BROILER PRODUCERS' WILLINGNESS TO PAY TO MANAGE NUTRIENT POLLUTION

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ABSTRACT

Economic incentives or disincentives play a major role on encouraging producers to implement environmentally benign production practices. We evaluated producers' willingness to pay (WTP) value to represent the level of disincentives that motivate farmers to mitigate nutrient pollution. The result obtained by using ordered response model showed that farm size, farm income, and land available to spread litter are major variables that determine the producers' WTP.

I. INTRODUCTION

The Conservation Reserve Program (CRP), Wetland Reserve Program (WRP) and Environmental Quality Incentive Programs (EQIP) encourage farmers to participate on pollution control programs. NRCS/USDA provides technical and/or financial support to help implement the environmentally friendly production practices. On the other hand, the regulations for Concentrated Animal Feeding Operations (CAFO) and Animal Feeding Operations (AFO) require producers to follow pollution control measures and restrict the level of pollution generation. The common goal of these policy instruments was to incorporate polluters on pollution reduction processes.

The agricultural nonpoint source pollution control requires the pollution generators' involvement on the pollution reduction programs (Claasan and Horan, 2000). However, the current environmental policy encourages farmers to implement pollution control practices voluntarily unless the farmers are CAFOs or AFOs.

It is widely accepted that the economic incentives/disincentives play a major role on encouraging producers to participate on environmentally benign production practices (Tarui and Polasky, 2005). In this study, I examine the level of economic disincentives that encourage (force) farmers to internalize the pollution control measures into their production practices. I assess the concept of disincentives for polluters to enforce pollution control efforts on polluters' production decision. For the purpose, I estimate the maximum dollar amount that can be charged as pollution abatement cost for an individual allowing him/her to be indifferent from existing utility level.

It is well established that the amount representing the producer's affordability or willingness to pay to control water pollution can't be derived through market transactions. I employ a contingent valuation approach to examine the affordability (or willingness to spend on water pollution control measures) of Louisiana broiler producers based on their household income; their perception about the need of environmental regulations; and other farm level characteristics. The amount is represented by the individual's is willing to pay (WTP) value for pollution control/abatement measures so as to continue his production practices at the current scale.

Broiler producer's desired willingness to pay level can be evaluated through a clear understanding of their utility function. The contingent valuation approach elicits the amount that the individual will be willing to pay and remain on his/her existing utility level. Using contingent valuation approach, I created a hypothetical scenario of potential governmental regulation that can be implemented if the broiler producers fail to accommodate environmentally friendly production practices. Using the hypothetical market for pollution abatement, I , obtained the individual's bid amount for controlling water pollution.

Under the contingent valuation, appropriate bid elicitation approach has always been a major issue. Respondent may not possess enough information; or they may consider that the question is too invasive of their privacy, and therefore fail to provide exact dollar amount that represents their WTP. This may lead to a completely erroneous responses giving rise to invalid parameter estimates. Therefore, a multiple bound questionnaire, accompanied with a modification where the individuals are provided with multiple bid intervals, is employed. The respondents then choose a category where their stated WTP value falls. The WTP value of a broiler producer represents an amount that an individual can afford and are willing to contribute to improve water quality.

II. LITERATURE REVIEW

The continuous and evolving nature of environmental policy and its adverse effect on profit level forces farmers to search for alternative solutions to mitigate increased water pollution. Increased number of regulated CAFO/AFO operations and strengthened permit requirements (EPA, 2003) for these operations are the examples of government being more stringent on water quality regulations. Meantime, the BMP adoptions and obeying the CAFO and AFO regulations are the examples of farmers being more concerned about the regulation and standards. Thus, the perceived threat of stringent regulation convinced the producers to implement environmental friendly production practices with no/partial amount of cost share.

Large scale producers falling under CAFO and some AFO operations are forced to employ environmentally benign production practices to comply with the permit requirements (EPA, 2003). Even though the increased number of regulated CAFO and AFO showed ambiguous result on reducing water pollution (Mullen and Center, 2004) the producers are required to abide by these regulations. In order to avoid the potential punishment, agricultural producers attempt to invest on environmentally friendly practices. This implies that the farmers are willing to pay (forced to pay) some amount in order to avoid potential harsh governmental regulation (to reduce water pollution) and continue the existing production practices.

