cows,* and *owned tractor* were positively associated with adoption of organic rice farming, whereas *house size* variable was negatively correlated with the adoption decision. The results showed that all farmers could obtain higher rice yield and rice income if they adopt organic farming. Additionally, the estimations of farmers' selection bias for rice yield and rice income suggested that farmers adopt a new farming system based on their relative advantage. Based on this study, farmers were encouraged to adopt organic rice farming to obtain the yield and income premium.

Key words: Organic rice farming, conventional rice farming, endogenous switching regression, selection bias, rice income, Cambodia.

INTRODUCTION

Over the past half-century, agriculture and industrial development have caused many environmental problems throughout the world. To help mitigate these problems, a better understanding of sustainable agriculture and farming systems is needed (Atsushi and Ping, 2010). Environmental problems and the health benefits associated with rectifying these problems have prompted many countries to adopt environmentally friendly practices in agriculture. Consequently, organic farming is gradually being promoted and practiced in many parts of the world. Southeast Asia is the latest region that has begun to encourage the adoption of agriculture systems that are socially and ecologically sustainable as they minimize the use of costly external inputs and promote the efficient use of farm-based resources (Chouichom and Yamao, 2010).

Cambodia, however, is certainly a latecomer in the adoption of organic agriculture practices. Nevertheless, according to the Cambodian Organic Agriculture Association [COrAA] (2011), Cambodia has great potential to engage in organic rice farming because many rice farmers never fully embraced the excessive use of external farm chemicals. In 2003, several NGOs and the

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Cambodian government began introducing organic rice among famers with great success. This may surprise anyone who is familiar with the difficult circumstances faced by Cambodian rice farmers. Some studies such as Taing (2008) and Sa (2011) showed that organic rice farming has helped increase rice yield and profit for Cambodian farmers. However, some farmers still held a negative opinion of it and consequently reverted to conventional farming after a few years of practicing organic farming. A variety of factors, which act as barriers for farmers in organic farming, inform such opinions. First, there are psychological and sociological costs of converting to organic farming for farmers themselves, in addition to the costs imposed by peers and family members (Gardebroek, 2006). Second, financial risks are inevitable during the transition period of conversion. During a sequenced three-year transition period, though farmers are required to practice organic rice farming, the product is not regarded as organic in that period. In the transition period, the product is recognized as a chemical-free product (COrAA, 2011). With the typically lower yields during this period, the conversion process is associated with a decreased yield and income for farmers. Other challenges include the insecure marketing channels for organic commodities (Khaledi et al., 2010; Lohr and Salomonsson, 2000).

As documented in many studies, the economic concerns of organic farming are the main factors influencing farmers' decision to adopt organic practices. For instance, Ponti et al. (2012) identify concerns among farmers about the competitiveness of organic agriculture vis-à-vis conventional agriculture. In addition, Sheeder and Lynne (2009) have acknowledged that economic concerns are the main factors driving farmers' adoption of ecologically friendly practices. Cary and Wilkinson (1997) also explained that ensuring farmers' profitability would be the effective method to promote the resource conservation practices among farmers. Similarly, Chouinard et al. (2008) reviewed that profit was one of the most prominent factors influencing the decision of farmers to adopt conservation technology. In the same way, Musshoff and Hirschauer (2008) also noted that the financial factors were important with regard to farmers' decision of conversion to organic production. Obviously, organic farmers often receive price premiums (Nieberg and Offermann, 2003), and empirical evidence attests that they obtain an additional profit margin as compared to conventional farmers (Taing, 2008; Sa, 2011). However, Imbens and Wooldridge (2009) argue that the superior performance of farmers that adopted new farming as compared to conventional farmers might reflect their initial differences. The better results of adopters of organic farming can be because better farmers may be more motivated and more likely to adopt the new program (Birkhaeuser et al., 1991). This means that a selection bias exists among farmers due to observable and unobservable characteristics that would have an effect on their adoption decision and their performance. A simple comparison between adopters and non-adopters may lead to biased estimation. Controlling for selection bias is therefore an important issue when estimating the impact of a new technology, program, project, or policy.

Although organic rice farming has many advantages for the Cambodian small-scale farmers who are increasingly applying excessive synthetic inputs, some farmers still have negative conscience about organic system that is influenced by a variety of factors. Chouichom and Yamao (2010) documented that farmers in developed world have concerns about environmental problems, while economic benefits are the main concerns of farmers in least developed countries. As a result, farmers' perception on the adoption of organic rice farming varies from locations to locations, and even farmers to farmers based on their personal, farming and economic characteristics.

Since many of the studies about organic rice farming in Cambodia have paid attention to only economic returns of organic rice farming, there were few empirical researches focused on factors affecting farmers' decision to adopt organic rice farming. In addition, many empirical studies have tried to access the economic benefits of organic rice farming, and acknowledged that organic rice farming could result in positive profit margin for farmers; however, as mentioned earlier, the better performances of organic farmers can be the results of their better characteristics rather than their organic or conventional practices. In this study, an endogenous switching regression approach that accounts for selection bias is employed to examine the determinants of organic rice adoption and to assess the impact of the adoption decision on rice yield and rice income.

