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IMPROVING VALUE ESTIMATES FOR RESTORATION

OF MISSISSIPPI'S BARRIER ISLANDS

By

GwanSeon Kim

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Agriculture
in the Department of Agricultural Economics

Mississippi State, Mississippi

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2011

IMPROVING VALUE ESTIMATES FOR RESTORATION

OF MISSISSIPPI'S BARRIER ISLANDS

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This research introduces a new value elicitation method for non-market valuation, referred to as the "quasi-double-bound (QDB)" method, applied to the case of barrier-island restoration in Mississippi. The objective of this thesis is to implement the QDB method in an actual stated-preference survey instrument and to test empirically whether the method elicits consistent responses and yields more efficient welfare estimates relative to the more-commonly used single-bound (SB) method. To test the QDB method, several models were estimated to derive a variety of welfare estimates for comparison to the estimates derived from the SB method. The QDB method introduced here results in a median willingness to pay (WTP) that was higher than the estimate of median WTP using the SB method in three of the five models estimated. The variances (i.e., confidence interval) of the QDB models were generally lower than those of the SB models.

Key words: quasi-double-bound method, single-bound method, willingness to pay

DEDICATION

I would like to dedicate this research to my family.

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This thesis would not have been possible without the support of many people. I wish to express my gratitude to all of those individuals. First of all, I would like to thank Dr. Daniel Petrolia, my major advisor, whose encouragement, supervision and support from the preliminary to the concluding level enabled me to develop an understanding of the subject. Deepest gratitude is also due to my other committee members, Dr. Matthew Interis and Dr. Barry Barnett, for providing valuable knowledge, assistance, and encouragement to do my best. I also would like to thank all the faculty, staff, and fellow students for sharing their knowledge and invaluable assistance. Finally, I wish to express my love and gratitude to my beloved family for their endless love.

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CHAPTER I

INTRODUCTION

General Problem

The contingent valuation method is one of the standard approaches to measure the value of environmental goods or quality, and it is based on stated preference. Generally, contingent valuation (CV) asks an individual's willingness to pay (WTP) for environmental goods or quality. To elicit the WTP, a bidding game was used initially by Randall *et al*. (1974). Recently dichotomous choice (referendum choice) is popularly used for CV study. The National Oceanic and Atmospheric Administration (NOAA) panel, who provided a guideline to obtain reliable data in CV, recommended using dichotomous questions in which respondents are asked to vote for or against an offered bid because it has the advantage of underlying incentive compatibility, and it mimics actual voting that people are accustomed to (Arrow *et al*., 1993).

The single-bound (SB) method is the simplest and most often utilized dichotomous choice method for eliciting WTP. In the SB approach, a survey respondent is offered a single program at a given price and it is assumed that he votes "yes" if the change in utility with the payment is positive, i.e., the value assigned to the proposed program or policy, expressed as willingness to pay (WTP), is higher than the offered bid;

otherwise he votes "no". Bids are varied across respondents, and over a sufficient number of respondents, a distribution of mean WTP can be estimated. The major shortcoming of the SB method is that it collects so little information from each respondent. All that is revealed is that the respondent's true WTP is either greater than (if a "yes" vote is registered) or less than (if a "no" vote is registered) the offered bid. Consequently, this method suffers from poor statistical efficiency. Hanemann (1985), Carson (1985), and Carson *et al.* (1986) proposed adding a follow-up question as a remedy. With this approach, a respondent is offered a follow-up vote in addition to the initial vote as in the SB. Specifically, he is offered a higher bid if he voted "yes" to the initial bid amount, or is offered a lower bid if he voted "no" to the initial bid. Thus, the latter method collect more information regarding the location of WTP and, all things equal, should provide tighter welfare estimates (Carson *et al*., 1994; Alberini, 1995; McLeod and Bergland, 1999; Carson and Groves, 2007). This latter method is now known as the double-bound (DB) method.

Kanninen (1993) states that many researchers agree that the double-bound procedure improves reliability of responses. Hanemann *et al*. (1991) find that the DB method is more statistically efficient than the SB approach, and conclude that efficiency will increase with more observations as the number of responses increase. Even though the double bound method is generally held to yield more statistical efficiency than the single-bound method, the double-bound method has been criticized by many researchers because it suffers from various forms of response bias (Cameron and Quiggin, 1994; Clarke, 2000; Cooper, Hanemann, and Signorello, 2002; Haab and McConnell, 2002;).

Further, as Cameron and Quiggin (1993) show, DB method may not necessarily be more efficient, as they find the dispersion of values are larger in the follow-up question than in the original question. In general, the bias in DB method is because respondents' expectations change after they answer the first question (Haab and McConnell, 2002).

A starting point bias is one of the possible biases in DB. Starting point bias occurs when the initial bid affects the response to the follow-up question (Mitchell and Carson, 1993 and Flachaire and Hollard, 2006). Hanemann *et al*. (1991) suggest that starting point bias can occur as a result of respondent wariness with multiple questions; however, this is likely not the case with a single follow-up question. Mitchell and Carson (1993) and Herriges and Shogren (1996) offer another explanation: a respondent anchors his WTP to the initial bid, perceiving it to be reflective of the true value of the project, and evaluates each subsequent bid relative to it. Cooper *et al.* (2002) and Clarke (2000) offer a different argument. They claim that if the scenarios used in double-bounded approach do not provide information about the follow-up question to the respondents before they confront the WTP question, respondents are surprised by different price offered from the follow-up question. The result is that the respondents tend to react negatively to the follow-up question.

Another reason for bias is a shifting effect. Carson *et al*. (1992), Alberini *et al*. (1997), and Cooper *et al*. (2002), and Watson and Ryan (2007) argue that this occurs when respondents perceive a lower (higher) quantity or quality of the proposed good or service when they are presented a lower (higher) price in the follow-up question.

Haab and McConnell (2002) and McLeod and Bergland (1999) cite strategic behavior as a source of response bias in DB. This is the case when respondents who said "yes" to the initial question answer "no" to the follow-up question irrespective of the bid, and it results that mean WTP will generally be lower using DB data due to the preponderance of "no" responses to the follow-up question. Altaf and DeShazo (1994), Cooper *et al*. (2002) and Carson and Grove (2007) argue that respondents interpret the follow-up question as an offer to bargain, and thus respondents answer "no" to the second bid in as effort to bring the price down. The result is that mane WTP will generally be lower using DB data due to the preponderance of "no" responses to the follow-up question.

Carson *et al*. (2009) and Cooper *et al*. (2002) propose potential remedies to the problems of bias in DB. Carson *et al*. (2009) propose two necessary conditions for consistency using the DB method. The conditions are that the first and second dichotomous votes be consequential, and that there are no links between the two votes. The authors tested these conditions experimentally with two decision rules: if respondents answer "no" to the second question, the result from the second question is replaced to the result from the first question, and the other rule is if respondents answer "no" to the second question, the result is replaced based on what they answered to the first question. The authors conclude based on their experimental findings that the DB method can provide reliable WTP estimates if these two conditions hold, but they mention that their experimental conditions are not likely to applicable to the field survey if two conditions are not reproducible in the field study.

Cooper *et al*. (2002) propose an alternative method, called the One-and-One-Half-Bound (OOHB) approach, to the double-bounded approach. To apply the OOHB approach, the authors used a different elicitation format by incorporating a split-sample treatment: one received the DB method and the other the OOHB method. For the double bounded model, respondents were given first bid, and then were asked a higher or lower bid based on their answer to the first bid. For the OOHB, respondents were given information about bid ranges between low and high before they confront first bid, and then they were given a randomly-selected bid from the ranges. The data obtained from the OOHB format were that if a respondent was given the lowest bid from the ranges, his possible responses could be no, yes-no, and yes-yes; on the other hand, if a respondent was given the highest bid from the ranges, his possible responses could be yes, no-yes, and no-no. The authors found that the OOHB model yield more efficient estimates than the single-bound and double bound model by comparing with coefficients of variation. Finally, they conclude that if use of the double-bound format is considered due to the response bias or sample design by using follow-up question, the OOHB model is possible alternative model.