The question remains on how much the broiler producer will be willing/ able to afford to reduce water pollution. Contingent valuation approach (WTP) measure has been employed in a wide variety of researches where non-market goods are involved (Urama and Hodge, 2006; Whitehead, 2006; Cho *et al*. 2005 Strazzera, *et al*. 2003; Hudson and Hite, 2003; Hite *et al*., 2002; Roach, *et al*., 2002; Whitehead *et al*., 2001; Stevens *et al*., 2000; Loomis *et al*. 1998; Hanemann, 1984). The approach has also been employed to elicit an individual's willingness to pay amount improvement in water quality improvements (Whitehead, 2006; Hite *et al*. 2002). Whitehead (2006) examined the WTP value for water quality improvement from consumer's point of view accommodating heterogeneity due to perceived water quality levels. On the other hand, Hite et al. (2002) evaluated the value of water quality improvement, from the producers' point of view.

The technique is based on the assumption that the maximum amount of money that an individual desires to pay represents their maximum WTP value for the purpose of controlling water pollution. Their result found that the producer's marginal willingness to pay for pollution reduction decreased with increased level of desired pollution reduction. According to Hite *et al*. the decrease in marginal WTP is due to the fact that the agricultural producers tend not to believe their production practices contribute enough to cause water pollution problems (Hite *et al*. 2002). In addition, the level of direct benefit received from water quality improvements also affected the amount of stated WTP.

Thus it can be argued that the producers are motivated enough (either due to regulation threat or voluntarily) to pay for pollution control measures. Then the contingent valuation approach becomes a relevant tool to extract the actual amount that an individual farmer is willing to pay to avoid harsh environmental regulation. For a non-market commodity like water pollution, this approach is a satisfactory technique to elicit the present value of a proposed policy even though; Hoen and Randall (1987) assert the approach as "not a flawless approach".

The main concern on contingent valuation approach becomes the development and framing of questionnaire. The contingent valuation questions usually follow dichotomous choice responses where individuals are asked whether to vote (yes/no) for the proposed bid options (Herrisen and Shogren, 1996). The dichotomous choice questions are found to be suffered from the anchoring effect (Herrisen and Shogren, 1996) drawing invalid conclusion.

With the anchoring effect in consideration, multiple bound question gained popularity in the recent years (Eelsh and Poe, 1998; Alberini, *et al*. 2003). The multiple bound questions provide a list of bid amounts from where a respondent chooses to represent his WTP value. Some authors argue that providing a list of alternative bids reduces the focus of respondents on single bid or sequential bids and therefore reduces the anchoring effect (Whitehead, 2002; Roach and Boyle, 2002; Rowe et al., 1996. In addition, literatures also established that the double and multiple bound questioning approaches increases the efficiency of parameter estimates (Whitehead 2002; Alberini *et al.* 2003).

In double and multiple bound questions, given the dichotomous type response, logit or probit models have mostly been used on contingent valuation studies (Whitehead *et al.*, 2001). Alberini *et* *al* (2003) used random effect logit model to estimate the WTP value form the multiple bound contingent valuation technique. The main goal of the study however, was to understand questionnaire design rather that estimating the expected value of WTP for open-water fishing.

Similarly, Whitehead (2002) employed random effect probit models on double, triple and multiple bound questions. The precision of WTP value increased with multiple bond questions in contingent valuation approach (Whitehead, 2002). Whitehead (2002) focused that the double bound questionnaire format provide better estimates for true WTP when a starting value of an individual's bid can't be assigned to represent the distribution of WTP values. Roach et al (2002) also claimed an increased efficiency in parameter estimates with multiple bound questionnaire setting of WTP value elicitation.

As mentioned by Whitehead (2002), providing starting value of WTP to the broiler producers while eliciting WTP becomes relatively difficult since no guideline exists to suggest potential value that an individual would be willing to pay. Due to such facts and anchoring effect in single bound question, a multiple bound questions formatting was found to be attractive in this study.

III. DATA

Dependent variables

Using a cheap talk method, respondents were informed about the hypothetical environmental regulation which may require them to pay for water pollution control measures. Based on multiple bid design three bid categories were provided to the respondents. The respondents were then asked to choose a category where his/her true WTP falls. The multiple bound questionnaire setting is preferred at least for two reasons;

- The tendency of yea saying to the given value even though the true WTP is less/greater than the provided can be reduced (Roach *et al.* 2002),
- The double bounded dichotomous choice model provides asymptotically more efficient estimates than single bounded model (Hanemann, *et al*. 1991).

Explanatory variables

It is assumed that individuals gain utility both from water quality improvements as well as from his/her net income. The observable characteristics that have positive/negative impact on individual's preferences for water quality control measures also include socioeconomic as well as the farm characteristics.

Farmer's demographic characteristics play a major role on the decision associated with water pollution and environmentally friendly production practices. Based on previous studies, respondent's *Age* is one of the important factors to impact the WTP decision (Hanemann, 1991). The age measures the producer's age at the time of data collection and is found to have mixed effect.

