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Factors Affecting Farmer′s Choice of Cultivating Landrace Rice: Using a Switching Regression Model

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Abstract : The study aim to investigate the influential factors of the farmer′s decision to cultivate landrace rice. To achieve our study, a switching regression model which contain two models, selection and outcome models is used as a tool. The Bayesian method is employed to joint the distribution of error terms of the selection and outcome models under the six copula functions. Results show that the selection model has the normal distribution while the outcome model has the logistic distribution. The Clayton copula is best fit to the farmer′s decision model. Overall, the more educated farmer is 4.7% less likely to grow landrace rice. The income from non-agricultural activities has slightly effect on the farmer′s decision. Further, the household with available water supply is 5.4% more likely to reduce the cultivated area of the landrace rice in the next season. This because of the local rice varieties is drought tolerant; therefore, the farmers would prefer to use available water for planting other crops that give a higher return.

Keywords : landrace rice; local variety rice; Bayesian; switching regression; copula; discrete choice model.

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1 Introduction

Rice fields cover about 11.3% of Thai agricultural land. The largest rice cultivated region in the country is the northeast, following by the northern, central, and southern regions. Thai rice can be grown under different environments, lowland and upland ecosystems. The lowland ecosystem is suitable for both irrigated and rainfed rice. The northern region are geographically surrounded by mountains and forests. The upland environment is drought-prone and steep areas. The rainfed-upland rice is practically grown in low valley fields and high valley fields of the region. Currently, 14.6 million rais of the northern region are under rainfed rice cultivation (1 rai approximately equals to 0.4 acres); especially, in Chiang Rai, Chiang Mai, Uttaradit, and Phayao provinces [1].

Most of the hilly areas in the northern region are inhabited by non-Thai ethnic minorities. Their livelihood rests on the mountain agriculture such as upland rice cultivation, maize, and fruit crop. Several varieties of landrace rice have existed in high altitude areas of Chiang Mai and Phayao provinces. The landrace rice is a local crop cultivar that has been developed through traditional farming practices and grown by local farmers. For many years, Bue-Po-Lo and Mei-Nong are common landrace rice cultivated in Chiang Mai province from generation to generation while the Kam-Pha-Yao is grown in Phayao province. An advantage of landrace rice are low water demand and drought tolerant. In year 2012, Naritsara [2]. found that the local variety rice (e.g., Kam variety) contain high amount of carbohydrate, fat, protein, vitamin A, B1, and B2, calcium, and anthocyanin which can help to reduce risk of cancer. The local variety rice has become substantially known in the market, giving an opportunity to upland farmers to increase the market value of their outputs. However, more than half of the farmers in the upland area produce rice only for household consumption.The landrace rice was commonly traded among households in the village; not for commercial sale.

A pervious study observed the farmer′s choice to adopt the technology under the agricultural structure and production system adjustment program (ASPSAP) in the Central Region of Thailand, see [3]. The researcher reported that the recommendation of the extension officers is strongly influent the farmers decision to join ASPSAP. On the other hand, the socio-economic characteristics of farmers are less correlated to the adoption rate of the technology. In year 1998, Ismet et al. [4]. have investigated the effects of government rice procurement and distribution, length of roads, and per capita income on the degree of market integration by using the multivariate cointegration tests. Researchers evaluated the market integration during a period of policy change, i.e., pre-self-sufficiency prior (1982-1984) and post-self-sufficiency (1985-1993) periods, as well as for the entire period (1982-1993). They found that the government intervention to widen the band between the floor and ceiling price significantly influenced market integration during both periods of post-self-sufficiency and entire period. Furthermore, the post-self-sufficiency period has a smaller degree of market integration compared to the pre-self-sufficiency period. These results suggested that the procurement program has significantly affected dynamic price adjustments. Pornpratansombat, Bauer, and Boland [5]. has determined the factors affecting farmer′s perceptions of the organic farming method for rice production in Surin Province, Thailand. The study found that water supply and farm gate price had significant impact on farmer′s choice to employ the organic farming method rather than the traditional farming practice.