<u>Quasi-Double-Bound Method</u>

This thesis develops new method to improve efficiency relative to SB method but does not suffer from biases of DB method, and thus this thesis proposes a novel variant of the DB method referred to, for convenience, as the "quasi-double-bound" (QDB) method. The QDB method works by having respondents evaluate, in the same survey instrument, three different programs that differ only in the quantity of the good provided. This information is then used to estimate WTP for the program of intermediate quantity by incorporating data from the questions pertaining to the relatively smaller and larger quantity programs. To apply this method, responses to the vote on the intermediate-quantity program are interpreted in the usual way as done using the SB method. The difference is that these data are augmented with additional information taken from the responses to the small- and large-quantity programs. To do so, this study makes two simplifying assumptions. First, this study assumes that the only fundamental difference between the three scenarios perceived by the respondent is quantity; second, that utility is non-decreasing in quantity (i.e., scale). Under these assumptions, these additional responses should be interpreted as follows. If a respondent votes "no" to a proposed bid for the large-quantity program, then this study assumes that he is also not willing to pay that same amount for the relatively smaller quantity offered in the intermediate-quantity program. For example, if a respondent voted "no" to paying $10 for the *large* quantity program, then he is also not willing to pay $10 for the relatively smaller quantity offered in the intermediate program. Similarly, if he voted "yes" to a proposed bid for the small quantity program, then this study assumes he is also willing to pay that same amount for the relatively larger intermediate quantity program. In this way, responses to the large-quantity and the small-quantity programs can, in certain cases, be used as additional information on the bounds on WTP for the intermediate-quantity program.

The QDB method should mitigate the potential for biases as discussed above. As noted above, stating point bias can occur when the respondent's response to the initial price affects the response to the follow-up question because the respondent anchors to the initially-offered bid, perhaps out of surprise from being offered the follow-up question, or because they perceive that there must necessarily be a change in quantity or quality of the program given the now lower (or higher) price, contrary to the researcher's intentions. With the QDB method, respondents are informed up front that they will be asked to evaluate three different programs and these programs have explicitly different prices and quantities. Consequently, respondents should not be surprised by the follow-up question(s), and because details on quantity/quality for each program are given explicitly, the respondent is much less likely to substitute his own notions of the quantity/quality to be provided. This mitigates the issues of surprise and respondent-perceived change in quantity or quality, so the likelihood of starting point bias and shifting effect should be reduced.

In addition, the problem of strategic behavior can occur in DB when respondents interpret the follow-up question as a signal that price is negotiable, and consequently behave as in as bargaining context. Thus, they are more likely to vote "no" in order to affect a lower price. However, the QDB method should suffer less from strategic behavior of this kind because each valuation question refers to a distinct program and should be less likely to signal a bargaining situation.

Because the QDB method requires three valuation questions for programs at different quantities, a new risk is introduced, ordering effect. In this case, the ordering effect can be considered a type of starting point bias. The ordering effect is a case where the position of a question in a sequence affects responses (Mitchell and Carson, 1993;

Powe and Beteman, 2003; Clark and Friesen 2008), such that, for example, respondents to a given question posed first differ systematically from the responses to the same question when posed last.

To sum up, with the QDB approach, the respondents are informed beforehand that they will be asked to evaluate three distinct programs to evaluate, they are provided detailed information on these three programs, and each program has distinct and explicitly stated price and quantity. Because of these differences between the QDB and DB method, and when controlling for any bias due to ordering effect, there is no obvious reason why respondent's answers to the three WTP questions in a QDB-based survey instrument should be inconsistent. The QDB will be explained in more detail in Chapter IV.

Research Objective

It is objective of this thesis to implement the QDB method in an actual stated-preference survey instrument and test empirically whether the method elicits consistent response and yields more efficient welfare estimates relative to the SB method.

Specific Problem

Petrolia and Kim (2009) measured Mississippi coastal residents' WTP for restoration of the Mississippi's barrier islands at three different scales: their current condition (Status-Quo), their condition before Hurricane Camille in 1969 (Pre-Camille), and their condition before 1900 (Pre-1900). The Status-Quo option also indicates involving restoring the least amount of land, and the Pre-Camille option indicates involving restoring the second least amount of land. Finally, the Pre-1900 option means involving restoring the most amount of land. To obtain data, they used the single-bound (SB) contingent valuation method to obtain welfare estimates for each individual scale. They estimated a random-effects probit model, and estimated WTP by using non-parametric and parametric methods: Turnbull, Random Effects Probit, Income Bound Random Effects Probit, and High-bid Bound Random Effects Probit. The estimated mean WTP values for the Pre-Camille scale using these four methods were $152, $144, $252, and $161 respectively.

The survey design used by Petrolia and Kim (2009) also coincides with the design necessary to carry out the QDB method. In the survey, the three different programs, the Status-Quo, Pre-Camille, and Pre-1900, differ only in the quantity of the good provided. The survey instrument matches exactly requirements of the QDB method mentioned in the earlier section. Therefore, this thesis applies the QDB method to the data collected from the survey to obtain alternative welfare estimates for the Pre-Camille option by incorporating data from the smaller-scale Status-Quo and larger-scale Pre-1900 scenarios.

As required by the QDB method, these three scenarios differ only in scale, i.e., in quantity of acres restored. Thus, in this case, this thesis assumes that if a respondent reports he is not willing to pay the proposed bid for the largest-scale Pre-1900 option, he is also not willing to pay that same amount for the relatively smaller intermediate-scale Pre-Camille option. Similarly, if he is willing to pay the proposed bid to maintain the current levels, i.e., he supports the Status-Quo option, he should be willing to pay at least that amount for the relatively larger intermediate-scale Pre-Camille option. In this way, a subset of responses to the Pre-1900 and Status-quo options (those voting "yes" to Status-Quo if response to the Pre-Camille was "no" and "no" to Pre-1900 if response to the Pre-Camille option was "yes") are used as additional information on the bounds of WTP for the Pre-Camille option. Implementing the Pre-Camille option implies restoring more land than there is now (Status-Quo option), and implementing the Pre-1900 option implies more land than in the Pre-Camille option.

CHAPTER II

REVIEW OF WELFARE THEORY

Measurement of Welfare

Environmental goods and services provide benefits to humans in much the same way as market goods. However, because of the public goods nature of environmental goods, many do not have markets, and thus prices do not exist. Thereby, the value of environmental goods is difficult to measure. Theoretical concepts of economic welfare used to evaluate the value of environmental goods include consumer surplus, compensating and equivalent variation, and compensating and equivalent surplus. The following discussion is based on Kolstad (2000).

Consumer Surplus

Consumer surplus is the most commonly-known economic welfare measure and the one taught first to students of economics. Although it is not the most appropriate welfare measure in all case (for reasons discussed momentarily), it provides a good starting point to discuss welfare measures. Consumer surplus is associated with Marshallian, or ordinary, demand. Ordinary demand is a function of price and income. Willingness to pay is related to consumer surplus. Willingness to pay indicates how much people are willing to pay for specific quantities of a particular good or service, and can be represented graphically as the area under the demand curve because each point on a demand curve indicates individual's maximum marginal willingness to pay at that quantity. Consumer surplus measures the welfare from consumption of a good, and is defined as the difference between WTP and what they actually pay, which is generally the market equilibrium price for the good or service. Consumer surplus is illustrated as the area under the demand curve and above the price line, P_0, in Figure 1. Also shown is the change in consumer surplus given a quantity change from the initial quantity of Q_0 to a new, lower, quantity Q_1. In this case, consumer surplus is reduced by the triangular area that is below the demand curve, above the price line, P_0, and between the quantities Q_0, and Q_1. This marginal measure can be interpreted as the reduction in consumer welfare associated with the change in quantity consumed.