Gillespie *et al*. find older farmers respond positively toward the measures of water pollution reduction (Gillespie *et al.*, 2007). On the other hand, Koundouri *et al.* (2006) found the variable affected the adoption of environmentally friendly irrigation practices negatively. Younger farmers were more knowledgeable and more risk taking due to longer planning horizon and therefore, were more likely to be more responsive to the environmentally friendly agricultural practices in a study conducted by Adesina and Zinnah (1993).

Level of *education* and *contact with extension agents* are employed to capture the effect of information effect on WTP value. The producers who have better information on the issues and importance of water quality through *education* are more likely to contribute toward environmental practices (Koundouri *et al.,* 2006). As Hite *et al* (2002) suggested that farmers have propensity not to believe their existing production practices contribute to water pollution problem. So, education through school or through contact with extension agents becomes crucial factors determining the level of WTP value. *Education* is measured in three categorical variables represented by three dummy variables for less than or equal to high school; college degree and graduate degree.

In addition the farmers who have visited extension agents and talked about farmer's contribution to water pollution are more likely to contribute to water pollution control measures.

Exposition of individual producers to the extension services is believed to generate awareness about ongoing nutrient pollution issues in the local areas. The variable is therefore, assumed to have positive effect on WTP value. *Contact with extension agents* was constructed using the information obtained indicating whether an individual has visited the extension agents in last year. The variable is then used as proxy for his/her general contact with the extension service providers.

The respondents were also asked about their *perception* regarding the necessity of water pollution control measures or regulations. Individuals' responses are recorded using a Likert scale, where five represents an individual strongly agrees with the statement "water pollution control measures and regulation are badly needed". Brox *et al.* (2003) includes perception about existing water quality on WTP study using five scale Likert measure. The perception about existing water quality significantly increased the willing to pay amount on their study. Similarly, the broiler producers who believe the water pollution control measures and regulations are badly needed are assumed to state higher WTP value.

Farmers' *off-farm income* represents whether the principal operator (owner) of broiler farm has income from other jobs except from broiler production. The individuals who have off-farm income are not constrained to remain on the business by paying an extra amount for water pollution control. Therefore, the individuals with off-farm income are believed to pay lower amount as compared to the ones who solely depend on broiler production to generate household income. Gillespie *et al.* (2007) finds the farmers with off-farm income are less responsive to water pollution control measures (2007).

Land available to litter application represents the total acreage available to spread the broiler litter on individual's land. Smaller area to litter application implies higher nutrient concentration and runoff to the surface water or need of litter transportation outside the production areas. In order to avoid a fear of governmental regulation and the hassle of transportation, the producers are willing to pay more in the form of pollution mitigation tax. Therefore the variable is assumed to be negatively related to the WTP amount.

IV. MODEL

Economic model for WTP

A rational broiler producer (i) is expected to choose a combination of market goods (z) and water pollution control measures to maximize utility given a limited budget (M). A simple utility function that accommodates environmental component, respondent's demographic characteristics, net income, as well as a payment vehicle defines the broiler producers' preferences over market good and environmental quality. Given the utility framework, an individual's utility function is explained by;

$$U^l = U(\boldsymbol{Z},\ M - T^l,\ Q^l) \qquad (1.1)$$

The M represents the individual's household income, which includes farm as well as off farm income net of existing tax. $\boldsymbol{Z}$ represents a vector of variables describing the characteristic of individuals as well as their farm. T^l is the change in tax under the proposed water pollution reduction policy and Q^l represent of water quality level under current condition or proposed policy.

Hanemann (1984) developed a utility theoretical framework to derive WTP and WTA from a dichotomous choice discrete response in contingent valuation studies. Based on Hanemann's argument, let's assume two possible levels of water quality represented by $l = (0, 1)$. $l = 0$ represents an initial or the existing level of water quality whereas, and $l = 1$ represents the level of improved water quality.

At the status quo of no water pollution reduction effort, the broiler producers receive utility $U^0 = U(\boldsymbol{Z},\ M,\ Q^0)$. At current condition, the current conditions are paid by current tax and fees, no changes in payment are required, then the T^l becomes zero. Accordingly, for proposed policy, a change is net income is expected which changes the utility function as $U^1 = U(\boldsymbol{Z},\ M - T^1,\ Q^1)$.

This represents the broiler producer's utility function with improved water quality and change in net income through change in tax.