To the best of our knowledge, none of the past researchers have investigated farmer′s choice of growing local variety rice. This indicates the need for further research regarding roles of households′ socio-economic status, farm input availability, and output prices play in the farmer′ decision. Therefore, this study aims to determine: 1) farmer′ characteristics, 2) households′socio-economic status, 3) farm resource availability, 4) marketing opportunity, and 5) institutional support program on the probability of cultivating landrace rice by the upland farmers. To achieve our study, the sample selection model with ordered outcome, as proposed by Luechinger, Stutzer, and Winkelmann [6], was employed to analyse the influential factors of the farmer′ decision.

2 Data Analysis

A survey through face-to-face interviews from individuals was conducted for this study. The survey covered 332 rice growers in six districts of Chiang Mai and Phayao Provinces (Samung, Hod, Omkoi, Maewang, Dokkhumtai, and Pong). A proportional stratified random sampling method was used to assign the sample units of each district segment. Then, the survey participants were selected from villages that produce both lowland rice and landrace rice. The interview was taken during September 2015 to January 2016 in the local northern Thai dialect. A Bayesian sample selection with ordered outcome model is applied to determine influential factors of the farmer′s choice. In this study, we consider gender, education (in years), experience (in years) of respondents, household income, and purpose of rice cultivation as explanatory variables for selection model, while members, water supply, income from agriculture, market condition, output price, and institutional support program were included as explanatory variables in the outcome model.

The whole survey of questionnaires is divided into four sections. Questions to obtain the farm households′ socio-economic status were asked in the first section. The second section contains questions regarding farmer′s attitude on the landrace rice. In the third section, Likert-scale questions were employed to determine influential factors of the farmer′s decision. At the end of the survey, demographic information (age, gender, and education) and experience of the respondents were collected.

The statistical summary of the explanatory variables for a sample selection model is listed in Table 1. The majority of the respondents are female 54%, and 57% of these are 41-60 years old. Average schooling years is 4.7 with 21.03 years′ experience in rice cultivation. Most of the households produce landrace rice for their own consumption and 27.7% of them have attended the training related to rice production. An average annual income of the households is 91,314.2 baht ($1 is approximately equal to 35). The households earn income mainly from agricultural productions such as rice, fruit, and vegetable. Their average income from agricultural activities is 55,198.3 baht per year.

Table 1: Statistical summary of the explanatory variables

Explanatory variables	Mean	Min	Max
Selection Equation			
Gender(0=male,1=female)	0.5451	0	1
Education(Years of schooling)	4.7018	0	16
Rice cultivation experience(duration in years)	21.0301	0	60
Training experience in agriculture(1=train,0=not train)	0.2771	0	1
Household annual income in Thai currency(baht)	91314.2	0	630000
Household annual income from non-agriculture(baht)	36115.9	0	492000
Purpose of rice cultivation(1=sale,2=consume,3=both)	2.1771	1	3
Outcome Equation			
Household annual income from agriculture (baht)	55198.25	0	600000
Number of household members	4.76506	0	13
Water supply (0 = not influential at all, and 10 = strongly influential)	7.7349	0	10
Market condition (0 = not influential at all, and 10 = strongly influential)	6.6325	0	10
Price of local variety rice (0 = not influential at all, and 10 = strongly influential)	5.3614	0	10
Price of substitute outputs (0 = not influential at all, and 10 = strongly influential)	4.6777	0	10
Financial support (0 = not influential at all, and 10 = strongly influential)	5.2439	0	10
Government support (0 = not influential at all, and 10 = strongly influential)	6.7469	0	10

About 78.3% of the households grow at least one variety of landrace rice and 21.7% grow other white rice. Only 9% of the households are willing to increase their cultivated areas. About 81.7% of the households insist to maintain the same cultivated area (Table 2).