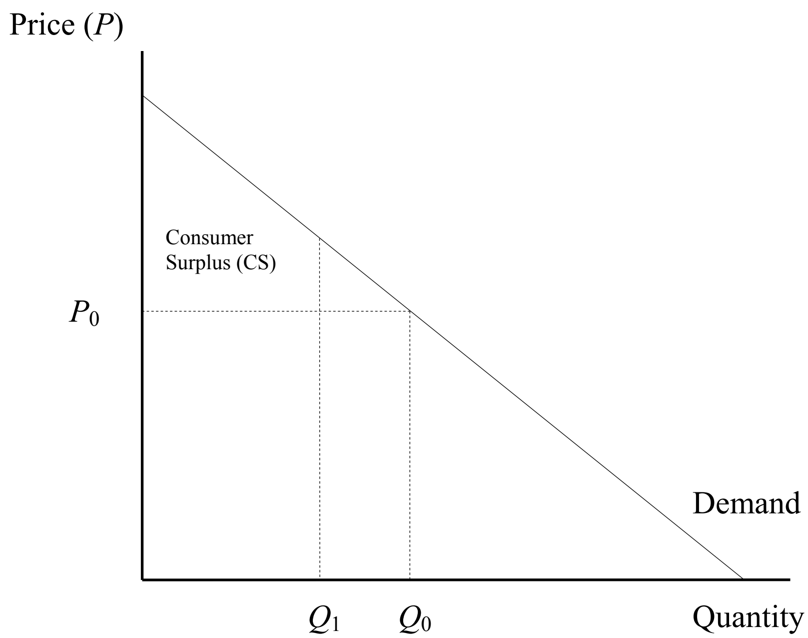

Figure 1

Consumer Surplus

Ordinary and Compensated demand

An alternative measure of welfare is based on Hicksian, or compensated demand. Ordinary demand is a function of price and income. In this case income remains constant along an ordinary demand curve, but utility changes as price changes. Compensated demand, on the other hand, is a function of price and utility. In this case, utility is constant along a compensated demand curve, but income changes as price changes.

Compensated demand reflects the substitution (price) effect only because income is compensated to keep utility constant. Ordinary demand reflects both the substitution and income effects. The substitution effect between two goods z and q is that if price of good z increases, people consume more q and less z because it becomes relatively more expensive than *q*. On the other hand, the income effect is that people consume less of both *z* and *q* because they cannot consume the same amounts of each good with the same amount of income (buying power has decreased).

Compensated demand is more appropriate for contingent valuation because the response elicited in a contingent valuation survey is one in which utility is assumed held constant given a change in income.

Compensating variation (CV) and Equivalent variation (EV)

There are actually two welfare measures associated with compensated demand, compensating variation and equivalent variation. They differ in the reference utility level used to measure welfare.

Compensating variation is that amount of money income required to *compensate* the individual in order to maintain the *original* level of utility after a price change. It can also be defined mathematically as $CV(P_z^0, P_z^1) = E(P_z^0, P_q, U_0) - E(P_z^1, P_q, U_0)$ where *E* is expenditure function, z and *q* are two goods, p_z and p_q are the prices of *z* and *q*, and U_0 is original utility. Equivalent variation is that the amount of money income required, in lieu of the price change, to yield a *new* level of utility *equivalent* to that which would have prevailed with the price change. Mathematical equation for the equivalent variation can be written as $EV(P_z^0, P_z^1) = E(P_z^0, P_q, U_1) - E(P_z^1, P_q, U_1)$ where U_1 is new level of utility.

Figure 2 shows the relationship between the ordinary demand curve $x_q(p_z, p_q, y)$ and compensated demand curves $h_q(p_z, p_q, U_1)$ and $h_q(p_z, p_q, U_0)$ where *y* is income. Figure 2 also illustrates different measures of welfare effect: the compensating variation, equivalent variation, and the consumer surplus. The line *CF* represents the ordinary demand curve for *z*, and there are two compensated demand functions which pass through *C* and *F* after price and before price changes. If initial price of p_z^0 for consumption of *z* drops to p_z^1, the consumer expands his consumption of *z* from z_0 to z_1. This change increases utility from the initial level U_0 to a new higher level U_1. The change in consumer surplus is represented by the area ABFC. The area *ABDC* which is to the left of the compensated demand curve *CD* is the compensating variation, and the area *ABFE*, which is to the left area of the compensated demand curve *EF*, represents the equivalent variation of the price change. Consumer surplus is thus bounded from below by equivalent variation and from above by compensated variation.

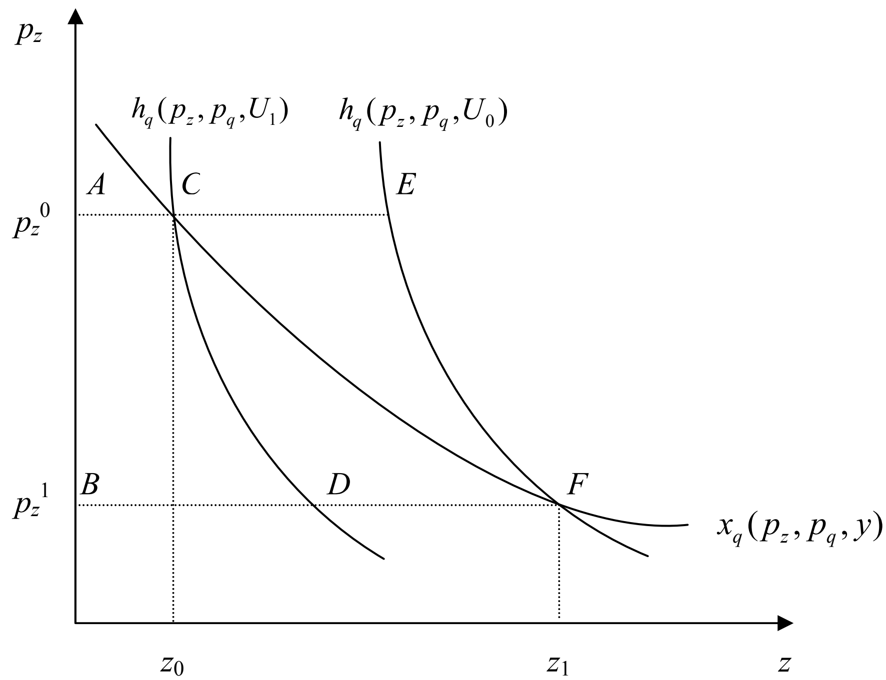

Figure 2

Compensating and Equivalent Variation

Compensating surplus (CS) and Equivalent surplus (ES)

This paper estimates the value of a change of a non-priced environmental good with restricted demand, and in this case, compensating and equivalent surplus (CS and ES, respectively) are the appropriate welfare measures. Compensating and equivalent surplus are identical to compensating and equivalent variation, except that CS and ES are simply the names given to CV and EV when applied to the case of restricted demand, i.e., where the quantity consumed cannot be chosen by the consumer. The compensating surplus can be defined mathematically as $CS(q_0, q_1) = E(p_z, q_0, U_0) - E(p_z, q_1, U_0)$, and the equivalent surplus can be defined as $ES(q_0, q_1) = E(p_z, q_0, U_1) - E(p_z, q_1, U_1)$.

Figure 3 shows the compensating and equivalent surplus graphically where *Y* on the vertical axis represents income, or equivalently, consumption of all other market goods, *q* on the horizontal axis represents quantity of the environmental good. I_{U0} is an indifference curve with initial utility of u_0, and I_{U1} is a new indifference curve with new utility of u_1. Suppose an increase the quantity of the environmental good *q* from q_0 to q_1. This change moves consumption from point *A* to point *B*. In figure 3, compensating surplus is the difference between income levels Y_0 and Y_1 because compensating surplus is the monetary value of *q* needed in order to return individual to the original level of utility with the quantity change. In this case, the compensating surplus represents the individual's maximum willingness to pay (WTP) to obtain the quantity change from q_0 to q_1 such that the final consumption point is *C*. On the other hand, equivalent surplus is difference between income levels Y_0 and Y_2 because it is the monetary value of *q* needed in order to make the individuals move to the new level of utility without the quantity changes such that the final consumption point is *D*, or willingness to accept (WTA) compensation.

