Farmers' willingness to switch to organic agriculture: A non-parametric analysis

Chang Hwan YU[1], Jin Chae YOO[2], Shun Bo YAO[1]

[1]Department of Economics and Management, Northwest A&F University, Yangling, People's Republic of China

[2]Department of Agriculture Economics, Chungbuk National University, Republic of Korea

Abstract: The present study estimates the farmers' willingness to switch to organic agriculture by using the one-and-one-half-bound dichotomous choice contingent valuation method. We survey 200 farmers in the Kwangsi-myeon, Yesan-gun (Chungnam, Korea) and ask them at what revenue level (based on a 40 kg bag of eco-friendly rice) they would be willing to switch from the conventional agricultural methods to organic agricultural methods. The Turnbull model, a non-parametric method, was then used to estimate the willingness to switch to organic agriculture. The presented results show that farmers would be willing to convert to organic agriculture if their revenues were increased to 107 369–109 230 KRW per bag from the reference value of 60 000 KRW.

Key words: cheap talk, contingent valuation method, hypothetical bias, one-and-one-half-bound method, organic agriculture, Turnbull model, willingness to accept

The excessive use of fertilizers and pesticides in agriculture, primarily in order to feed the growing population, has resulted in diseases and pests becoming resistant to the respective chemicals included in their production. Therefore, the agricultural ecosystem has gradually lost its homogeneity with the natural ecosystem and its cyclical process has become transformed or disconnected, destroying not only the agricultural ecosystem itself but also the surrounding ecosystems. Consequently, increasing production without incurring greater energy and material costs is a challenge.

Except for their food elements, farming goods have a strong public goods nature. In particular, unlike normal goods, their value cannot be estimated correctly by using the market mechanisms. Public goods are non-competitive (i.e., their consumption by an individual does not reduce other people's consumption) and non-exclusive, which allows for the free riding behaviour. Thus, public goods cannot be evaluated by applying the traditional market mechanisms and they are supplied at a less than the socially acceptable level.

Based on the foregoing, the use of organic farming techniques (organic agriculture hereafter) is rising as a solution to this urgent problem. Organic agriculture avoids using the excessive energy and materials by understanding and applying the eco-friendly farming processes. In addition, it enables farmers to maintain productivity and to secure food supply by preserving the balance of the agricultural ecosystem (Lim 2005). Organic agriculture thus offers a number of societal benefits including the protecting nature, maintaining biodiversity, improving scenery, and supporting communities. However, such ecological services are rarely valued in the market, leading to their underestimation or poor supply. To overcome this barrier to the policy and institutional framework, it is thus necessary to assess the value of the functions of organic agriculture.

In this paper, we examine the willingness of Korean farmers to switch from the conventional farming methods to organic agriculture. The Cultural Heritage Administration of Korea has encouraged organic agriculture by releasing the rehabilitated white storks in the Yesan-gun, Chungnam. However, this farming technique is expensive to implement because of the high costs of creating the watering holes, connecting passages, digging vegetated channels as the habitats where they can live, and using the antagonistic microorganisms, companion plants, and biotic pesticides. Moreover, additional expenses are incurred for providing the continuous labour and using the eco-friendly farming materials. Accordingly, it is essential to offer an economic support to farmers in order to enhance their use of organic agriculture.

In this study, we use the one-and-one-half-bound dichotomous choice contingent valuation method (OOHB method hereafter) to assess the farmers' willingness to accept (WTA) a switch to organic agriculture (Cooper et al. 2002). Then, we use the Turnbull model, a non-parametric method proposed by Haab and McConnell (2002), in order to estimate the WTA values. The OOHB method has been used in several studies in Korea (Lee et al. 2007; Kwak et al. 2008; Yoo and Kim 2008; Won et al. 2009; Yoo et al. 2009; Jeong et al. 2010) to assess the willingness to pay for environmental goods and cultural heritage. However, no Korean study has yet examined the farmers' willingness to switch to organic agriculture by using the OOHB model.

DATA AND METHODS

In order to release the rehabilitated white storks for organic agriculture, it is essential to create a habitable environment for them. This approach to organic agriculture has various advantages from providing safe and fresh farming products to offering cultural and eco-tourism services (e.g., the provision of places to visit). In addition, it offers people the eco-education and makes them realize the importance of the environmental system. However, the major disadvantage of this ecological approach is its high cost, which might cause the production to decline and the labour and material inputs to increase. Accordingly, in this study we specified changing to organic agriculture as the object of the value estimation.