ORGANIC RICE FARMING IN CAMBODIA

Considering potentials of organic rice farming in Cambodia, in 2003, some international and local organizations together with Cambodian government started to promote organic rice farming among Cambodian farmers with the intention to obtain the market opportunities of organic rice in developed countries (COrAA, 2011). The significant improvement of organic rice farming have begun in 2005 after the introduction of organic certification that supported farmers to establish a set of guidelines for organic rice farming and an internal quality control mechanism. The internal quality control officers were assigned within each cooperative member to inspect the organic fields based on the guidelines of organic standard. The certification is then issued based on the inspection to prove farmers' products (Scheewe, 2011).

Fragrant rice varieties, such as PhkaMalis and PhkaRumduol, are normally grown by organic rice farmers, which are considered as premium rice with relatively higher price compared to other varieties. These cultivars are photoperiod sensitive that flower during November. Hence, these varieties can be grown only in wet season under rain-fed lowland fields, which are normally grown by smallholder farmers. Compost and cow manure are the major sources to generate organic fertilizer for organic rice farmers in Cambodia, which is considered not sufficient to maintain and enhance soil fertility, while there are only few organic rice farmers adopting cultural practice, such as cover crop, mixed crop, and crop rotation, to improve soil fertility as well as reduce the risks of pest damage (COrAA, 2011).

Many of the organic rice farmers have practiced the principles of the System of Rice Intensification (SRI) introduced by Centre d'Etudeet de Développement Agricole Cambodgien, meaning Cambodian Center for Study and Development in Agriculture (CEDAC), but they reject to apply synthetic input. Some comparative studies between organic and conventional rice farming in Cambodia, such as Taing (2008) and Sa (2011), suggested that organic rice farmers could obtain higher yields by practicing SRI's principles in combination with precision of organic practice. However, there is no sufficient data documented in governmental report.

MATERIALS AND METHODS

Site selection and data collection methods

This study employed a two-stage sampling technique. First, we selected three targeted organic cooperatives for purposive sampling. These were the Trapaing Sronger Agriculture Development Cooperative located in Tram Kak District, Takeo Province, with 40 members; the Srer Cheng Organic Agriculture Development Cooperative located in Srer Cheng Commune, Chum Kiri District, Kampot Province, with 202 members; and the Chhuk Organic Agriculture Development Cooperative, located in Chhuk District, Kampot Province, with 32 members. Secondly, we randomly selected organic farmers from each cooperative, and conventional farmers from the same study area. We collected data on rainy season rice production in 2013. This was done through face-to-face interviews using structured questionnaires from March to April 2014. In total, we interviewed 247 farmers, but only 221 responses were used for analysis, of which 84 were responses of organic farmers and 137 were those of conventional farmers. The summary of samples in each cooperative is shown in Table 1.

Table 1. Total samples by each study site.

Districts	Organic farmers	Conventional farmers	Total
Tram Kak	27	24	51
Chumkiri	36	64	100
Chhuk	21	49	70
Total	84	137	221

Source: Own survey (2014).

Empirical model

Accounting for potential endogenous effects is a crucial aspect in assessing the impacts of adoption of a new technology (Lapple et al., 2013). According to Faltermeier and Abdulai (2009), in order to estimate the impact of the adoption of a new technology accurately, farmers should be randomly assigned to either the adoption or the non-adoption group. However, farmers surveyed in this study decided on their own whether or not to adopt organic rice farming, and we did not specifically observe the longitudinal data of this study. If we directly compare the outcome variables of organic farmers and conventional farmers without considering the self-selection bias, we will obtain biased estimates. This implies that we should use an estimation method that is able to account for this bias to obtain accurate estimation of the impact of the adoption of organic rice farming.

Endogenous switching regression was applied in this study because it accounts for both observable and unobservable characteristics of farmers when estimating the impact of the adoption of organic farming. Propensity score matching is also a standard approach that could be employed in this study; however, it only accounts for observable characteristics and it should only be used if we can safely assume the absence of unobservable characteristics that can create a selection bias (Dehejia and Wahba, 2002; Heckman et al., 1997). In this study, it is believed that observable and unobservable factors influence farmers' adoption decision and their performance. For instance, motivation may be an unobserved variable that can affect both farmers' performance and their decision to adopt organic production of rice.

By using endogenous switching regression model, it is possible to examine the determinants of organic rice adoption, as well as to derive the impact of the adoption decision on the outcome variables of interest by estimating conditional and unconditional expectations. This allows the comparison of the expected performance of farmers under organic and conventional farming.

The methodology of the model

We applied Maximum Likelihood estimation to obtain our results of the endogenous switching regression model by using the movestay command in STATA (Lokshin and Sajaia, 2004).

Consider the following model that describes the choice of farmers to adopt organic farming and the factors that determine their performance:

If $\gamma Z_i + u_i > 0$ => farmer i chooses to conduct organic

farming ($I_i = 1$);
If $\gamma Z_i + u_i \leq 0$ => farmer i chooses not to conduct organic farming ($I_i = 0$).