Table 2: Distribution of the upland rice growers

Category	Frequency	Proportion
Selection equation		
Grow landrace rice	260	0.7832
Not grow landrace rice (grow the white rice)	72	0.2168
Outcome Equation		
reduce the cultivated area	22	0.0877
maintain same size of the cultivated area	205	0.8167
increase the cultivated area	24	0.0956

3 Econometric Models

3.1 The Sample Selection Model with Ordered Outcome

The study aim to estimate the effect of explanatory variables on the farmer′s decision of cultivating landrace rice. The explanatory variables include households socio-economic status, farm resource, marketing opportunity, and institutional support program. The farm size of landrace rice depends on whether farmers are currently growing or not growing landrace rice. It is important to understand the self-selection approach of an inference when the participants self-selected themselves into the treatment and they are not participants are not randomly drawn from the population, see [7] and [6]. To overcome this concern, a switching regression model of selection and outcome models was developed. The selection model of landrace rice growers is specified as a binary discrete variable with two possible values: (1) the farmer currently grows landrace rice; and (2) the farmer does not grow any landrace rice. The selection model can be written as

$$s_i^* = Z_i^{'}\gamma + v_i \tag{3.1}$$

where $Z_i^{'} = (Z_{i1}, Z_{i2}, ..., Z_{ik})$ and k is the number of explanatory variables (k = 7). The explanatory variables includes gender, education, and experience on rice cultivation, planting purpose, and household annual income. γ is the estimated parameter for the variable k, and v is a random error term which can be logit or normal distribution. The variable s_i^* is a binary response variable of an individual i ($i = 1, 2, ..., n$) which takes a value of 1 if the farmer grows at least one variety of landrace rice and zero when the farmer does not grow any landrace rice.

The outcome model of the farmer′s choice is expressed as

$$y_i^* = X_i^{'}\beta + u_i \tag{3.2}$$

where y_i^* is the ith farmers decision ($i = 1, 2, ..., n$), $X_i^{'} = (X_{i1}, X_{i2}, ..., X_{ik})$ and k is the number of explanatory variables ($k = 8$). β is the estimated parameters, and u_i is a random error term for the outcome model.

Simplified further, the equation (3.2) can be written as

$$\begin{aligned} y_{i0}^* &= X_{i0}^{'}\beta + u_{i0} \\ y_{i1}^* &= X_{i1}^{'}\beta + u_{i1} \end{aligned} \tag{3.3}$$

where y_{i0}^* is an indicate variable for the individual i who are not cultivating any landrace rice during the survey time. y_{i1}^* is the indicate variable for the landrace rice growers. This variable is discrete and has three values: (1) when the farmer want to reduce the cultivated area of landrace rice for the next harvest season, y_{i1}^*=1, (2) when the farmer insist to remain the same size of cultivated area, y_{i1}^*=2, and (3) when the farmer want to expand the area of the landrace rice cultivation, y_{i1}^*=3. These ordered outcomes can be determined by the following condition:

$$y_{i1}^* = j \;\text{ iff } c_{i1,j} < y_{ij}^* \leq c_{i1,j+1}, \quad j = 1, 2, 3 \tag{3.4}$$

The threshold values $c_{i1,j}$ can be any number between ∞ and $-\infty$ and $c_{i1,j+1} > c_{i1,j}$ for any j.

In conventional approach, the joint distributions $f(v, u_{i0})$ and $f(v, u_{i1})$ are assumed to be a bivariate normal distribution for the model. However, this could limit the model with linear relationship and same marginal distribution as addressed by Wichitaksorn, Choy and Gerlach [8]. In addition, the probability of observing $y^*_{i1} = j$ depended on the outcome of the selection variable s^*_i, and the y^*_{i1} may not be independent, see [7] and [6]. To overcome this problem, a copulas method was employed to join the $f(v, u_{i0})$ and $f(v, u_{i1})$. The probabilities of an ordinal outcome can be specified as