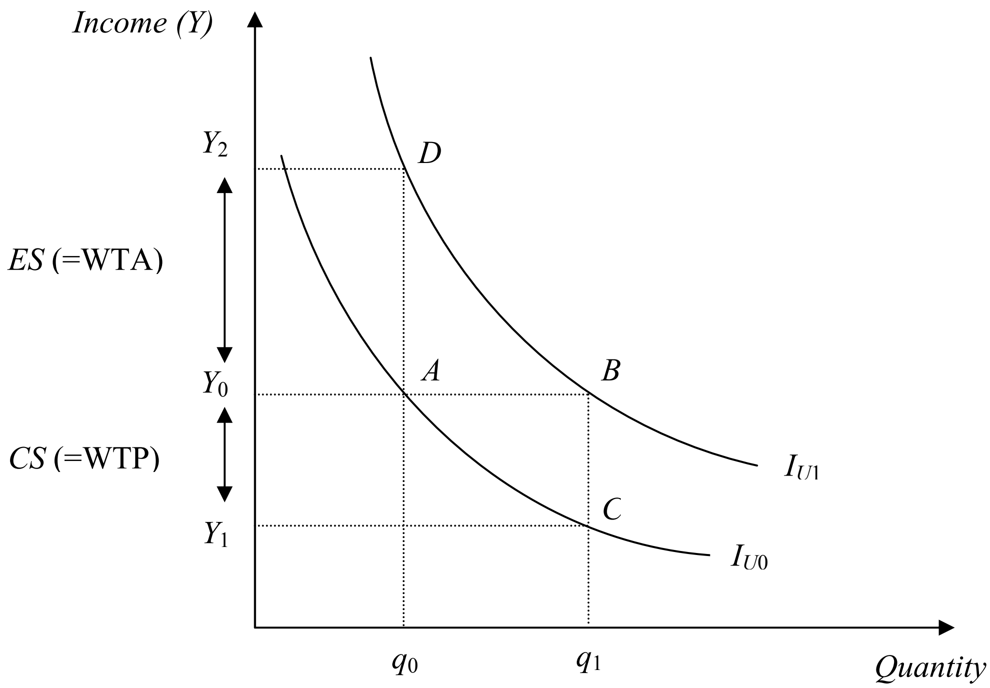

Figure 3

Compensating and Equivalent Surplus

CHAPTER III

VALUATION METHODS AND MODELS

Contingent Valuation

Contingent valuation (CV) is a survey based economic technique to value non-market goods. Contingent valuation can be used to estimate individuals' willingness to pay for changes in environmental quantity and/or quality (Haab and McConnell, 2002).

Ciriacy-Wantrup (1947) first proposed the contingent valuation method to estimate the values of non-market goods (Carson *et al.* 1993). Later, Davis (1963) implemented the contingent valuation method to measure the benefits of a recreational area in Maine. In the 1970s, many researchers and economists used the CV method to measure the value of different recreational areas. One of the most well known early CV studies was conducted by Randall, Ives, and Eastman (1974) to measure the value of improved air quality, and this study was published in the first volume of the *Journal of Environmental Economics and Management*. Thereafter, the CV method was developed and improved and was popularly used in various environmental economic studies.

However, the CV method was subject to debate by economists and other researchers regarding whether it was a reliable method to estimate the value of environmental goods. The Exxon Valdez oil spill in 1989 was a challenge and developmental opportunity for the CV method in order to assess its validity. By way of the Exxon Valdez oil spill, there grew a controversy between economists on the CV method. Diamond and Hausman (1994) and Desvousges *et al*. (1993) argued that CV is not an appropriate method for measuring passive use values. On the other hand, Randall (1993), Hanemann (1994), and Portney (1994) argued that CV is a valid and useful approach. The National Oceanic and Atmospheric Administration (NOAA) appointed a panel of six expert economists, Kenneth Arrow Robert Solow, Edward Leamer, Paul Portney, Roy Randner, and Howard Schuman in order to refine previous CV studies (Arrow *et al*., 1993). The NOAA panel concluded that "CV studies can produce estimates reliable enough to be the starting point for a judicial or administrative determination of natural resource damage including lost passive-use value" (Arrow *et al*., p.4610). Moreover, the NOAA panel provided guidelines for the proper use of the method that are still followed today.

Random Utility Model

The random utility model is a well-known model to analyze dichotomous CV responses. Hanemann (1984) was the first to develop a basic model for the random utility, and McFadden (1974) utilized a framework for the random utility. The discussion follows Haab and McConnell (2002). In the contingent valuation case there are two choices or alternatives, either "for" or "against" the contingent valuation (CV) program. Let indirect utility for respondent j be written

$$u_{ij} = u_i(y_j, z_j, \varepsilon_{ij})$$

where $i = 1$ if the CV program is implemented, and $i = 0$ is for the status quo. y_j is the j^{th} respondent's discretionary income, and z_j is an m-dimensional vector of household characteristics and choice attributes, and ε_{ij} is a known component of preference by the individual respondent but not observed by the researcher. Based on this model, respondent *j* will answer yes to a required payment of t_j if utility with CV program, minus the payment, exceeds utility of the status quo:

$$u_1(y_j - t_j, z_j, \varepsilon_{1j}) > u_0(y_j, z_j, \varepsilon_{0j})$$

Because a random part of preferences is unknown, only a probability statement about yes or no can be made. The probability of a yes response is the probability that the respondent assumes that he is better off in the proposed CV program with the required payment, so that $u_1 > u_0$. For respondent *j*, this probability is

$$\Pr(yes_j) = \Pr(u_1(y_j - t_j, z_j, \varepsilon_{1j}) > u_0(y_j - t_j, z_j, \varepsilon_{0j}))$$

Two modeling decisions are needed for estimating a model due to the fact that this model provides general parametric estimation. First, the functional form of utility must be made. Second, the distribution of ε_{ij} must be specified. All approaches clearly identify that the utility function be additively separable in deterministic and random parts:

$$u_i(y_j, t_j, \varepsilon_{ij}) = v_i(y_j, z_j) + \varepsilon_{ij}$$

Using the additive specification of the equation, the probability of respondent *j* becomes

$$\Pr(yes_j) = \Pr(v_1(y_j - t_j, z_j) + \varepsilon_{1j}) > v_0(y_j, z_j) + \varepsilon_{0j}))$$

This also can be written as

$$\Pr(yes_j) = \Pr\left[v_1(y_j - t_j, z_j) - v_0(y_j, z_j) > \varepsilon_{0j} - \varepsilon_{1j})\right]$$

However, the differences in the random components between the status quo and the proposed CV program cannot be identified. Therefore, the random term can be written as $\varepsilon_{ij} \equiv \varepsilon_{1j} - \varepsilon_{0j}$, a single random term. Then let $F_\varepsilon(a)$ be the probability that the random variable *ε* is less than *a*. Therefore the probability of a yes is

$$\Pr(yes_j) = 1 - F_\varepsilon\left[-(v_1(y_j - t_j, z_j) - v_0(y_j, z_j))\right]$$

At this point, a more specific utility function is needed for estimation. For example, the linear utility function, which is the simplest and most commonly estimated function, is specified as follows. The linear utility function results when the deterministic part of the preference function is linear in income and covariates

$$v_{ij}(y_j) = \alpha_i z_j + \beta_i y_j$$

where y_j is discretionary income, z_j is an m-dimensional vector of variables related to individual *j* and α_i is an m-dimensional vector of parameters, so that $\alpha_i z_j = \sum_{k=1}^{m} \alpha_{ik} z_{jk}$.

The deterministic utility for the proposed CV program is

$$v_{1j}(y_j - t_j) = \alpha_1 z_j + \beta_1 (y_j - t_j)$$

where t_j is the price offered to the j^{th} respondent. The status quo utility is

$$v_{0j}(y_j) = \alpha_0 z_j + \beta_0 y_j$$

The change in deterministic utility is

$$v_{1j} - v_{0j} = (\alpha_1 - \alpha_0) z_j + \beta_1 (y_j - t_j) - \beta_0 y_j$$

It can be rewritten as

$$v_{1j} - v_{0j} = (\alpha_1 - \alpha_0)z_j + (\beta_1 - \beta_0)y_j - \beta_0 t_j$$

If one assumes that the marginal utility of income is constant between the two CV states, then $\beta_1 = \beta_0$ and the utility difference becomes

$$v_{1j} - v_{0j} = \alpha z_j - \beta t_j$$

where $\alpha = \alpha_1 - \alpha_0$ and $\alpha z_j = \sum_{k=1}^{m} \alpha_k z_{jk}$ with the deterministic part of preferences specified, the probability of responding yes becomes

$$\Pr(yes_j) = \Pr(\alpha z_j - \beta t_j + \varepsilon_j > 0)$$

where $\varepsilon_{ij} \equiv \varepsilon_{1j} - \varepsilon_{0j}$ as defined already.