As noted in the Introduction, the OOHB method is a contingent valuation method and thus it may be subject to the hypothetical bias. To overcome this bias, Cummings and Taylor (1999) suggested the so-called cheap talk technique. The term 'cheap talk' is derived from the game theory. If there is a Nash equilibrium in any game, even if an oral agreement to choose a different strategy rather than the balance strategy is made between the parties before the game, such an agreement does not affect the strategy of the actual game. The cheap talk technique describes the hypothetical bias to survey parties and therefore it is a way to announce in advance that you need more a careful decision-making in order to reduce such bias.

To collect data, 200 farmers from the Kwangsi-myeon (Yesan-gun) were interviewed from July to August 2010. Compared with the baseline market price of a 40 kg bag of rice (60 000 KRW), we asked them about the level of revenue at which they would be willing to switch to the production of eco-friendly rice. This was based on the following six revenue levels per 40 kg bag: 72 000 KRW (120% increase), 84 000 KRW (140%), 96 000 KRW (160%), 108 000 KRW (180%), 120 000 KRW (200%), and 1320 000 KRW (220%).

The OOHB method used herein is as follows. After explaining that the premium price of 40 kg rice would be fixed between the minimum price (WTA^-) and the maximum price (WTA^+), we asked whether the respondent would be willing to change from conventional farming to organic agriculture under the condition that the premium price for 40 kg rice was set at the WTA^-, randomly selected between the WTA^- and WTA^+. If the respondent A replied 'yes,' there was no follow-up question (because that would go below the stated price range). If the respondent A said 'no,' we asked the WTA^+ at what revenue level he/she would switch.

We believe that eliminating the element of surprise has the potential to remove discrepancies in the responses to the two valuation questions, but it comes at the cost of not always being able to ask the second valuation question: the second question will be appropriate for half the time, in average, but not for the rest of the time. Hence, we refer to this as the one-and-one-half-bound format (Cooper et al. 2002).

In the next step, we asked the same question under the condition that the premium would be set at the WTA^+. We gave the respondent B the same information about the premium price range. However, we asked whether he/she would be willing to change to organic agriculture if the premium price were set at the WTA^+. A negative response led to no further questions. Otherwise, we asked the same question under the condition that the premium would be set at the WTA^-. Thus, the probability of asking an additional question was 50%, depending on each respondent's answer. The OOHB method is based on the assumption that we only know the WTA^- and WTA^+, which is the price range of the evaluated environment goods, and that the actual price of goods is uncertain.

WTA^- WTA^- WTA^+ There are three expected answers to these questions, namely (yes), (no, yes), and (no, no). As noted above, there is no additional question in the first case WTA^+ compared with the second and third cases. For the respondent B, by contrast, the expected answers for the WTA^+ are (no), (yes, no), and (yes, yes). Hanemann's (1989) random utility model, a typical contingent valuation method, is then used to assess the Hicksian welfare. When respondents are questioned, they face two options. One is to make a profit by switching to organic agriculture (before switching) and the other is to provide ecological services by switching to organic agriculture (after switching). However, the WTA is given to them in the form of a compensation amount in the latter case.

To provide a specific explanation of the selection process, we specified the following parameters: the state of organic agriculture (i), individual respondent (j), personal income (y_j), the characteristics of respondent (z_j), and an unknown error (ε_{ij}).Hence, the equation of the individual utility function (1) is as follows:

$$u_{ij} = u_i(y_j, z_j, q^i, \varepsilon_{ij}) \quad (1)$$

i = 0, 1 [(0 = present state (q^0), 1 = improved state (q^1)]
j = individual respondent
y_j = personal income
z_j = characteristics of respondent (sex, age, educational background, residence)
ε_{ij} = unknown error

A condition of a respondent answering 'yes' to the question of being willing to accept the price of b_j to switch to organic agriculture is that the utility of switching must be greater than or equal to rejecting it. The value of utility can thus be expressed as

$$u_1(y_j + b_j, z_j, q^1, \varepsilon_{1j}) \geq u_0(y_j, z_j, q^0, \varepsilon_{0j}) \quad (2)$$