$$
\begin{aligned}
P(y^*_{i0} = j, s^* = 0\,|X\ ,Z) &= P(c_{i0,j+1} - X'\beta_0 < u_{i0} \le c_{i0,j} - X'\beta_0, v \le -Z'\gamma)\\
&= P(c_{i1,j+1} - X'\beta_0, v \le -Z'\gamma) - P(u_{i0} < c_{0,j} - X'\beta_0, v \le -Z'\gamma)\\
P(y^*_{i1} = j, s^* = 1\,|X\ ,Z) &= P(c_{i0,j+1} - X'\beta_1 < u_{i1} \le c_{i1,j+1} - X'\beta_0, v > -Z'\gamma)\\
&= P(u_{i1} < c_{i1,j+1} - X'\beta_1, -v < -Z'\gamma) - P(u_{i1} < c_{i1,j} - X'\beta_1, -v < -Z'\gamma)
\end{aligned} \tag{3.5}
$$

The copula is proposed to generate the joint distribution functions for the selection and outcome models. Copula is a multivariate joint distribution function, and they exist in an n-dimensional copula C such that for all $x_1, ...x_n \in R^2\ \bar{R}$ with

$$F(x_1, ..., x_n) = C(F_1(x_1), ..., F_n(x_n)) \tag{3.6}$$

$$C(u_1, ..., u_n) = C(F_1^{-1}(u_1), ..., F_n^{-1}(u_n)) \tag{3.7}$$

where $u_1, ..., u_n$ are n-dimensional cumulative distribution functions of standardized residuals which is uniform on the interval $[0, 1]$.Thus, Eq.(3.5) can be rewritten as

$$
\begin{aligned}
P(y^*_{i0} = j, s = 0\,|X\ ,Z) &= C(\Phi(c_{i0,j+1} - X'\beta_0), \Phi(-Z'\gamma), \theta_0)\\
&\quad - C(\Phi(c_{i0,j} - X'\beta_0), \Phi(-Z'\gamma), \theta_0)\\
P(y^*_{i1} = j, s = 1\,|X\ ,Z) &= C(\Phi(c_{i1,j+1} - X'\beta_1), 1, \theta_1)\\
&\quad - C(\Phi(c_{i0,j} - X'\beta_1), 1, \theta_1)\\
&\quad - C(\Phi(c_{i1,j+1} - X'\beta_1), \Phi(-Z'\gamma), \theta_1)\\
&\quad + C(\Phi(c_{i1,j} - X'\beta_1), \Phi(-Z'\gamma), \theta_1)
\end{aligned} \tag{3.8}
$$

where $C(u, v)$ can be Gaussian copula, Joe copula, Student-t copula, Gumbel copula, Clayton copula, or Frank copula, and v, u_{i0} and u_{i1} are assumed to be either normal or logistic distribution (logit or probit model). Φ represents the cumulative normal distribution or logistic distribution function. θ_0 and θ_1 are dependent parameters of the bivaiate copula.

3.2 Bayesians Markov Chain Monte Carlo Sample Selection Model with Ordered Outcome

We have $\psi = \{c_0, c_1, \beta_1, \gamma, \theta_1\}$ as the parameters for the outcome model. The joint probability distribution of the ordinal outcome obtained in the previous section was applied to the Bayesian Markov Chain Monte Carlo. The construct function of the posterior distribution can be written as

$$Pd(\psi\,|y_i^*\,, s^*, X, Z) = L(\psi\,|y_i^*\,, s^*, X, Z) \cdot p(\psi) \tag{3.9}$$

where $L(\psi\,|y_i^*\,, s^*, X, Z)$ is the likelihood function obtained from Eq.(3.8) and the $p(\psi)$ is the prior density of the outcome parameters ψ. The prior for β_1 and γ_1 is given by

$$\begin{aligned} \beta_1 &\sim N(b_1, B_1^{-1}) \\ \gamma_1 &\sim N(g_1, G_1^{-1}) \end{aligned} \tag{3.10}$$

where b_1 and g_1 are prior mean parameter of the outcome and selection equation, respectively. B_1^{-1} and G_1^{-1} are the inverse of the variance-covariance matrix. For the threshold variable c_0 and c_1, the copula dependence parameters are assumed to have uniform distribution as proposed in Pitt, Chan, and Kohn [9], Smith and Khaled [10], and Wichitaksorn, Choy, and Gerlach [8].