Farmer's performance with organic rice ($I_i = 1$) is $y_{1i} = \beta_1 X_{1i} + \varepsilon_{1i}$ (1)

Farmer's performance with conventional rice ($I_i = 0$) is
$y_{0i} = \beta_0 X_{0i} + \varepsilon_{0i}$ (2)

Z_i is a vector of all selected variables that affect the decisions of farmers to adopt organic rice. X_{1i} and X_{0i} are two vectors of selected variables that affect the performance of farmers under organic and conventional farming respectively. y_{1i} and y_{0i} are dependent variables measuring rice production performance (rice yield and rice income); γ, β_1 and β_0 are parameters to be estimated; u_i, ε_{1i}, and ε_{0i} are three random error terms. These error terms are assumed to have a trivariate normal distribution with mean vector zero and the following covariance matrix:

$$\mathrm{cov}(\varepsilon_1, \varepsilon_0, \mathrm{u}) = \Omega = \begin{bmatrix} \sigma_u^2 & \sigma_{1u} & \sigma_{0u} \\ \sigma_{1u} & \sigma_1^2 & , \\ \sigma_{0u} & , & \sigma_0^2 \end{bmatrix},$$

where σ_u^2 is the variance of the error term in the decision equation, and σ_1^2 and σ_0^2 are variances of the error terms in the outcome equations. σ_{1u} is the covariance of u_i and ε_{1i} and σ_{0u} is a covariance of u_i and ε_{0i}. The covariance between ε_{1i} and ε_{0i} is not defined as y_{1i} and y_{0i} since they are never observed simultaneously. We can assume that $\sigma_u^2 = 1$ (γ is estimable only up to a scalar factor). The model is identified by construction through nonlinearities. Given the assumption with respect to the distribution of the disturbance terms, the logarithmic likelihood function for the system of equations (1) and (2) is as follows:

$$lnL = \sum_i \left(I_i w_i \left[ln\{F(\eta_{1i}\} + ln\left\{ f\left(\frac{\varepsilon_{1i}}{\sigma_1}\right)/\sigma_1 \right\} \right] + (1 - I_i) w_i \left[ln\{1 - F(\eta_{0i}\} + ln\left\{ f\left(\frac{\varepsilon_{0i}}{\sigma_0}\right)/\sigma_0 \right\} \right] \right).$$

Here, F is a cumulative normal distribution function, f is a normal density distribution function, w_i is an optional weight for observation i, and η_{ji} is given by:

$$\eta_{ji} = \frac{\gamma Z_i + \rho_j \varepsilon_{ji}/\sigma_j}{\sqrt{1 - \rho_j^2}}; j = 1, 0,$$

$\rho_1 = \sigma_{1u}^2/\sigma_u\sigma_1$ is the correlation coefficient between ε_{1i} and u_i, and $\rho_0 = \sigma_{0u}^2/\sigma_u\sigma_0$ is the correlation coefficient between ε_{0i} and u_i. To make sure that the estimated ρ_0 and ρ_1 are bounded between −1 and 1 and that the estimated σ_1 and σ_0 are always positive, the maximum likelihood method directly estimates $\ln\sigma_1$, $\ln\sigma_0$, and atanh ρ, which is given by:

$$\mathrm{atanh}\ \rho_j = \frac{1}{2} ln\left(\frac{1 + \rho_j}{1 - \rho_j}\right).$$

ρ_1 and ρ_0 have economic interpretations based on their signs and level of significant correlation. If ρ_1 and ρ_0 have different signs, positive and negative, and significant correlation, the implication is that individuals who adopt organic farming earn higher outcomes than what random individuals from organic rice sample would have earned, and conventional farmers have higher outcomes than random individuals from non-adopters group. Whereas, the negative sign of ρ_1 and positive sign of ρ_0 imply an unlikely scenario conversely with the previous condition. In addition, if both ρ_1 and ρ_0 have identical sign (both are positive) and significant correlation, it suggests that organic farmers obtain higher outcomes irrespective of their farming, while conventional farmers obtain lower outcomes in both farming. Conversely, if both coefficients have the negative sign, it indicates the contrast condition with positive sign in the previous condition (Fuglie and Bosch, 1995; Lokshin and Sajaia, 2004; Maddala, 1983).

After getting the parameters, the following conditional and unconditional expectations were estimated:

Unconditional expectation:

$xb_{1i} = E(y_{1i} | x_{1i}) = x_{1i}\beta_1$ (3)

$xb_{0i} = E(y_{0i} | x_{0i}) = x_{0i}\beta_0$ (4)

Conditional expectation:

$yc_{(1\_1i)} = E(y_{1i} | I_i = 1, x_{1i}) = x_{1i}\beta_1 + \sigma_1\rho_1 f(\gamma Z_i)/F(\gamma Z_i)$ (5)

$yc_{(0\_1i)} = E(y_{0i} | I_i = 1, x_{1i}) = x_{1i}\beta_0 + \sigma_0\rho_0 f(\gamma Z_i)/F(\gamma Z_i)$ (6)

$yc_{(0\_0i)} = E(y_{0i} | I_i = 0, x_{0i}) = x_{0i}\beta_0 + \sigma_0\rho_0 f(\gamma Z_i)/[1-F(\gamma Z_i)]$ (7)

$yc_{(1\_0i)} = E(y_{1i} | I_i = 0, x_{0i}) = x_{0i}\beta_1 + \sigma_1\rho_1 f(\gamma Z_i)/[1-F(\gamma Z_i)]$ (8)

Here, xb_{1i} estimates the expected performances of all farmers under organic farming; xb_{0i} estimates the expected performances of all farmers under conventional farming; $yc_{(1\_1i)}$ is the estimation of the expected performances of organic farmers under organic farming; $yc_{(0\_1i)}$ is the estimation of the expected performances of organic farmers under conventional farming; $yc_{(0\_0i)}$ is the expected performances of conventional farmers under conventional farming; $yc_{(1\_0i)}$ is the expected performances of conventional farmers under organic farming. σ_1 and σ_0 are the standard errors of ε_{1i} and ε_{0i}; ρ_1 is the correlation coefficient between ε_{1i} and u_i; and ρ_0 is the correlation coefficient between ε_{0i} and u_i.