Expressed as a probability function,

$$\Pr(\text{yes}) = \Pr[u_1(y_j + b_j, z_j, q^1, \varepsilon_{1j}) > u_0(y_j, z_j, q^0, \varepsilon_{0j}) \quad (3)$$

The total number of respondents (T_j) is the sum of those that say 'yes' (Y_j) and those that say 'no' (N_j). The 'no' answer of the cumulative probability is shown in the Equation (5). If the cumulative probability (F_j) is not monotonically increasing, a monotonic increase in force can occur through a comprehensive process. Adjusting the cumulative probability (F_j) is shown in the Equation (6):

$$T_j = Y_j + N_j \quad (4)$$

$$F_j = \frac{N_j}{T_j} = \frac{N_j}{N_j + Y_j} \quad (5)$$

$$f_j^* = F_j - F_{j-1} \quad (6)$$

The Turnbull method for estimating the cumulative probability (F_j) of negative responses is as follows. Therefore, the minimum bound (b_d^j) and the maximum bound (b_u^j) can be summarized into three cases: (yes), (no, yes), and (no). By considering each case is expressed as (M_y^j), (M_{ny}^j) and (M_n^j), the total number of respondents is thus:

$$N^j = M_y^j + M_{ny}^j + M_n^j \quad (7)$$

Estimating the probability is shown in the Equations (8) and (9):

$$r = Pr_1\left(b_d^j \geq WTA\right) = \frac{M_y^j}{N^j} \quad (8)$$

$$Pr = Pr_2\left(b_u^j \geq WTA\right) = \frac{(M_{ny}^j + M_y^j)}{N^j} \quad (9)$$

For a higher price of (j), the question is equal to the lower price of (j + 1), the ($b_u^j = b_d^{i+1}$) and thus the Equation (10) is valid:

$$\Pr\left(b_u^j \geq WTA\right) = \Pr\left(b_d^{j+1} \geq WTA\right) \quad (10)$$

The Equation (11) indicates the average WTA computed by using the Turnbull model and the Equation (12) demonstrates the variance in the WTA:

$$E_{\text{mean}B}(WTA) = \sum_{j=0}^{M} b_j \times f_j^* + 1 \quad (11)$$

$$V(E_{\text{mean}B}(WTA) = \sum_{j=1}^{M^*} \frac{F_j^*\left(1 - F_j^*\right)}{T_j}(b_j - b_{j-1})^2 \quad (12)$$

RESULTS

Statistical analysis

Table 1 shows the demographic characteristics of 200 sampled farmers and the explanatory variables. The average age was 67.9 years, and the men's response rate was higher than that for women. In average, the education level was 8.15 years, which was above the elementary school graduation, and the faming career was 44.5 years; the annual income per farm was 19 400 000 KRW. The average number of family members was 2.7.

Table 2 indicates the responses to the WTA question. When a lower price was offered, the proportion of negative responses was high and vice versa, as expected. Altogether, 85% of the farmers said 'no' when the lowest price was offered, while 63% said 'yes' when

Table 1. Respondents' characteristics and explanatory variables

	Variables	Mean	Standard deviation	Min	Max
Individual	AGE (year)	67.92	9.77	32.00	89.00
	SEX (man = 1, woman = 0)	1.26	0.44	0.00	1.00
	MAR (married = 1, single = 0)	1.00	0.00	0.00	1.00
	EDU (education, year)	8.15	2.53	6.00	16.00
	WEXP (farming career, year)	44.45	13.23	5.00	65.00
House	INC (house income, 10 000 won)*	1.94	1.20	1.00	6.00
	FAMILY (the size of family)	2.71	1.50	1.00	9.00

*1 = less than 10 000 000 KRW; 2 = 10 000 000–14 900 000 KRW; 3 = 15 000 000–19 990 000 KRW; 4 = 20 000 000–24 900 000 KRW; 5 = 25 000 000–30 000 000 KRW; 6 = more than 30 000 000 KRW

the highest one was offered. The proposed distribution was thus biased towards the lowest price, meaning that the WTA was unlikely to be an overestimate, as expected. The probabilities of accepting the amount calculated are presented in Table 3.