Hanemann (1984) argues that an individual know his/her utility function while it is unknown to the researchers. Therefore, an individual's utility function is consisted of empirically measureable component $V(\cdot)$ and stochastic econometric error ε^l. Thus, individuals' standard utility functions with (equation 1.2) and without (equation 1.3) proposed change are expressed as;

$$U^1 = V(\boldsymbol{Z},\ M - T^1,\ Q^1)\ +\ \varepsilon^1 \qquad (1.2)$$

$$U^0 = V(\boldsymbol{Z},\ M,\ Q^0) +\ \varepsilon^0 \qquad (1.3)$$

It is assumed that broiler producers compare the utilities under current (equation 1.2) and proposed water quality and net income scenario (equation 1.3). The underlying reasoning of the individual's choice of whether to maintain status quo of no water pollution or undertake a water pollution control measures to improve water quality is based on the following condition;

$$V(\boldsymbol{Z},\ M - T^1,\ Q^1)\ +\ \varepsilon^1 \geq V(\boldsymbol{Z},\ M,\ Q^0) +\ \varepsilon^0 \qquad (1.4)$$

The model implies that an individual compares the proposed improvement on water quality and change in net income, with current condition, and evaluates the difference on utilities under both of the plans. It is assumed that the individual then decides whether to pay or how much to pay for the proposed program so as to keep the utility level unchanged (negligibly changed). The difference in utility under current and proposed conditions can be expressed as;

$$dU = V(\boldsymbol{Z},\ M - T^1,\ Q^1)\ +\ \varepsilon^1 - V(\boldsymbol{Z},\ M,\ Q^0) +\ \varepsilon^0$$

$$= V(\boldsymbol{Z},\ M - T^1,\ Q^1)\ - V(\boldsymbol{Z},\ M,\ Q^0) - (\varepsilon^0 - \varepsilon^1)$$

$$= d\boldsymbol{V} -\ (\varepsilon^0 - \varepsilon^1) \qquad (1.5)$$

Where the errors ε^0 and ε^1 are assumed to be identically and independently distributed with zero means.

Econometric models for WTP

The ordered response model

The three levels of payment categories are defined by an ordinal scale response index where, j represent three categories of payments. If the respondents' WTP value is below \$300 then j takes a value of 1; if the utility difference falls within \$300 and \$500, j is 2; and if the WTP value is greater than \$500 then j takes the value of 3. The data allows estimation of parameters using probit models (Boccaletti and Nardella, 2001; Jin et al., 2008).

For econometric purpose, the latent value of WTP takes the three values as follows (Johnston, 1999; Jin et al., 2008);

$$\mathrm{WTP}_i = 1 \quad \text{if} \quad \mathrm{WTP}^* \leq \gamma_1$$

$$\mathrm{WTP}_i = 2 \quad \text{if} \quad \gamma_1 < \mathrm{WTP}^* \leq \gamma_2$$

$$\mathrm{WTP}_i = 3 \quad \text{if} \quad \mathrm{WTP}^* \leq \gamma_2 \qquad (1.6)$$

Where γ represent unobserved threshold parameters that outline the interval where utility difference falls and the WTP^* represents the utility difference. The γ_j determine the boundary where the value of WTP map into the given differences on utility (Davidson, 1993).

Let the WTP^* is defined by;

$$\mathrm{WTP}_i^* = \boldsymbol{Z}_i\boldsymbol{\beta} + \varepsilon_i \qquad (1.7)$$

$$\boldsymbol{Z}_i\boldsymbol{\beta} = \beta_0 + \beta_0\, highschool + \beta_2 collage + \beta_3 offincome + \beta_4 age + \beta_5 litterland + \beta_6 contact + \beta_7 perception$$

Where, the stochastic error $\boldsymbol{\varepsilon}_i$ is assumed to have standard normal distribution with mean zero and variance of one. The errors are assumed to be independent and identically distributed. The $\boldsymbol{\beta}$ represents a vector of parameters to be estimated and $\boldsymbol{Z}_i$ represent a vectors of individual as well as farm characteristics.

Now based on the equations 1.2 to 1.7 the probability that the difference on utility falls between the proposed and existing water quality is represented by;

$$
\begin{aligned}
P(\text{WTP}_i = 1) &= P(\text{WTP}_i^* < \gamma_1) \\
&= P(\boldsymbol{z}_i\boldsymbol{\beta} + \varepsilon_i < \gamma_1) \\
&= P(\varepsilon_i < \gamma_1 - \boldsymbol{z}_i\boldsymbol{\beta}) \\
&= \Phi(\gamma_1 - \boldsymbol{z}_i\boldsymbol{\beta})
\end{aligned}
$$