Indicators for premiums of conducting organic rice

Based on equations (3) through (8), three indicators can be constructed to compare farmers' performance in organic and conventional farming (Cai et al., 2008).

ATE = (3) – (4)

ATE is equal to a general farmer i's expected performance (irrespective of his/her choice of organic farming) under organic farming minus his/her expected performance under conventional farming. The mean of ATE gives us the average performance premiums from the adoption of organic farming.

ATT = (5) – (6)

ATT is equal to a sampled organic farmer i's expected performance under organic farming minus his/her expected performance under conventional farming. The mean of ATT measures the performance premium for the sampled organic farmers from adoption of organic farming.

ATU = (7) – (8)

ATU is equal to a sample conventional farmer i's expected performance under organic farming minus his/her expected performance under conventional farming. The mean of ATU indicates the average performance premium for the sample conventional farmers from adoption of organic farming.

Indicators for farmers' relative performances under each farming

Cai et al. (2008) suggested this comparison for a more detailed analysis of the selection bias among farmers adopting a new farming practice:

D_{1_1} = (5) – (3) and D_{0_1} = (6) – (4)

D_{1_1} compares the average performance of a sampled organic farmer i under organic farming to the performance of a general farmer (with the same characteristics) under organic farming. A positive value of D_{1_1} indicates that under organic farming, farmers who actually conduct the organic farming tend to perform better than those who did not. On the other hand, D_{0_1} compares the average performance of a sampled organic farmer under conventional farming to the average performance of a general farmer under conventional farming. A positive value of D_{0_1} indicates that under conventional farming, farmers who actually conduct organic farming would also have performed better than those who did not:

D_{0_0} = (7) – (4) and D_{1_0} = (8) – (3)

Similarly, D_{0_0} compares the average performance of the sample conventional farmer under conventional farming to the average performance of a general farmer (with the same characteristics) under conventional farming. A positive value of D_{0_0} indicates that under conventional farming, farmers who did not conduct organic farming tend to perform better than those who did. On the other hand, D_{1_0} compares a sample conventional farmer i's average performance under organic farming to the average performance of a general farmer under organic farming. A positive value of D_{1_0} indicates that under organic farming, farmers who did not conduct organic farming tend to perform better than those who did.
D_{1_1}, D_{0_1}, D_{0_0}, and D_{1_0} measure the selection bias of farmers for adopting organic rice farming. Four patterns in these variables are possible:

1. $D_{1\_1} > 0$, $D_{1\_0} < 0$, $D_{0\_1} > 0$, and $D_{0\_0} < 0$: This situation indicates that the sampled organic farmers tend to perform better irrespective of whether they are under organic farming or conventional farming. That is, better farmers tend to choose to adopt organic farming.
2. $D_{1\_1} > 0$, $D_{1\_0} < 0$, $D_{0\_1} < 0$, and $D_{0\_0} > 0$: This situation indicates that the sampled organic farmers tend to perform better under organic farming but perform poorly under conventional farming. In other words, farmers who have a comparative advantage in organic farming tend to choose to adopt organic farming, while those who have a comparative advantage in conventional farming tend to choose conventional farming.
3. $D_{1\_1} < 0$, $D_{1\_0} > 0$, $D_{0\_1} > 0$, and $D_{0\_0} < 0$: This situation indicates that the sampled organic farmers tend to perform worse under organic farming but perform better under conventional farming. This is an unlikely scenario because it implies that farmers who do not have a comparative advantage in organic farming tend to adopt organic farming, while those who do have a comparative advantage in organic farming nevertheless tend to choose conventional farming.
4. $D_{1\_1} < 0$, $D_{1\_0} > 0$, $D_{0\_1} < 0$, and $D_{0\_0} > 0$: It indicates that the sampled organic farmers tend to perform worse irrespective of whether they undertake organic or conventional farming. That is, better farmers tend to choose conventional farming.

Description of data variables

We have used *rice yield* and *rice income* as outcome variables to assess the impact of organic rice farming. Rice income is equal to total rice revenue minus total cost (we exclude the family labor cost in variable cost: total cost = fixed cost + variable cost). We included *age, gender, education,* and *farming labor* as farmers' characteristics. *Rice plots, rice field size, selling, other farm activities, number of cows* and *number of poultry* were included as farm characteristics. Finally, *house size, off farm job,* and *own-tractor* are used as indicators of farmers' wealth. The detailed definitions and descriptive

Table 2. Descriptive statistics and definition of variables.

Variable	Definition	Unit	Mean	SD
Adopter	= 1 if farmer produces organic rice	Dummy	0.38	0.49
Yield	Total rice yield per hectare	t/ha	2.86	0.98
Rice income	Total rice income per hectare (excluding family labor cost)	US$/ha	603.13	454.50
Age	Age of household head	Years	46.15	11.27
Gender	= 1 if household head is male	Dummy	0.90	0.30
Education	Years of schooling of household head	Year	5.90	3.49
Farming labor	Number of family labors available for rice farming	Person	2.79	0.98
Rice plots	Numbers of rice plots farmers owned	Number	2.57	1.02
Rice field	Total rice field size farmers owned	Ha	1.02	0.55
Selling	= 1 if farmers sell their rice	Dummy	0.80	0.40
Other farm	= 1 if farmers have other farm activities besides rice farming	Dummy	0.29	0.45
Number of cows	Numbers of cows they owned	Number	2.60	1.37
No.of poultry	Numbers of poultry they raised	Number	81.41	443.53
House size	The square meter of house farmers owned	M^2	38.21	15.11
Off farm	= 1 if farmers have off-farm job	Dummy	0.21	0.41
Own-tractor	= 1 if farmers have two-wheel tractor	Dummy	0.19	0.39

Source: Own survey (2014).