For the sampling, we employed the Metropolis-Hastings to sample the parameter set in the model. We drew the parameter β_1 and γ_1 for $N(\bar{b}, se)$ where $\bar{b}$ and se are the estimated parameters and standard errors from the least squares method. For the copula parameters, we draw the dependence parameter from truncated normal to the (-1,1) interval for Normal and Student-t copulas, $(1, \infty)$ interval for Joe copula, and $(-\infty, \infty)$for Frank copula. We then accepted or rejected the proposal value by using

$$r = \min\left\{\frac{Pd(\psi^{(1)}\,|y_i^*, s^*, X, Z}{p(\psi^{(0)}, |y_i^*, s^*, X, Z}, 1\right\}. \tag{3.11}$$

If the random $unif(0,1) < r$, we can update parameter $\psi^{(1)} = \psi^{(1)}$ or otherwise set $\psi^{(1)} = \psi^{(0)}$. The 10,000 draws of the parameters were made in the study, and the first 2,000 draws were discarded as a burn-in. The remaining 8,000 draws were used to estimate the mean for Bayesian inference.

4 Results

4.1 Selection model for the households decision

Six copula functions were estimated to evaluate a goodness of fit of the households′ decision model. Deviance Information Criteria (DIC) was used as a selection tool. The DIC is more preferred when giving the lowest value. Table 3 presents estimated values of the DIC for the six copula models.

Table 3, show that the distribution of the selection model is normal and the outcome model is logistic; and joint these two models by Clayton copula gives the lowest DIC value. We found that the DIC is equal to 701.03, therefore, the Clayton copula with normal-logistic marginal specification is used in our sample selection model.

Table 3: A comparison of DIC values for the six copula models

DIC	Gaussian	Student-t	Joe	Frank	Gumbel	Clayton
N-N	813.309	2036.34	845.495	397.291	829.602	832.591
N-L	955.446	2034.77	765.181	694.524	1218.571	701.033
L-N	770.776	2033.49	862.734	849.702	813.095	823.782
L-L	957.929	2031.46	769.775	5021.705	914.268	2536.546

Source: Calculation
Note : N=normal margin, L = logistic margin

4.2 Determinant Factors of Landrace Rice Growers

Individuals who cultivate landrace rice in the selection model were asked further to specify their choices whether to maintain, decrease, or increase the area of landrace rice cultivation. The results can be discussed into two parts. In the first part, influential factors of the landrace rice cultivation decision is explained through the binary choice probit model. Then, in the second part, the influential factors of the potential outcomes are determined through ordinal logit model where the estimated coefficients only indicate the effect of the explanatory variables on the latent variable y_{1i}^{*}. Table 4 and Table 5 present the estimated results of posterior mean and standard deviation of the selection and outcome models, respectively.

The estimated mean parameters in the Table 4 and 5 are used to compute the marginal effects of the explanatory variables in order to explain the change in the probabilities of dependent variable for selection and outcome models. The results are shown in Table 6. The estimated results in table 6 show that all of the explanatory variables affect households$'$ decision of growing landrace rice, as well as the size of landrace rice cultivation.

Table 4: Estimated results of the selection equation

Variables	Clayton Copula	
Selection Model	Mean Posterior	SD Posterior
intercept	0.1845	0.1413
Gender	0.0182	0.0276
Education	-0.0471	0.0004
Rice cultivation experience	0.0079	0.00003
Agriculture training experience	-0.3135	0.1805
Planting purpose	-0.4369	0.0268
Household annual income	0.00001	0.00018
Household income from non-agriculture	-0.00004	0.00019