According to the Turnbull method, the Table 4 shows that when F_j is less than F_{j-1}, F_j is adjusted into (f_j^*); therefore, the value that is supposed to be adjusted F_j is removed and F_{j-1} is computed as

$$\frac{N_{j-1} + N_j}{T_{j-1} + T_j} \quad (N_j = T_j - Y_j).$$

The average WTA calculated from the Equation (11) was found to be 108 312 KRW, as shown in the calculation below:

$$E_{\text{mean}B}(WTA) = \sum_{j=0}^{M} b_j \times f_j^* + 1 =$$
$$= 66\,000 \times 0.15 + 78\,000 \times 0.62 + 90\,000 \times 0.175 + 102\,000 \times 0.138 + 114\,000 \times 0.050 + 126\,000 \times 0.050 + 138\,000 \times 0.375 = 108\,312 \text{ KRW}$$

The variances in the WTA were derived from the Equation (12) as follows:

Table 2. Distribution of responses to questions

b_j(won)	NN or N	YN or NY	YY or Y	Total (person)
72 000~84 000	34	3	3	40
84 000~96 000	26	10	4	40
96 000~108 000	13	16	11	40
108 000~120 000	9	14	17	40
120 000~32 000	11	4	25	40
Total	93	47	60	200

NN = no, no; N = no; YN = yes, no; NY = no, yes; YY = yes, yes; Y = yes

$$V(E_{\text{mean}B}(WTA) = \sum_{j=1}^{M^*} \frac{F_j^*(1-F_j^*)}{T_j}(b_j - b_{j-1})^2$$
$$= \frac{0.375*0.625}{40}(138\,000 - 132\,000)^2$$
$$= \frac{0.050*0.575}{40}(126\,000 - 120\,000)^2$$
$$= \frac{0.050*0.525}{40}(114\,000 - 108\,000)^2$$
$$= \frac{0.138*0.338}{40}(102\,000 - 96\,000)^2$$
$$= \frac{0.175*0.213}{40}(90\,000 - 84\,000)^2$$
$$= \frac{0.063*0.105}{40}(78\,000 - 72\,000)^2 = 225\,601.8$$

Tus, based on the 95% confidence interval, the mean value of acceptance was estimated to be 107 372 to 109 253 KRW.

$$\text{WTA Area} = 108\,312 \pm 1.98 \times 474.98$$
$$= 107\,372 \sim 109\,253$$

Table 3. Amount of respondents that suggested the probability of acceptance

WTA	Pr1	Pr2	Mean of Pr
72 000 ≤	–	$\frac{3+3}{40} = 0.15$	0.15
84 000 ≤	$\frac{3}{40} = 0.075$	$\frac{10+4}{40} = 0.35$	0.213
96 000 ≤	$\frac{4}{40} = 0.1$	$\frac{16+11}{40} = 0.675$	0.388
108 000 ≤	$\frac{11}{40} = 0.275$	$\frac{14+17}{40} = 0.775$	0.525
120 000 ≤	$\frac{17}{40} = 0.425$	$\frac{4+25}{40} = 0.725$	0.575
132 000 ≤	$\frac{26}{40} = 0.625$	–	0.625

Table 4. The OOHB estimated model

b_j	T_j	Y_j	$F_j = (\frac{N_j}{T_j})$	f_j^*
–72 000	–	–	1.000	0.150
72 000	40	6	0.850	0.062
84 000	80	17	0.788	0.175
96 000	80	31	0.613	0.138
108 000	80	42	0.475	0.050
120 000	80	46	0.425	0.050
132 000	40	25	0.375	0.375

Y_j = the frequency of answering 'yes' for the WTA

According to the presented results, 108 312 KRW (95% confidence interval 107 372–109 253 KRW) represents the average revenue level necessary to induce the willingness to switch to organic agriculture based on a 40 kg bag of rice. Considering the potential decrease in production and the increase in operating costs for switching to organic agriculture, the amount of compensation uncovered herein does not seem to be very large. Indeed, it is likely to be underestimated. Thus, the future research might aim to compare the consumer willingness to pay for the eco-friendly rice with the combined total value.