Table 3. Descriptive statistics and statistical significance tests.

Variable	Organic farmers (N=84)		Conventional farmers (N=137)		Difference
	Mean	SD	Mean	SD	
Age	47.345	9.930	45.420	11.990	1.922
Gender	0.940	0.238	0.880	0.330	0.065
Education	7.107	3.058	5.170	3.540	1.939***
Farming labor	2.845	1.047	2.760	0.940	0.086
Rice plots	2.821	1.008	2.420	1.000	0.405***
Rice field	1.167	0.521	0.940	0.540	0.230***
Selling	0.964	0.187	0.690	0.460	0.271***
Other farm	0.440	0.499	0.190	0.390	0.251***
Number of cows	3.119	1.500	2.280	1.180	0.834***
Number of poultry	121.738	468.643	56.680	427.270	65.059
House size	39.354	12.383	37.510	16.570	1.841
Off farm	0.262	0.442	0.180	0.390	0.079
Owned tractor	0.250	0.436	0.150	0.360	0.097*

Source: Own survey (2014).
Note: * significant at 10%, ** significant at 5%, *** significant at 1%.

statistics of all variables are shown in Table 2.

RESULTS AND DISCUSSION

Descriptive results

Summary statistics and statistical significance tests for organic farmers and conventional farmers are shown in Table 3. The results show that the level of education of the head of the household for organic farmers is statistically higher than that for conventional farmers. This suggests that farmers that are more educated are more likely to adopt new farming practices. Education aids the adoption of new farming practices as information is more accessible to these farmers, and they are likely to have better skill in adapting to the new farming practices. In addition, most organic farmers are large-scale business oriented farmers who own more plots and have larger rice fields. This is indicated by the fact that 96% of organic rice farmers sold their rice as compared to 69%

Table 4. Production performances of organic and conventional farmers.

Variable	Organic farmers		Conventional farmers		Difference
	Mean	SD	Mean	SD	
Family labor (man-day/ha)	240.53	173.78	198.82	141.00	41.71*
Hired labor (man-day/ha)	42.17	45.34	38.39	40.77	3.77
Total labor (man-day/ha)	282.70	154.29	237.21	124.83	45.49**
Family labor cost (US$/ha)	451.00	325.84	372.79	264.37	78.21*
Hired labor cost (US$/ha)	114.36	124.24	96.49	102.05	17.87
Total labor cost (US$/ha)	565.36	282.77	469.28	228.55	96.08***
Yield (t/ha)	3.32	1.02	2.58	0.84	0.75***
Price (US$/kg)	0.36	0.05	0.28	0.04	0.08***
Fixed cost (US$/ha)	24.43	29.94	32.63	33.76	-8.20*
Variables cost[a] (US$/ha)	186.39	155.32	315.38	221.84	-128.99***
Total cost (US$/ha)	210.82	165.80	348.01	225.19	-137.19***
Rice income[b] (US$/ha)	973.77	415.16	375.88	303.47	597.90***

Source: Own survey (2014).
Note: * significant at 10%, ** significant at 5%, *** significant at 1%.
a: Family labor cost is not included in variable cost; b: Rice income = (Yield * Price) – (Fixed cost + Variable cost).

of conventional farmers. The significantly higher percentage of organic farmers who have other activities taking place on their farm, farmers who have two-wheel tractors, and have a higher number of cows clearly indicates that they are generally wealthier than conventional farmers.

Table 4 presents a comparison of production performances of organic and conventional farmers. Before comparing the production performances, we examined the differences in the required labor input in both farming systems. Table 4 indicates that organic farming requires a significantly higher labor input than conventional farming. Organic farmers required 240.53 man-day/ha of family labor as compared to conventional farmers who required only 198.82 man-day/ha of labor. Table 4 shows no significant difference in hired labor input between the two groups. For total labor input, organic farmers employed a statistically higher number of labor hours than conventional farmers. Clearly, with a 45.49 man-day/ha difference in total labor requirement, organic farming is more labor-intensive as compared to conventional farming. With regard to labor cost, organic farmers spent a significantly higher amount on family labor cost and total labor cost than conventional farmers did. However, there is no significant difference in the cost of hired labor between the two groups.

Based on a simple comparison, results indicate that organic farmers obtained 0.75 tons/ha higher yield and US$597.90/ha higher total rice income vis-à-vis conventional farmers. Variable cost and total cost of organic farmers are also significantly lower than that for conventional farmers due to the application of a higher amount of chemical fertilizer in conventional farming. However, this simple comparison does not control for selection bias. Therefore, we cannot draw the conclusion that organic rice farming would result in a positive impact on rice yield and rice income for farmers as the better outcomes observed for organic farmers can be a result of better observable and unobservable characteristics of the farmers themselves.