Source: Calculation

Table 5: Estimated results of the outcome equation

Variables	Clayton Copula	
Outcome Model	Mean Posterior	SD Posterior
intercept	-0.9702	0.0109
Household income from agriculture	4.79E-07	0.9973
Number of family members	0.0164	0.0027
Water Supply	-0.0637	0.0135
Market condition	0.0131	0.0236
Price of local variety rice	0.045	0.0267
Price of substitute outputs	0.0432	0.0125
Financial support	0.0062	0.015
Government support	-2.5861	0.0272
$c_{1,j+1}$	2.0124	0.001
θ_1	5.5454	1.8478

Source: Calculation

Table 6: Marginal effects of the household landrace rice cultivation and order logit model(clayton copula)

Variables			
Selection model	Marginal effects		
Gender	0.0278		
Education	-0.0072		
Rice cultivation experience	0.0012		
Agriculture training experience	-0.0477		
Planting purpose	-0.0665		
Household annual income	0.00001		
Household income from non-agriculture	-0.00001		
	Marginal effects		
Outcome model (the order logit model)	(y^*_{i1}=1)	(y^*_{i1}=2)	(y^*_{i1}=3)
Predicted probabilities	0.8597	0.1386	0.0017
Household income from agriculture	0.00004	0.00001	0.00001
Number of family members	0.0091	0.0014	0.0001
Water Supply	-0.0548	-0.0088	-0.0001
Market condition	0.0127	0.0018	0.0002
Price of local variety rice	0.0387	0.0062	0.0001
Price of substitute outputs	0.0371	0.0059	0.0001
Financial support	0.0053	0.0008	0.0001
Government support	-0.0222	-0.0035	-0.0004

Source: Calculation

The predicted probabilities are evaluated at the data sample means. For the selection model, we found that female have a higher probability to cultivate landrace rice. Females are 1.82% more likely to cultivate the landrace rice than males. The main reason for this finding is that most of the upland women are housewives and/or working at home. Thus, they are more willing to cultivate landrace rice nearby the residential area than working off the farm in other towns. On the other hand, more educated respondents are 4.7% less willing to grow landrace rice. Furthermore, the households′ income from non-agricultural activities reduce the probability of the farmer′s decision to cultivate the landrace rice by 0.001. In recent year, some of the household members have migrated to work in urban areas, therefore, the higher income from non-agricultural means could possibly discourage farmers to grow landrace rice.

The findings of the outcome model indicate the increase in number of household members, water supply, and price of substitute products would increase the probabilities of farmers to reduce the size of landrace rice cultivation. A one unit increase in the number of family members, landrace rice growers are 0.91% more likely to reduce the cultivated area while 0.14% and 0.01% are willing to maintain and increase the size of cultivated area, respectively. A major reason supporting this finding is that more members in the household could create additional income; especially, from the non-agricultural activities. Hence, the households are less interested in cultivating landrace rice. Further, the household with available water supply is 5.4% more likely to reduce the cultivated area of the next season, 0.88% less likely to maintain the size of the cultivated land, and 0.01% is not willing to increase the size of the cultivated land. This result is not surprising because most of the local rice varieties is drought tolerant. Therefore, the farmers could use available water to plan other crops which give a higher benefit.

5 Conclusion

This study investigated the influential factors of the farmer′s decision to cultivate landrace rice by using the switching regression model. The ordered outcome model of farmer′s decision was estimated by using the Bayesian approach. The distribution of error terms of the selection and outcome models was joint under six copula functions. Results show that the selection model has the normal distribution while the outcome model has the logistic distribution. The DIC value of the Clayton copula is lowest; therefore, it is best fit to our households decision model.

Overall, gender, education, and experience of the respondents, household income are significantly influent the farmer′s decision to grow landrace rice. Also, the number of household members, market price of rice, market condition, water supply, and institutional support program are significantly influent the farmer′s decision in reducing or expanding the size of their landrace rice fields of the next harvest season. These results suggest it may be more efficient for the government and/or policy makers to consider the farmer′s characteristics, market condition, and the availability of farm resources before implementing an agricultural support program; especially for the program related to landrace rice production.

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