Similarly, the probability that $y_i = 2$ is;

$$
\begin{aligned}
P(\text{WTP}_i = 2) &= P(\gamma_1 \leq \text{WTP}_i^* < \gamma_2) \\
&= P(\gamma_1 \leq \boldsymbol{z}_i\boldsymbol{\beta} + \varepsilon_i < \gamma_2) \\
&= P(\varepsilon_i < \gamma_2 - \boldsymbol{z}_i\boldsymbol{\beta}) - P(\varepsilon_i < \gamma_1 - \boldsymbol{z}_i\boldsymbol{\beta}) \\
&= \Phi(\gamma_2 - \boldsymbol{z}_i\boldsymbol{\beta}) - \Phi(\gamma_1 - \boldsymbol{z}_i\boldsymbol{\beta})
\end{aligned}
$$

And the probability that $y_i = 3$ is;

$$
\begin{aligned}
P(\text{WTP}_i = 3) &= P(\text{WTP}_i^* \geq \gamma_2) \\
&= P(\boldsymbol{z}_i\boldsymbol{\beta} + \varepsilon_i \geq \gamma_2) \\
&= P(\varepsilon_i \geq \gamma_2 - \boldsymbol{z}_i\boldsymbol{\beta}) \\
&= \Phi(\boldsymbol{z}_i\boldsymbol{\beta} - \gamma_2) \qquad (1.8)
\end{aligned}
$$

where, P is an probability operator. Provided all these probability density functions for ε_i, the unknown model parameters that can be estimated by maximizing the following log likelihood function;

$$
\begin{aligned}
\ell\,(\gamma_1\,\gamma_2, \boldsymbol{\beta}) = &\textstyle\sum_{\text{WTP}_i=1} \log[\Phi(\gamma_1 - \boldsymbol{z}_i\boldsymbol{\beta})] + \sum_{\text{WTP}_i=2} \log\,[\Phi(\gamma_2 - \boldsymbol{z}_i\boldsymbol{\beta}) - \Phi(\gamma_1 - \boldsymbol{z}_i\boldsymbol{\beta})] \\
&+ \textstyle\sum_{\text{WTP}_i=3} \log[\Phi(\boldsymbol{z}_i\boldsymbol{\beta} - \gamma_2)] \qquad (1.9)
\end{aligned}
$$

The effects of changes in explanatory variables on the probability of WTP falling in a given range are not explained by the estimated coefficients (Green, 2008) in case of probit models. It is therefore, the effects of explanatory variables are expressed in terms of marginal effects which can be derived as follows;

$$
\frac{\partial P(\text{WTP}=1|z)}{\partial z} = -\phi \boldsymbol{z}_i\boldsymbol{\beta})\boldsymbol{\beta}
$$

$$\frac{\partial P(\mathrm{WTP}=2|z)}{\partial z} = (\phi(-\boldsymbol{z}_i\boldsymbol{\beta}) - \phi(\gamma - \boldsymbol{z}_i\boldsymbol{\beta}))\boldsymbol{\beta}$$

$$\frac{\partial P(\mathrm{WTP}=3|z)}{\partial z} = \phi(\gamma - \boldsymbol{z}_i\boldsymbol{\beta})\boldsymbol{\beta} \qquad (1.10)$$

The marginal effect is the slope of the curve that relates an explanatory variable to $P(\mathrm{WTP} = j|\boldsymbol{z})$ controlling the effect of other variables (Long, 1997). The sign of marginal effect is not required to be same as that of coefficients (Long, 1997).

The interval regression model

The boiler producer's WTP value is coded by an interval where an individual's latent value y_i^* falls. Such data collection approach replaces the unknown γ by known cell limits, a_1 and a_2 and define WTP as in equation 1.10. Wooldridge (2002) suggests an interval regression to estimate $E(y^*|\boldsymbol{z})$ when the upper and lower limits of the intervals are known. The approach is consistent with Whitehead et al.(2001) and Doorslaer and Jones (2003). Instead of estimating $\boldsymbol{\beta}$ and γ as in ordered probit model, the interval regression estimates the parameters $\boldsymbol{\beta}$ and σ^2, where $\sigma^2 = Var(\mathrm{WTP}^*|\boldsymbol{z})$. The model assumes $y^*|\boldsymbol{z} \sim \mathrm{Normal}(\boldsymbol{z}\boldsymbol{\beta}, \sigma^2)$ instead of standard normal for probit and logistic for logit regressions.