Empirical results

Effect of organic rice farming on rice yield and its determinants

The results of the endogenous switching regression model are shown here. We assess the impact of organic rice farming by using rice yield and rice income as the outcome variables of interest. The first section will present the result of adoption of organic rice farming on rice yield. These results are displayed in Table 5.

Table 5 shows that *age, education, selling, other farm,* and *number of cows* are positively correlated with the adoption of organic rice farming. The statistically positive correlation of age and education suggests that older educated farmers tend to adopt organic farming because new information is more accessible to them and they have better skill for adapting to new farming practices. The more productive of age tended to be more eager to learn and know about new knowledge so that it could accelerate the process of adoption of technology (Kusmiati et al., 2007). This result is similar to that of Khaledi et al. (2010), who find that older farmers are more likely to adopt organic farming. Similarly, the respondents with a higher level of education were usually more rational, open, and able to access the advantages of organic farming; therefore, it is easier to introduce an

Table 5. Endogenous switching regression estimates of the rice yield.

Variable	Adoption of organic		Organic		Conventional	
Y = logYield (t/ha)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age	0.024**	0.010	0.011	0.002	-0.001	0.001
Gender	0.062	0.363	-0.074	0.058	0.066*	0.036
Education	0.104***	0.032	0.007	0.009	-0.006	0.004
Farming labor	-0.116	0.106	0.010	0.015	-0.007	0.013
Rice plots	-0.109	0.110	0.004	0.017	-0.008	0.014
Rice field	0.347	0.228	-0.054	0.038	0.001	0.027
Selling	1.132***	0.365	0.175	0.130	0.039	0.031
Other farm	0.764***	0.242	-0.026	0.060	-0.040	0.031
Number of cows	0.226***	0.086	0.006	0.017	-0.026**	0.011
Number of poultry	0.000	0.000	0.000	0.000	0.000	0.000
House size	-0.018**	0.008	-0.003	0.002	0.001	0.001
Off farm	0.230	0.244	-0.063*	0.036	0.032	0.029
Owned tractor	0.439	0.290	0.033	0.043	0.063*	0.038
Constant	-3.116***	0.692	0.534	0.336	0.385***	0.070
σ			0.116***	0.011	0.137***	0.013
ρ			-0.114	0.941	-0.899***	0.079

Source: Own survey (2014).
Note: * significant at 10%, ** significant at 5%, *** significant at 1%.

innovation to them (Kusmiati et al., 2007). These results are consistent with Azam (2015), Koesling et al. (2008), Mzoughi (2011), and Shaban (2015).

The positive correlation between the variable *selling* and the adoption decision indicates that farmers who sold their products are more likely to adopt organic rice farming. This is because these farmers are business oriented, and are aware of the benefits of the organic product, which typically sells at a premium. This result is consistent with that of Azam (2015), Koesling et al. (2008), and Mariano et al. (2012). The result also suggests that farmers who engaged in other farm activities besides rice farming and owned a larger number of cows are more likely to adopt organic rice farming. This is probably because they are able to generate a sufficient amount of organic fertilizer for their organic farming when they have other farm activities and a large number of cows. Koesling et al. (2008) had similar results.

On the other hand, only *house size* is negatively associated with adoption of organic farming. Since *house size* was regarded as an indicator of the wealth of the farmer, this result suggests that richer farmers are less likely to adopt organic farming. This result is inconsistent with Kalyebara (1999) who noted that high-income farmers are about twice as likely to adopt soil-conserving measures as compared to poor farmers in Uganda. Usually richer farmers in Cambodia often engage in off-farm activities; so they are more likely to be engaged in other businesses in addition to rice farming.

In the outcome equation of organic farmers in Table 5, the result points out that only *off farm activities* is negatively correlated with *rice yield* for organic farmers. It suggests that organic farmers who have off farm jobs are likely to be less productive in rice production since they probably have little spare time to focus on their rice field. For outcome equation of conventional farmers, the result suggests that *gender* and *owned tractor* are positively associated with *rice yield*, while *numbers of cow* is negatively correlated with *rice yield*. This means that female conventional farmers get a lower rice yield as compared to male farmers. Additionally, farmers who owned more cows are likely to have a lower rice yield, while farmers who owned two-wheel tractors produce a higher yield than those who do not. It indicates that the two-wheel tractor is more productive than animal power.

The correlation coefficients ρ_1 (organic) and ρ_0 (conventional) are both negative. However, the correlation coefficient is significant only for ρ_0. From the sample, it implies that conventional farmers obtain higher yield than what random farmers would have earned, while those conducting organic farming obtain no higher or lower yield than random farmers (Lokshin and Sajaia, 2004). The model suggests that selection bias occurs among conventional farmers who have a comparative advantage in it.

Table 6 illustrates the effects of organic farming on rice yield, and the selection bias among farmers. The fourth column of Table 6 shows that rice yield will increase when farmers adopt organic farming. All the three groups, pooled sample (ATE), organic farmers (ATT), and conventional farmers (ATU), show a significant difference

Table 6. Estimates of the effects of organic farming on rice yield.