Random Willingness to Pay Model

An alternative to the random utility model is the random WTP model, whish was initially proposed by Cameron and James (1987). This thesis follows the latter. In the closed-ended CV survey data which is dichotomous referendum choice, each individual is offered bid, t_i, and by his response his true WTP is either greater than or less than t_i. Then, it assumes that

$$Y_i = x_i^{'}\beta + \varepsilon_i$$

where Y_i is unobserved continuous valuation (WTP), x_i is a vector of explanatory variables, and it has some known distribution with a mean of $x_i^{'}\beta$. ε_i is error term. By employing the offered bid as

$$I_i = 1 \text{ if } Y_i > t_i$$

$$= 0 \text{ if } Y_i < t_i$$

where I_i is discrete indicator variable. So probability of "yes" can be written as

$$\Pr(I_i = 1) = \Pr(Y_i > t_j) = \Pr(\varepsilon_i > t_j - x_i^{'}\beta)$$

$$= \Pr\left[\frac{\varepsilon_i}{\sigma} > \frac{(t_i - x_i^{'}\beta)}{\sigma}\right] = 1 - \Phi\left[\frac{(t_i - x_i^{'}\beta)}{\sigma}\right]$$

where Φ is the standard normal cumulative density function, and σ is standard deviation, and assume that the error term is normally distributed. The log-likelihood function, which maximize likelihood of observed respondents' choices actually made, becomes

$$\log L = \sum_{i=1}^{N}\left\{I_i \log\left[1 - \Phi\left(\frac{t_i - x_i^{'}\beta}{\sigma}\right)\right] + (1 - I_i)\log\left[\Phi\left(\frac{t_i - x_i^{'}\beta}{\sigma}\right)\right]\right\}$$

The existence of t_i allows σ to be specified, which is possible to separate β in order to determine the underlying valuation function. The likelihood function expresses the joint probability of observing the responses to the WTP question actually observed. This study estimates the model using the maximum likelihood estimator; it also finds the parameter estimates that maximize the probability of observing the actual responses made. Equivalently, this study can maximize the log-likelihood function, which is:

<u>Single-Bound Dichotomous-Choice Method</u>

The single-bound (SB) contingent valuation method was initially proposed by Bishop and Heberlein (1979). In the single-bound method, a proposed environmental improvement is described to a respondent and offered at a specified price, (t). The respondent is then asked for a "yes" or "no" response to whether they are willing to pay t for the specified environmental improvement. Thus, the method works as a referendum. The single-bound method provides one of two bounds on WTP for each respondent. If the respondent answers "yes" to the given single amount of t, willingness to pay is assumed to be greater or equal to t; otherwise, willingness to pay is assumed to be less than or equal to t, and it can be denoted as

$$t \leq WTP \text{ if respondent answer "yes"}$$

$$t \geq WTP \text{ if respondent answer "no"}$$

Double-Bound Dichotomous-Choice Method

The double-bound (DB) contingent valuation method was developed by Hannemann, Loomis and Kanninen (1991). The method works in generally the same way as the SB method, except that, depending upon the response (yes or no) to the initial bid, the respondent is offered a second, higher (in the case of a yes response) or lower (in the case of a no response) bid for the same environmental improvement. This method provides both lower and upper bound for each respondent, and the bounds on WTP can be written as

$$t^1 \leq WTP \leq t^2 \text{ for the yes-no responses}$$

$$t^1 \geq WTP \geq t^2 \text{ for the no-yes responses}$$

$$WTP \geq t^2 \text{ for the yes-yes responses}$$

$$WTP \leq t^2 \text{ for the no-no responses}$$

where t^1 is initial bid price and t^2 is second bid price (Haab and McConnell, 2002). The reader is directed back to Chapter 1 for a review of the relative merits and shortcomings of the SB and DB methods.

CHAPTER IV

EXPERIMENTAL DESIGN

This section includes explanations of the variables which are used for constructing models of WTP to restore Mississippi's barrier islands. Additionally, this section describes survey methods and questions related to the variables.

Carson (1991) addresses six main components for a successful CV study, and Kolstad (2010) explains each component in detail. The six main components are: define the market scenario, choose the elicitation method, design market administration, identify the sample, design the survey, and estimate the WTP function.

Defining the market scenario refers to providing information about the CV program to a respondent in order to let him make an informed decision. It is an important part of the CV survey because data will not be meaningful or useful if the description of the market scenario provided is vague, not realistic, or not useful to respondents. Moreover, the market scenario needs to include a payment vehicle (e.g., tax) which is how the payment is to be made in the scenario. The NOAA panel suggests that respondents be reminded of their own budget constraints and that follow-up questions be used to check that the respondents understand the scenario. Choosing elicitation method indicates how WTP will be elicited. There are four methods to elicit the value: direct question, bidding game, payment card, and referendum or discrete choice. The NOAA panel recommends the referendum choice because possible bias can be minimized and this method is easier for respondents to answer (i.e., “yes or “no”). Design market administration refers to how the survey is to be administered to respondents. The four basic ways for administration are mail, internet, telephone, and in-person. In-person survey is preferred by the NOAA panel as the best and most reliable administration method, but it is also the most expensive and potentially suffers from interviewer bias. Sample design refers to identifying the sample, and there are two issues here. The first issue is what the relevant population is, which is called the sampling frame, and the second issue is how to draw the sample. Experimental design is the actual design of the survey, and it includes which bid values are to be used and which questions are relevant to the WTP model to be estimated. The final component is estimation of the WTP function, which drives the experimental design to ensure collection of the data necessary for estimation.

Study Area

The following background information regarding Mississippi’s barrier islands was provided to survey respondents.

“Mississippi has five barrier islands: Cat, West Ship, East Ship, Horn, and Petit Bois. They lie roughly parallel to the coast, between 9 and 12 miles offshore. Combined, they contain 6,545 areas of land mass.”

Figure 4 shows a map for the Mississippi barrier islands in 2006.

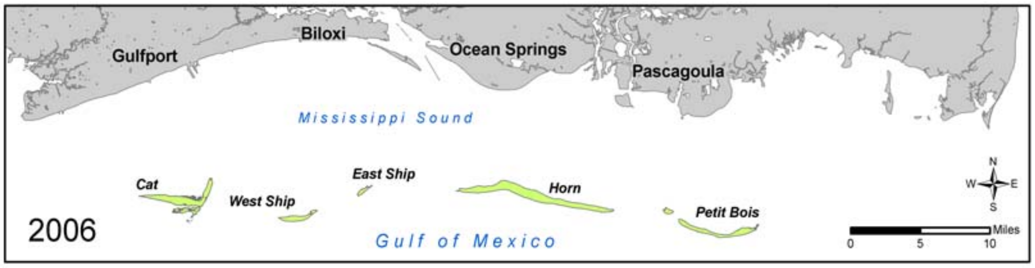

Figure 4

Mississippi Barrier Islands in 2006

"Except for a portion of Cat Island, the islands are part of the Gulf Islands National Seashore, maintained by the National Park Service. Horn and Petit Bois Islands are also designated wilderness areas under the federal Wilderness Act. Additionally, West Ship Island is accessible to the general public via ferry and contains a public beach area. West Ship is also home to Fort Massachusetts, a former military installation whose construction began in 1859. The fort is now an historic site, also maintained by the National Park Service."

"The barrier islands are home to a variety of wildlife, including alligators, lizards, snakes, turtles, and frogs. The most easily seen species are birds: over 260 species, including osprey, pelicans, bald eagles, skimmers, plovers, and terns use the island for nesting or migratory rest stops. The islands also separate Mississippi Sound from the open waters of the Gulf (see map above), providing the right conditions for marine life reproduction and juvenile growth. Additionally, this separation provides a calmer environment for commercial and recreational navigation. Finally, the barrier

islands play a role in reducing storm surge and wave energy during a tropical storm, which may reduce the severity of damage on the mainland resulting from the storm."