The $\boldsymbol{\beta}$ and σ^2 are estimated by maximizing the following likelihood function (Check whether stata performs MLE with intreg command).

$$\ell\,(\boldsymbol{\beta}, \sigma^2) = \sum_{\mathrm{WTP}_i=1} \log\left[\Phi\left(\frac{a_1 - \boldsymbol{z}_i\boldsymbol{\beta}}{\sigma^2}\right)\right] + \sum_{\mathrm{WTP}_i=2} \log\left[\Phi\left(\frac{a_2 - \boldsymbol{z}_i\boldsymbol{\beta}}{\sigma^2}\right) - \Phi\left(\frac{a_1 - \boldsymbol{z}_i\boldsymbol{\beta}}{\sigma^2}\right)\right]$$

$$+ \sum_{\mathrm{WTP}_i=3} \log\left[\Phi\left(\frac{\boldsymbol{z}_i\boldsymbol{\beta} - a_2}{\sigma^2}\right)\right] \qquad (1.11)$$

V. RESULT AND DISCUSSION

Producer's WTP function is estimated using ordered probit and interval regression approaches. Table 1.1 presents the summary statistics of the variables used in the analysis and the table 1.2 presents the estimated coefficients and their standard errors obtained from maximizing the two equations at 1.9 and 1.11.

Table 1.1: Summary Statistics for the Variables Used

Variables	Mean	Std. Dev	Min	Max
High school degree =1	0.689	0.466	0	1
College degree =1	0.243	0.432	0	1
Graduate degree =1	0.068	0.253	0	1
Individual has off farm income =1	0.324	0.471	0	1
Age of farmer at the time of survey	53.284	12.184	25	79
Percentage of total land, where litter is usually applied	0.460	0.489	0	3.125
Individual has contact with extension agents	0.608	0.492	0	1
Perception that "Water pollution is badly needed" in the scale of 1-5	3.775	1.124	1	5

A summary statistics of the variables used in the analysis are presented in table 1.1. Nearly 69 percent of the farmers hold only high school degree at most. About 24 percent were collage students only 7% of the broiler producers have graduate level education. About 32% of the broiler farmers had off farm income. More than 60% farmer had contacted with extension agents in previous year. On an average, 46% of the total land is used to spread broiler litter.

The model significance and the R square values are also presented at the end of table 1.2. The table 1.3 presents the marginal effects along with their standard errors. The ordered probit model is significant at 0.06 percent while the interval regression model is significant at <0.0001 percent level of significance.

Socioeconomic or the demographic variables such as age, education, and incomes are included in the model in order to capture the variability in individual-specific characteristics. Most of the demographic variables are significant with expected signs. While the perception of an individual regarding the water quality regulations shows no effect on WTP amount. The perception about existing water quality showed no significant effect on willingness to pay to improve minor water quality problems (Brox, et al., 2003). However, the same study showed a significant effect of the perception on WTP value, while the proposed policy addressed major water quality problems.

The insignificant effect of water quality perception and the need of regulation originate from the fact that the agricultural producers fail to realize their production practices contribute enough to cause water pollution problem (Hite et al. 2002). Thus, the producers' WTP value may not be affected by the perception of water quality if the producers perceive water quality problem as minor (Brox, et al., 2003).

Table 1.2: Parameter Estimates Using Ordered Response Models on Stated WTP Range

	Ordered probit Regression	Interval regression
Independent Variables	Coefficients (Rob. Std. Err.)	Coefficients (Rob. Std. Err.)
College degree = 1	1.024**	98.228**
	(0.455)	(43.829)
Graduate degree = 1	1.248**	133.624**
	(0.518)	(58.375)
Individual has off farm income =1	-1.005**	-90.939***
	(0.500)	(36.179)
Age of farmer at the time of survey	0.043**	3.484**
	(0.020)	(1.451)
Percentage of total land, where litter is usually applied	-0.771	-53.945*
	(0.553)	(30.455)
Individual has contact with extension agents	0.231	18.124
	(0.363)	(35.654)
Perception that "Water pollution control measures are badly needed" scale of 1-5	-0.075	-0.921
	(0.149)	(16.073)
constant		86.943
		(115.019)
γ_1	2.443	
	(1.323)	
γ_2	3.816	
	(1.329)	
Number of observations	59	59
Pseudo R square	0.217	0.203 (MacFadden's)
Prob. > F	0.069	0.0001

Note: The numbers in parenthesis are robust standard errors

It is assumed that farmers with higher education are knowledgeable about the negative impact of water pollution on human health as well as on natural ecosystem (Urma and Dodge, 2006). Therefore, the educated producers are more responsive to water pollution control measures. As expected the result indicated the individuals with higher education tend to pay greater amount for water pollution control measures as compared with individuals having less than high-school degree. The both dummy variables for education; the *college degree* and *graduate degree*, are significant at 0.05 and 0.01 percent level of significance.

The marginal effects (table 1.3) of education levels show a negative effect on first level of WTP, while it is positive for higher WTP values (level 2 and 3). Thus, the individuals who hold either college or higher degree are willing to pay more for water control measures than those with only high-school degree at most. For an individuals with graduate degree, the probability of paying <300 decreases by 0.465, however, probability of paying $300-500 and >$500 increases by 0.285 and 0.180 respectively (However, the variable is significant at 0.16 for WTP value >$500).