DISCUSSION AND CONCLUSION

We used a contingent valuation method in order to survey 200 Korean farmers about their willingness to switch to organic farming techniques. We selected the area of Kwangsi-myeon, Yesan-gun, because this is an ecological area that has a symbiotic relation with white storks. The presented estimation results showed that the average revenue level for a household to switch was 108 312 KRW by applying the non-parametric Turnbull model, with the 95% confidence interval of 107 372 to 109 253 KRW based on a 40 kg bag of rice.

The contingent valuation method is a simple, flexible nonmarket valuation method that is widely used in the cost/benefit analysis and the environmental impact assessment. One possible way of estimating these benefits is to elicit the individuals' WTA for these benefits through a survey method. However, this method is subject to a severe criticism. It is a survey and it computes statistically the average value of the presented willingness to pay and the WTA. The possibility of being weighted depending on the ways of surveying has been a point of dispute in the process of development because this method aims to ask the subjects about their willingness to pay and the WTA. Until now, a relatively low bias has been caused by the widely used Double-Bounded Dichotomous Choice method. However, in recent years, the willingness to pay and the WTA has been known to demonstrate a relatively high extraction efficiency by utilizing the OOHB method.

It has been suggested that there is a difference in the income level generated by general agriculture and organic farming. Farmers may switch to organic farming to offer benefits to consumers in the form of safe agricultural products. However, the amount estimated in this study is not guaranteed by the transition to organic agriculture except for the operating expenses, and thus the amount of compensation is not very large. During the transition to organic agriculture, the income shortfalls or difficulties caused by switching (e.g., the farm failure or the price rises due to the government policies) require the attention of the government in order to preserve a stable income and to enlarge the sustainable organic agriculture. Nevertheless, organic farming is expected to continue growing. To meet this demand, it is urgent that both the government and the local autonomous entities prepare proper measures to encourage the development of organic agriculture. In this regard, the findings of this study should be helpful for improving the awareness of and preference for the future farming techniques.

REFERENCES

Cooper J.C., Hanemann W.M., Signorello G. (2002): One-and-one-half-bound dichotomous choice contingent valuation. The Review of Economics and Statistics, *84*: 742–750.

Cummings R.G., Taylor L.O. (1999): Unbiased value estimates for environmental goods: A cheap talk design for the contingent valuation method. American Economic Review, *89*: 649–665.

Haab T.C., McConnell K.E. (2002): Valuing Environmental and Natural Resources. Edward Elgar Publishing Ltd.

Hanemann W.M., Kanninen B.J. (1999): The statistical analysis of discrete-response CV data. In: Bateman I.J., Willis K.E. (eds.): Valuing Environmental Preference: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries. Oxford University Press, Oxford.

Jeong Y.J, Kong K.S., Yoo, J.C. (2010): Using the one-and-one-half bound dichotomous choice method to estimate the total economic value of regional cultural heritage: A case study on Sangdang Mountain Fortress in Cheongju City. Journal of the Korean Regional Development Association, *22*: 87–104.

Kwak S.Y., Lee J.S., Yoo S.H. (2008): Measuring the economic benefits of establishing the ecological sports park: A contingent valuation study. Journal of the Korean Association of Public Policy, *10*: 257–276.

Lee J.S., Yoo S.H., Gwak S.J. (2007): Measuring the economic benefits of water quality improvement of Nakdong River: Using the one-and-one-half-bound dichotomous choice model. Journal of the Korean Economics and Business Association, *25*: 111–129.

Lim K.S. (2005): International Trends in Ecological Agriculture. Wooriwadaeum.

Won D.H., Kim H.J. Kim Y.K. (2009): An econometrics analysis of the public acceptance of the nuclear thermal effluents heating. Journal of the Korean Economics and Business Association, *27*: 189–209.

Yoo S.H., Han J.H., Park S.H. (2009): The economic benefits from restoring the ecological integrity of the Anseong River. Journal of the Korean Regional Science Association, *25*: 57–73.

Yoo J.C., Kim J.E. (2008): Using one and one-half bounded dichotomous choice contingent valuation methods to estimate non-market value of otters in Cheongju, Cheongwon Region. Environmental and Resource Economics Review, *17*: 349–379.

Received: 12th June 2013
Accepted: 18th December 2013

Contact address:

Shun Bo Yao, Northwest A&F University, Department of Economics and Management, No. 3 Taicheng Road, Yangling, Shaanxi 712100, People's Republic of China
e-mail: yaoshunbo@nwsuaf.edu.cn