Market Scenario

For the market scenario, the respondents were introduced to a hypothetical market scenario with maps regarding a restoration program for barrier islands in Mississippi. The given brief information about the market scenario regarding a barrier island restoration program is:

"The Mississippi barrier islands are continuously changing shape, size, and location. As the maps on the opposite page show, the islands have changed considerably since 1850. In general, the pattern over the years has been for the islands to slowly move westward, losing land in some places and gaining it in others. Overall, though, total land area has decreased by 36 percent since the 1850s, falling from a combined 10,290 acres to 6,545 acres. The principle causes of land loss are frequent intense storms, sea-level rise, and reduction in sand supply related to ship-channel dredging. Although no exact predictions can be made, it is expected that they will continue to lose more land in the future."

Figure 5 contains four different maps from four points in time showing how the barrier islands have changed in shape, size, and location over the past century: the 1850 map shows the barrier island just prior to 1900, the 1966 map shows just prior to Hurricane Camille in 1969, the 2002 map shows condition before Hurricane Katrina, and the 2006 map shows current conditions.

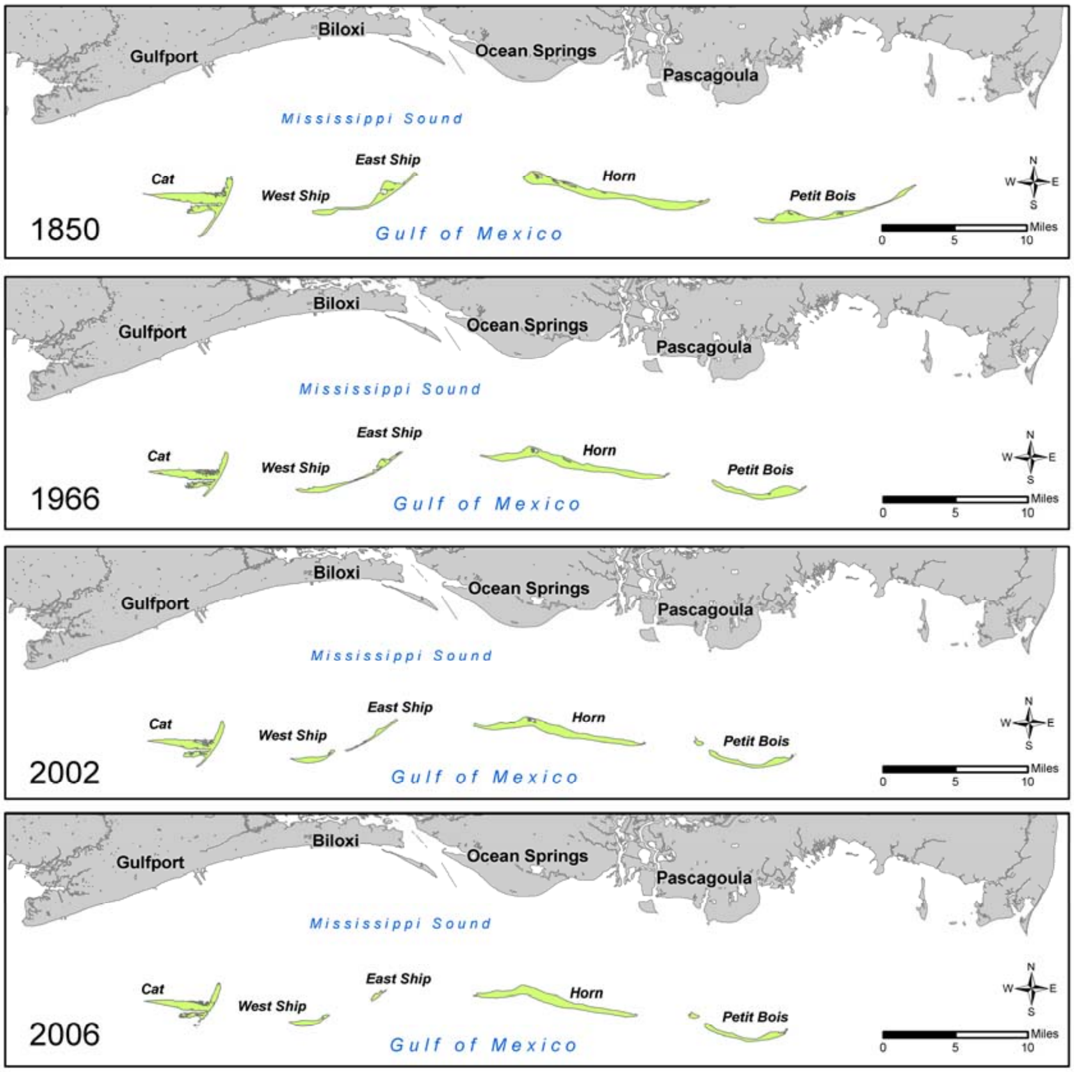

Figure 5

Mississippi Barrier Islands over time

The respondents, then, were given brief introduction each of the three different scenarios before they confront each WTP question. The given introduction about the restoration scenarios is:

"On the following pages, three restoration scenarios for the Mississippi Barrier Islands that are being considered by the State of Mississippi and the Army Corps of Engineers will be described to you and you will be asked about your support for them. For each option, you will be asked to answer 'Yes' or 'No', to whether you would be willing to pay some amount of money to support each possible option."

After given the introduction, the respondents were given three different types of restoration options explicitly with brief information of each scenario: the Status-Quo Option, the Pre-Camille Option, and the Pre-1900 Option.

"The Status Quo option would maintain the barrier island in their current state, and it should prevent any additional land loss. It is estimated that periodic maintenance would keep the barrier islands in their current state for the next 30 years even though it is unknown how much additional land may lost after that period."

Figure 6 shows effects of the Status-Quo option provided to the respondents.

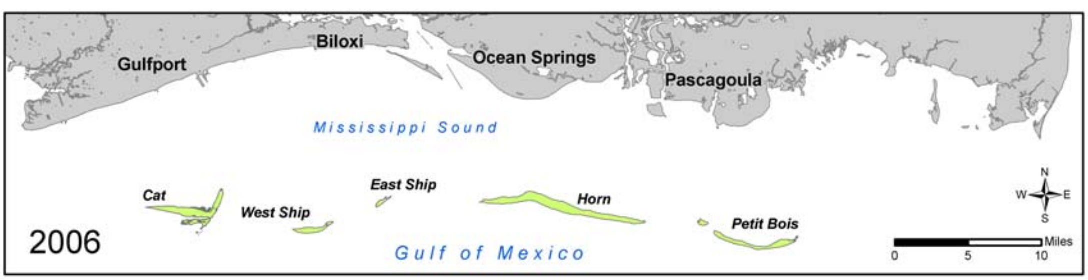

Figure 6

Restoration option for the Status-Quo Option

"The Pre-Camille option would maintain existing land and restore the land area that has disappeared since Hurricane Camille made landfall in 1969. A total 2,338 acres would be added to the island under this restoration plan, a 36% increase from current acreage."

Figure 7 provides map of the restoration plan for the Pre-Camille option.

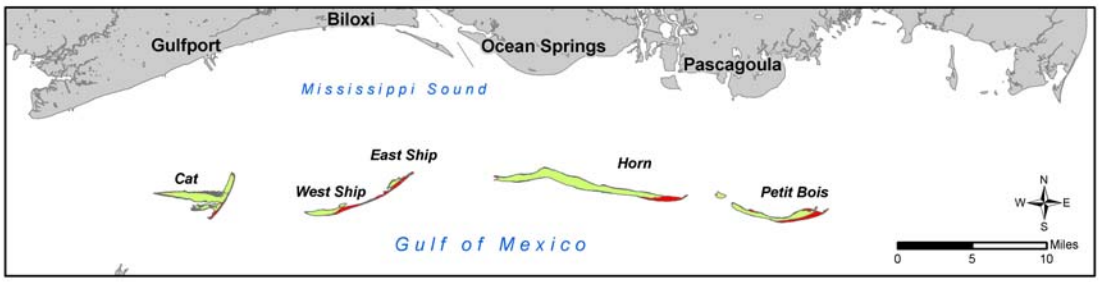

Figure 7

Restoration option for the Pre-Camille Option

"The Pre-1900 option was described in the survey that this option would maintain existing land and restore the land area that has disappeared sign 1850. A total of 5,969 acres would be added to the islands under this restoration plan, 91% increase from current acreage."

Figure 8 shows the Pre-Camille restoration option.