Sample groups	Organic	Conventional	YGAOF	YDOF	YDCF
	Mean (t/ha)	Mean (t/ha)	Diff. (t-test)	Diff. (t-test)	Diff. (t-test)
Pooled sample	3.136	2.138	ATE = 0.997***		
Organic farmers	3.204	1.674	ATT = 1.530***	D_{1_1} = 0.069	D_{0_1} = -0.465***
Conventional farmers	3.094	2.486	ATU = 0.607***	D_{1_0} = -0.042	D_{0_0} = 0.348***

Source: Own survey (2014).
Note: YGAOF: Yield Gained from Adoption of Organic Farming; YDOF: Yield Difference under Organic Farming; and YDCF: Yield Difference under Conventional Farming.
* Significant at 10%, ** significant at 5%, *** significant at 1%.

when we compared the performance in organic farming to conventional farming. Sampled organic farmers would gain 1.530 t/ha if they shifted to conduct organic farming, while conventional farming would increase their rice yield by 0.607 t/ha if they shifted to organic farming. This suggests that organic farming would result in yield gain when farmers shift to organic farming. This result is consistent with that of Taing (2008) and Sa (2011), who suggest that organic farmers produce a higher yield than conventional farmers by using a simple comparison. Our findings are consistent with those of Badgley and Perfecto (2007) who noted that organic farming, in general, obtained high yield ratios in developing countries due to the fact that many existing conventional farming practices in the developing world do not apply optimal amounts of synthetic fertilizer, and do not manage their farming practices well.

As discussed in the methodology section of the model, D_{1_1}, D_{0_1}, D_{0_0}, and D_{1_0} measure farmers' selection bias for organic farming. The fifth column of Table 6 shows that all farmers under organic farming get similar yields since there is no significant difference between the expected yields from conducting organic farming as compared to the pooled sample. However, there is a significant difference in the rice yield under conventional farming (in the sixth column of Table 6) vis-à-vis the pooled sample. This suggests that sampled conventional farmers are likely to be better in conventional farming, and there is a hidden selection bias among conventional farmers, which is why conventional farmers do not adopt organic farming. The signs of D_{1_1}, D_{1_0}, D_{0_1}, and D_{0_0} ($D_{1\_1}> 0$, $D_{1\_0}< 0$, $D_{0\_1}< 0$, and $D_{0\_0}> 0$) indicate that the sampled organic farmers tend to have a higher rice yield under the organic farming but a lower yield under conventional farming. Therefore, farmers who have a comparative advantage in organic farming tend to choose to adopt organic farming, while those who have a comparative advantage in conventional farming tend to remain conventional farmers.

Effect of organic rice farming on rice income and its determinants

This section presents the effect of organic rice farming on farmers' rice income when farmers adopted organic farming practices. In Table 7, rice income was included as outcome variable. The results in Table 7 are similar to those in Table 5. However, another variable, *own tractor* is significantly correlated with the adoption decision. This clearly suggests that farmers that are business oriented are more likely to adopt organic rice farming. Additionally, farmers who owned a tractor can successfully engage in organic rice farming that requires good land preparation for easier weed and pest control. This result is in line with that of Mariano et al. (2012) who noted that farmers who own machinery are more likely to adopt organic farming.

In the outcome equation of rice income, the results indicate that *selling, other farm* and *number of cows* are positively correlated with *rice income* for organic farmers. It suggests that organic farmers who are business oriented with more farming activities and a greater number of cows tend to get a higher rice income. As mentioned in the previous section, obtaining this higher rice income is probably aided by the production of a large amount of organic fertilizers, which is possible for farmers who engage in other farm activities and have a larger number of cows. However, *house size* of organic farmers is negatively correlated with *rice income,* which implies that richer organic farmers are likely to get lesser rice income since richer farmers may focus more on activities other than rice farming. Once again, for the outcome equation of conventional farmers, the result points out that *selling* is positively correlated with *rice income,* suggesting that business oriented farmers, both organic and conventional, are likely to get a higher rice income. Surprisingly, *education* is negatively correlated with rice income of conventional farmers. This is because educated conventional farmers tend to focus on activities other than rice farming for their income. Educated farmers often have off farm jobs in addition to rice farming, which results in poor management of the rice field.

The correlation coefficient ρ_1 (organic farmers) is positive and significantly different from zero, while ρ_0 (conventional farmers) is negative but not significant. It means that farmers who choose to conduct organic farming earn a rice income in organic farming that is higher than the income a random farmer from the sample

Table 7. Endogenous switching regression estimates of the organic rice income per hectare.

Variable	Adoption of organic		Organic		Conventional	
Y = Log Rice Income (US$/ha)	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Age	0.021**	0.010	0.001	0.001	0.000	0.001
Gender	-0.069	0.380	0.029	0.054	0.023	0.037
Education	0.097***	0.035	0.006	0.005	-0.009*	0.005
Farming labor	-0.125	0.105	0.012	0.013	0.009	0.015
Rice plots	-0.114	0.115	0.001	0.015	0.007	0.015
Rice field	0.256	0.233	-0.031	0.031	-0.018	0.028
Selling	1.323***	0.354	0.186**	0.081	0.070*	0.038
Other farm	0.896***	0.250	0.079*	0.041	0.055	0.037
Number of cows	0.282***	0.087	0.023*	0.012	-0.006	0.014
Number of poultry	0.000	0.000	0.000	0.000	0.000	0.000
House size	-0.027***	0.009	-0.004**	0.001	0.000	0.001
Off farm	0.142	0.252	-0.027	0.032	0.035	0.031
Owned tractor	0.688**	0.285	-0.029	0.035	-0.012	0.044
Constant	-2.745***	0.690	2.838***	0.163	2.836	0.074
σ			0.119***	0.021	0.132***	0.012
ρ			0.691**	0.275	-0.377	0.388

Source: Own survey (2014).
Note: * significant at 10%, ** significant at 5%, *** significant at 1%.