Individual farmers who has off-farm income significantly increase the probability of paying less dollars (<$300) for pollution control measures. At the same time, having off-farm income decreases the probability of paying higher WTP. The result showed that the probability of choosing WTP less than $300 is 0.280 greater for individuals with off-farm income as compared to the ones without off-farm income. In contrary, the probability of stating WTP in between $300 and $500 is 0.239 lower for individuals with off-farm income as compared to the ones without the off-farm income.

Age is an important variable contributing toward WTP decision (Brox, et al., 2003; Gillespie *et al.*, 2007). Age is positively associated with the likelihood of environmentally friendly management practices (Gillespie *et al.*, 2007). At the same time, it is also found that the older individuals tend to spend less on water pollution control measures (Brox, et al., 2003). The result of this study showed age is significantly and negatively associated with the choice of less than $300 as their WTP value. However, the probability of paying larger amount (WTP in between $300 and $500) for water quality control measure increases with age. A ten year increase in respondent's age increases the probability of paying in between $300 and $500 by 0.12 and decreases the probability of paying less than $300 by 0.14. Thus, older individuals are willing to spend more on water quality control measures.

Contact with extension agent is a measure of individual's knowledge about the broiler litter and associated pollution impact on nearby water bodies. The result showed individuals who have contacted the extension agent in the past year tend to pay more for water pollution control measures. However, the estimated parameter is not statistically significant.

Table 1.3 : Marginal effects of Ordered Probit Models on Stated WTP Ranges

variable |	P(WTP=1)	P(WTP=2)	P(WTP=3)	
	dy/dx	dy/dx	dy/dx	Mean
College degree =1	-0.366**	0.271**	0.095	0.254
	(0.155)	(0.117)	(0.068)	
Graduate degree =1	-0.465***	0.285***	0.180	0.068
	(0.176)	(0.104)	(0.124)	
Individual has off farm income =1	0.280***	-0.239***	-0.041	0.305
	(0.102)	(0.096)	(0.027)	
Age of farmer at the time of survey	-0.014**	0.012***	0.002	52.966
	(0.006)	(0.006)	(0.002)	
Percentage of total land, where litter is usually applied	0.251	-0.210	-0.041	0.464
	(0.169)	(0.151)	(0.033)	
Individual has contact with extension agents	-0.074	0.062	0.012	0.627
	(0.115)	(0.096)	(0.020)	
Perception that "Water pollution is badly needed" in the scale of 1-5	0.024	-0.020	-0.004	3.746
	(0.049)	(0.042)	(0.008)	

As the WTP value on data represented an interval where the true WTP falls, an interval regression was also employed (Whitehead, et al. 2001). The interval regression is similar to the ordered logit model when the threshold values are known to the researchers. The conclusion from interval regression is not different from that from the ordered probit model. All the variables significant on ordered probit model are also significant on interval regression model. Additionally, the parameters have the same signs in both models.

The effects of variables are interpreted as in case of ordinary regression. Individual with graduate degree pays about $98 more than the counterpart with only high-school degree. Similarly one year older broiler producers pay $3.48 more to control nutrient pollution control measure.

Table 1.4: Coefficient estimates using generalized ordered probit model

	P(WTP=1)	P(WTP=1)2
Variables	Coefficients (Robust Std. Err.)	Coefficients (Robust Std. Err.)
College degree =1	1.087**	1.087**
	(0.478)	(0.478)
Graduate degree	1.440***	1.440***
	(0.522)	(0.522)
Indiviual has off farm income =1	-0.949*	-0.949**
	(0.530)	(0.530)
Age of farmer at the time of survey	0.035*	0.035**
	(0.020)	(0.020)
Percentage of total land, where litter is usually applied	-0.933*	-0.933*
	(0.576)	(0.576)
Individual has contact with extension agents	0.106	0.106
	(0.379)	(0.379)
Perception that "Water pollution is badly needed" in the scale of 1-5	-0.199	0.960*
	(0.163)	(0.570)
constant	-1.492	-7.844***
	(1.375)	(2.762)

A likelihood ratio test was employed to test the parallel regression assumption in order to examine whether the slope coefficients vary based on the categories of WTP. The test statistics (Chi square with 6 df = 17.49) was significant indicating violation of parallel regression assumption. Further analysis detected that the perception about the need for environmental regulation violated the assumption. I therefore, employed generalized ordered probit model relaxing the parallel regression assumption. The estimated coefficients and their standard errors are presented in table 1.4.

Now, the perception variable is allowed to have different effect on different categories of stated WTP values. The result showed that individuals' perception significantly and positively affected the likelihood of paying higher amount ($300 to $500) for water pollution control and decreased the probability of paying less (< $300). However, the effect of the perception is not statistically significant for WTP category < $300.