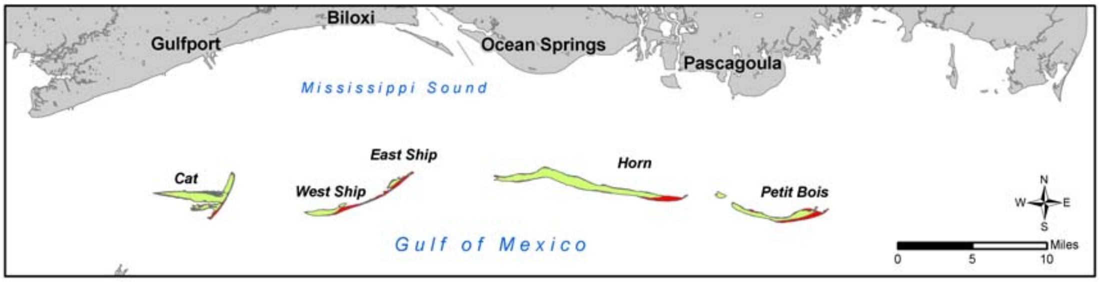

Figure 8

Restoration option for the Pre-1900 Option

Elicitation Method

A dichotomous referendum-style question was used for the elicitation method, such that each respondent said "yes" to the restoration or "no." In the referendum choice question, a survey question is incentive compatibility if the respondents can do no better than answer truthfully. If the survey question is not incentive compatible, i.e., if respondents do not answer truthfully, the elicited values from the WTP question are meaningless. In the survey used in this thesis, the WTP entails two key conditions: a majority vote would be necessary to implement the project, and everyone must pay if the project is implemented. With these incentives, the respondents can do no better than to respond truthfully to the question. For example, suppose a respondent honestly would be better off paying the proposed bid and having the project implemented. If he does not answer truthfully (i.e. he responds "no") to the question, he marginally increases the probability that the project is not implemented, in which case he will be worse off. On the other hand, suppose a respondent honestly would be better off without the project implemented and without having to pay for it. If he does not answer truthfully (i.e. he responds "yes") to the question, he marginally increases the probability that the project *is* implemented and that he has to pay for it, in which case he will be worse off. Therefore, there are no reasons for respondents not to reveal their answers truthfully to WTP question.

The respondents were asked to evaluate three different types of restoration options: Status-Quo Option, Pre-Camille Option, and Pre-1900 Option. Each restoration option stated that the program would entail restoration and periodic maintenance for the next 30 years, and would cost each Mississippi taxpaying household a one-time payment of $X. One of the five bids were recoding assigned to each survey for each restoration option: $7, $13, $20, $26, and $33 for the Status-Quo option; $77, $153, $230, $306, and $383 for the Pre-Camille Option; and $195, $391, $586, $782, and $977 for the Pre-1900 option. The given willingness to pay question for each restoration option is:

"Suppose a State referendum were held today on the restoration option. A majority vote would be necessary to implement the project and, if passed, the payment would be collected on your 2008 state income tax return. Would you support the restoration option and therefore be willing to make a <u>*one-time*</u> *payment of $X to implement it?"*

☐ 1- **Yes** ☐ 1- **No**

Quasi-Double-Bound Method

In this thesis, welfare estimates for restoration of the Mississippi Barrier Islands to their Pre-Hurricane Camille footprint were estimated by using additional data from the two other related scenarios: the Status-Quo and Pre-1900 option.

Figure 9 shows how the QDB method operates. The respondent is asked weather he is willing to pay a certain amount to restore the barrier islands to the Pre-Camille footprint, referred to as the "Pre-Camille" option. If he responds "yes", it obtains a lower bound on his WTP, which is the bid offered, and if he votes "no" it has an upper bound on his WTP. With the SB method, this is the only information obtained as represented by the first decision in Figure 9. Following the QDB method, however, the respondent that votes "yes" to the Pre-Camille option is also asked if he is willing to fund the larger-scale Pre-1900 option at a higher cost. If he responds "no" to this option at the given bid, then, because the Pre-1900 option involves restoring a greater quantity of land than the Pre-Camille option, this study assumes that he would also not be willing to pay this higher bid for the relatively smaller-scale Pre-Camille option. Therefore, the bid asked for the Pre-1900 option can be interpreted as an upper bound on the respondent's WTP for the Pre-Camille option. On the other hand, if the respondent answers "yes" to the Pre-1900 option, it gives no new information because both the size of the project and the elicited bid amount differ between the two questions. Using the same concept, if the respondent answers "no" to a given bid to the Pre-Camille option, it has an upper bound on his WTP. The respondent is also asked if he is willing to pay some lower amount for the relatively smaller-scale Status-Quo option. In this case, this study can assume that if the respondent answers "yes" to this option, he would also be willing to pay this lower amount for the Pre-Camille option because the Pre-Camille option involves restoring a relatively greater quantity of land. Thus, the bid asked for the Status-Quo option can be interpreted as a lower bound on the respondent's WTP for the Pre-Camille option. If the respondent, however, answers "no" to the Status-Quo option, it provides no new information.

Figure 9 only shows bounds for the unbounded model which indicate the model allows WTP range between $-\infty$ and $+\infty$, but this study also tests bounded model which allows WTP range cannot be lower than zero and higher than respondents' income: $-\infty$ is replaced with zero and $+\infty$ replaced with income. Difference between the unbounded and bounded models will be explained in more detail in Chapter VI.

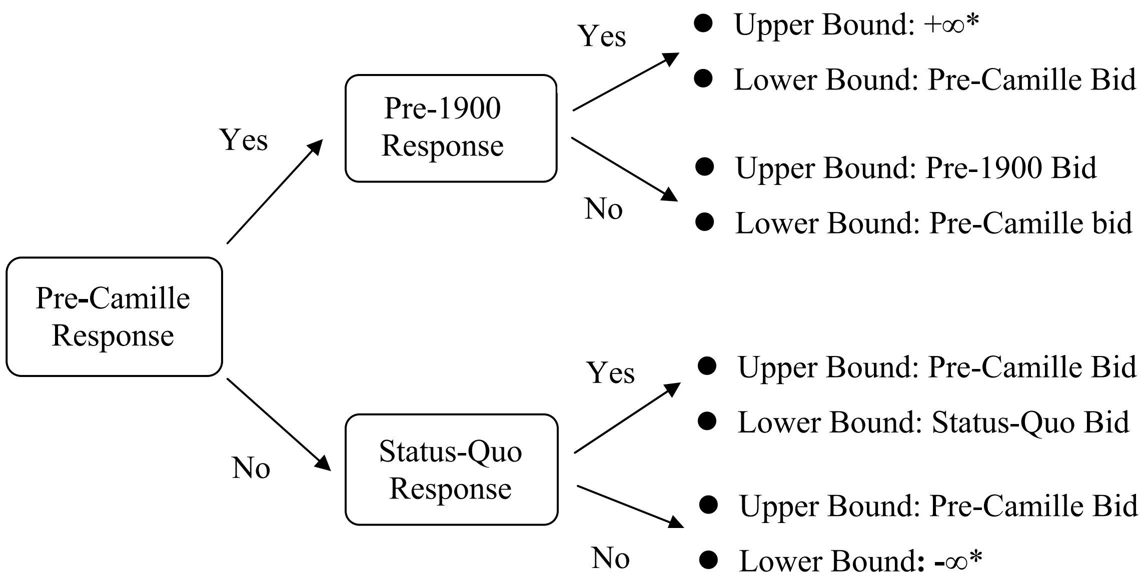

Figure 9

WTP Intervals for Pre-Camille option, based on responses following Quasi Double-Bound Method

*This figure shows bounds for the unbounded model. For the bounded model, +∞ is replaced with income and -∞ replaced with zero.

Market Administration Design and Sample Identification

A mail survey was used to collect data for this study. A survey included 12 pages and 37 questions was mailed to 3,000 Mississippi households on February 27, 2008, with half sent to a random sample of coastal residents (Hancock, Harrison, and Jackson counties) and half sent to a random sample across the remaining 79 non-coastal counties.

Survey Design

Factors hypothesized to affect choice include the following: offered price (bid), income, residency, two government programs, ability of government agency, concerns on characteristics of Mississippi's barrier islands, gender, race, age, income, comfort with survey questions, and survey treatments. These are discussed in detail below.