Table 8. Estimates of the effects of organic farming on rice income per hectare.

Sample groups	Organic	Conventional	YGAOF	YDOF	YDCF
	Mean (US$/ha)	**Mean (US$/ha)**	**Diff. (t-test)**	**Diff. (t-test)**	**Diff. (t-test)**
Organic farmers	932.72	252.96	ATT = 679.76***	D_{1_1} = 310.60***	D_{0_1} = -49.82***
Conventional farmers	447.73	337.49	ATU = 110.24***	D_{1_0} = -174.40***	D_{0_0} = 34.71***

Source: Own survey (2014).
Note: YGAOF: Yield Gained from Adoption of Organic Farming; YDOF: Yield Difference under Organic Farming; and YDCF: Yield Difference under Conventional Farming.
* Significant at 10%, ** significant at 5%, *** significant at 1%.

would have earned. Those conducting conventional farming do no better or worse than a random individual does (Lokshin and Sajaia, 2004). The model suggests that selection bias occurs among organic farmers who have a comparative advantage in organic farming when rice income was regarded as the outcome variable. The selection bias will be illustrated in Table 8.

Table 8 presents the effects of organic farming on farmers' rice income, and the selection bias among farmers. The results show that rice income will increase if farmers shift to conduct organic farming because of a price premium for organic products. As shown in the fourth column of Table 8, there is a significant difference for all the three groups. Farmers in the pooled sample, organic farmers, and conventional farmers obtain 319.35 US$/ha, 679.76 US$/ha, and 110.24 US$/ha of rice income respectively. The result suggests that the adoption of organic farming results in a higher rice income. Mansoori et al. (2012), Sa (2011), Setboonsarng et al. (2008), and Taing (2008) also confirm similar results. However, the findings of this study are in contrast to those of Uematsu and Mishra (2012), who noted that organic farmers are not significantly better off in terms of farm household income since organic farmers incurred significantly higher production costs that is divided among labor costs, insurance expenses and marketing charges. On the other hand, our study finds that the production costs of conventional farming are significantly higher than organic rice farming.

The signs of D_{1_1}, D_{0_1}, D_{0_0}, and D_{1_0} ($D_{1\_1} > 0$, $D_{1\_0} < 0$, $D_{0\_1} < 0$, and $D_{0\_0} > 0$) indicate that the sampled organic farmers tend to have a higher rice income under the organic farming but a lower income under conventional farming. It obviously means that farmers who have a comparative advantage in organic farming tend to choose to adopt organic farming, while those who have a comparative advantage in conventional farming tend to do conventional farming. Selection bias occurs in both groups of farmers when they try to judge the new farming practices based on their experiences and conditions. To increase the adoption of organic rice farming, an effective extension program should be implemented to help farmers realize the benefit of organic rice farming.

CONCLUSION AND RECOMMENDATIONS

Although economic concerns play a strong role in influencing the decision of farmers to adopt organic farming, moral and social concerns also play a significant role (Mzoughi, 2011). The result of the adoption decision equation indicates that the variables: *age, education, selling, other farm activities, number of cows,* and *owned tractor* are positively associated with adoption of organic rice farming, whereas the *house size* variable is negatively correlated with the adoption decision.

The result indicates that all farmers will obtain a higher rice yield and rice income if they adopt organic farming. Additionally, in terms of rice yield, organic farmers do no better or worse than conventional farmers under organic farming, while conventional farmers are better in conventional farming as compared to organic farmers. This suggests a hidden selection bias among conventional farmers. With regard to rice income, organic farmers tend to earn a higher rice income under organic farming but a lower income under conventional farming. The estimations of farmers' selection bias for rice yield and rice income suggest that farmers who have a comparative advantage in organic farming tend to adopt organic farming, while those who have a comparative advantage in conventional farming tend to conduct conventional farming. Therefore, farmers are good at evaluating a new technology based on their psychology and sociological conditions before adopting it. Specifically, conventional farmers believe that they are better at conducting conventional farming as compared to adopting a new technology.

The main findings of this article help researchers, policy makers, and related institutions conclude that organic farming would result in better outcomes for Cambodian farmers. Although organic farming requires a higher labor input, it would also result in a higher rice income. Therefore, it is strongly recommended that farmers should choose to adopt organic rice farming.

Based on the result of adoption decision equation, it is recommended that the government and related institutions should provide training courses, extension services, and other supportive policies to encourage younger and less educated farmers to adopt organic farming since they are otherwise less likely to adopt organic rice farming. All related institutions should guide farmers to be business oriented in rice production to get benefits from producing organic rice. In addition, because organic farming requires a large amount of organic fertilizers, farmers should be encouraged to engage in other farm activities and raise more livestock. This would help them generate sufficient amounts of organic fertilizers. Economical and effective tools should be innovated and introduced to farmers to ease farming activities.

Because Cambodia has great potential in the organic rice industry, it is recommended that all stakeholders work together to improve organic rice farming in Cambodia. This is especially because the high demand of organic rice from developed countries enhances the opportunity to gain from the adoption of organic farming practices. The government should sustain the price of organic rice by expanding market channels. Moreover, the implementation of contract farming and farm insurance are highly recommended in order to secure the production of organic rice.

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