Table 1.5: Marginal effects estimated from generalize ordered probit model

Variables	P(Y=1) Marg. Eff	P(Y=2) Marg. Eff	P(Y=3) Marg. Eff
College degree =1	-0.386***	0.356***	0.030
	(0.160)	(0.140)	(0.048)
Graduate degree	-0.528***	0.438***	0.090
	(0.163)	(0.154)	(0.098)
Indiviual has off farm income =1	0.263***	-0.255**	-0.008
	(0.109)	(0.109)	(0.013)
Age of farmer at the time of survey	-0.011*	0.011*	0.000
	(0.006)	(0.006)	(0.001)
Percentage of total land, where litter is usually applied	0.301*	-0.290*	-0.011
	(0.172)	(0.170)	(0.018)
Individual has contact with extension agents	-0.034	0.033	0.001
	(0.120)	(0.116)	(0.005)
Perception that "Water pollution is badly needed" in the scale of 1-5	0.064	-0.075	0.011
	(0.054)	(0.056)	(0.014)

In addition, using generalized ordered probit model showed the portion of land available for litter spreading significantly affects the WTP value (the variable was not significant with ordered probit specification). So, having a larger portion of land to spread broiler litter increases the likelihood of paying less for pollution abatement and decreases the probability of choosing to pay higher amount ($300 to $500). The farmers spread broiler litter as fertilizer for crop production, the crop demand for fertilizer may utilize larger portion of poultry litter (if not all produced by broiler production practices) and therefore less pollution runoff. The individuals with larger portion of land available for litter application believe the pollution runoff should not be a problem from their land. Thus, their production practices don't contribute enough nutrient pollution to pollute the nearby waters. Therefore, these farmers are less likely to pay larger amount for water quality control measures.

The mean WTP value was calculated using the estimates from interval regression model. The table 1.6 presents the estimated average WTP that a broiler producer would like to pay in order to control water pollution caused by their own broiler production. The table also presents the standard deviation of the mean.

Table1.6: Average value of WTP	**Mean**	**Std. dev**	**Obs.**
Estimated WTP amount	260.955	86.328	71

VI. CONCLUSION

Broiler production is under a threat of stringent government regulation (MacDonald, 2008) which, Segerson and Miceli (1998) believe, is important to protect the environmental quality. Their study concluded that the voluntary practices are more effective if a strong background threat of regulation exists to facilitate the voluntary practices (Segerson and Miceli, 1998). Therefore, the idea of punishing/charging CAFOs and AFO if it fails to obtain a permit or fails to meet desired level of pollution abatement efforts seems important to improve water quality.

However, the question of “how much” and “what should be considered” before setting up a standard payment level, remained vague. I therefore, evaluated the maximum dollar amount that an individual is willing to pay (WTP) for pollution control/abatement measures. I evaluated the concept of providing negative incentives for polluters to enforce pollution control efforts on their production decision. A contingent valuation approach is employed to examine the affordability (or willingness to spend on water pollution control measures) of the farmers based on their socioeconomic as well as farm level information.

The evaluation of individual’s willingness to pay will be useful at the policy level to understand the amount that a farmer is willing to pay/bear for pollution control measures. The policy instruments such as pollution abatement tax can be generated based on the amount the farmers are willing to pay. In addition, the examination of WTP will also be helpful to set up an incentive payment, which can be set beyond the individual's desire to bear the cost of pollution abatement. This reduces the government expenditure on incentive payment.

This will reduce the adverse effect of higher incentive payment on production practices. For example, larger incentive payments provided to help reduce pollution may divert producers' interest from production toward receiving subsidy. (such as, if the incentive payment is greater than profit level, the farmers may leave the production practice) since, the producers are willing to pay the amount of estimated WTP they require only the difference from their reservation price.

This study is relevant because there is increasing trend of governmental interventions with more and more stringent environmental regulations to force the farmers to consider environmental aspects of their production practices. Therefore, the farmers become encouraged to pay for pollution control and remain in the business for their livelihood. Also, there exist only few studies on examining the farmer's willingness to pay values to reduce agricultural pollution externalities.

One drawback is the failure of this study to estimate the dollar amount that an individual can afford to reduce the negative impact of his/her production practices. Returned survey did not produce enough observations to use individual's dollar value of WTP. I therefore, measured the WTP using intervals where the individual's true values may fall. As this study is based on farmers' value of the better environment, lack of complete information about the negative effects of pollution on the health and ecosystem and enough knowledge about the proposed tax policy may have resulted into failing to provide exact amount of WTP value.

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