Offered bid and income

In the model, income and offered bid are included because theoretically income and price affect respondent's choice to the given proposed program. The contingent valuation survey used for this study is associated with hypothetical choice, so there is no budget constraint. Income is included because theory would say that their budget constraint should affect WTP, so the income variable captures the effect of budget constraint. Income is hypothesized that if people have more income, they are more willing to pay. The law of demand creates the need for the offered bid, and the associated hypothesis is that the probability of a "yes" response decreases as the price of the offered bid increases the offered bid.

Opinion on various Government programs

The variables for opinion on various government programs aiming at protection of the Mississippi coast and its residents from hurricanes, and other hazards indicates what people think are the most important issues in terms of improving quality of life in the Mississippi Gulf Coast. These variables influence a respondent's choice because the probability of support to the proposed program is changed based on respondent's consideration on different government programs. The details of the question used are discussed in the next chapter.

Confidence in the ability of government agency

The variable for confidence in government agencies is one of the independent variables because it is hypothesized that an individuals' level of confidence in government agencies' ability to carry out hurricane and storm surge protection affect their willingness to pay for the restoration of the barrier islands. This variable will be discussed in detain in the next chapter. The details of the question used are discussed in the next chapter.

Perceived storm surge mitigation benefit

The variable for perception on a characteristic of Mississippi's barrier islands is used one of the independent variables. It is hypothesized to affect a respondent's decision because if respondents perceive that Mississippi's barrier islands are important characteristic on reducing storm surge, wave energy, and reducing damage from storms and hurricane. The details of the question used are discussed in the next chapter.

Residency

It is hypothesized that if respondents are residents of the Mississippi Gulf Coast, they are more willing to pay restore the Mississippi's barrier islands than if they were non-residents. The variable was obtained by referendum choice question: respondents were asked to choose "yes" if they are resident from three coastal counties (Hancock, Harrison, and Jackson) and "no" otherwise.

Other Demographics

A gender, race, and age are used as demographics variables to estimate WTP for the proposed programs because those variables are hypothesized to affect a respondent's decision.

Comfort level with Survey Questions

The variable for the comfort level with survey questions is used, and it is hypothesized that a respondents' decision will be influenced positively when the respondents are comfortable with answering the questions in the survey. The details of the question used are discussed in the next chapter.

Survey Treatment effects

The sample was split in order to test sample bias by using three treatments. The first treatment is question order. The question order of restoration options were presented in order of ascending quantity (scale): the current condition (Status-Quo), the condition before Hurricane Camille (Pre-Camille), and the condition before 1900 (Pre-1900) to half the sample, and in descending to the other half. Ascending order is treated as the control group, and descending order is treated as the treatment group.

The second treatment was a labeling treatment. Half of the sample was presented restoration options with generic titles, (Option 1, 2, 3), i.e., unlabeled. The other half were labeled with the historical references as Status-Quo, Pre-Camille, and Pre-1900.

The restoration option with unlabeled title is treated as the control group, and the restoration option with the historical reference is treated as the treatment group.

The third treatment was a variant of the "cheap talk" treatment introduced by Cummings and Taylor (1999). Half of the respondents were given the survey with additional text about an issue of uncertainty to the WTP question, and another half of respondents were not given the additional text. Exclusion of additional text is treated as the control group, and inclusion of additional test is treated as the treatment group. The additional text used in the survey was:

"Sometimes, people may be uncomfortable giving a simple "yes" or "no" answer to these types of hypothetical questions. Although we want you to express your opinion, we also want you to be as comfortable as possible with your answers.
Thus, we have included additional questions asking about how sure you are of each answer and the main reasons for your answers and any concerns you may have.
Additionally, you will have another opportunity at the end of the survey to express any remaining concerns, thoughts, or opinions you have about the questions, issues, or the survey itself. We hope that this format will allow you to express your opinion for each restoration option as completely and as comfortably as possible."

These three different treatments will be discussed in detail in the next chapter.

CHAPTER V

SURVEY RESULTS

This chapter provides the survey results with questions asked in detail. A total of five-hundred and ninety four surveys were returned. The overall response rate was 20%. Table 1 describes comparison of the sample and the population demographics. The data used for the population was obtained from the 2005-2009 American Survey Community 5-Year estimates (USCB 2010). Comparing with the population, the sample is more male, whiter, older, more educated, more republic, and wealthier than the population. The sample is 61.26% male whereas the population is 48.50%. While 86.94% of the sample is white, only 60% of the population is white. The sample is 28.15% comprised of persons at least 65 years of age, whereas the population is 12.50% comprised of this demographic. The average number of people per household for the sample is 2.4; this number is 2.6 for the population. The sample is 47.95% comprised of persons with a bachelor's degree or higher level of education; the population is 19.1% comprised of this demographic. Moreover, the median income of the sample is $83,514; the median income of the population is $36,796. In the sample, the percentage of coastal residents in the sample is 62.16% while the percentage of coastal residents in the population (Hancock, Harrison, and Jackson counties of Mississippi) is 12.03%. This population consists of 355,075 individual (there are a total of 2,951,996 Mississippi residents). The sample itself consists of three hundred and seventy-four respondents.

Table 1

Comparison of Sample and Population Demographics Proportions (N=444)

		Sample	Population*
Gender	Male	61.26%	48.50%
Race	White	86.94%	60.00%
Age	65 years and over	28.15%	12.50%
Number of Household** (median)		2.4	2.6
Education**	Some school	2.05%	21.20%
	High school	50.00%	31.20%
	Bachelor's Degree	30.45%	12.40%
	Master's, Professional or Doctoral Degree	17.50%	6.70%
Political party**	Republican	53.20%	N/A
Income (median)		$83,513	$36,796
Residency	Coastal	62.16%	12.03%

*Population data from ACS 05-09 estimates
**Number of observation is 436, 440, and 438 respectively

Kruskal-Wallis equality-of-population rank tests and t-tests were used for treatment bias for the three treatments: question order, different name of restoration option, and inclusion or exclusion of “cheap talk” language. No statistical differences in demographic indicators were found across treatments.

Table 2 shows the frequency and proportion of “yes” and “no” responses to the WTP questions for the three restoration scenarios by offered bid. Overall, 72.25% of respondents answered "yes" and 27.75% answered "no" to the Status-quo option. For the Pre-Camille option, 43.69% answered "yes", and 56.31% of respondents answered "no". Additionally, 29.49% of respondents answered "yes", whereas 70.51% of respondents answered "no" to the Pre-1900 option.

Table 2

WTP for each restoration option with bid

Status Quo Option					
Bid	No	Proportion of No Responses	Yes	Proportion of Yes Responses	Total
$7	18	0.15	69	0.22	87
$13	27	0.22	69	0.22	96
$20	27	0.22	62	0.20	89
$26	20	0.17	56	0.17	76
$33	29	0.24	59	0.19	88
Total	121		315		436
Pre-Camille Option					
Bid	No	Proportion of No	Yes	Proportion of Yes	Total
$77	35	0.14	53	0.27	88
$153	47	0.19	51	0.26	98
$230	59	0.24	33	0.17	92
$306	46	0.18	31	0.16	77
$383	63	0.25	26	0.14	89
Total	250		194		444
Pre-1900 Option					
Bid	No	Proportion of No	Yes	Proportion of Yes	Total
$195	47	0.15	40	0.31	87
$391	63	0.21	31	0.24	94
$586	66	0.22	23	0.18	89
$782	59	0.19	18	0.14	77
$977	71	0.23	16	0.13	87
Total	306		128		434

Table 3 shows the frequency and proportion of "yes" and "no" responses to the Pre-Camille option by bid using the QDB method. For the QDB method, additional WTP responses from the Status-Quo and Pre-Camille option were used to augment WTP information for the Pre-Camille option. Note that under the QDB method, only "yes" responses from the Status-Quo option and "no" responses from the Pre-1900 option are used because the remaining responses provide no new information on WTP for the Pre-Camille option. In general, as bid increases, the proportion of "no" responses increase.

Table 3

WTP responses for the Pre-Camille option by bid using the QDB method

Bid	N	No	Proportion of No	Yes	Proportion of Yes
$7*	21	0	0.00	21	1.00
$13*	29	0	0.00	29	1.00
$20*	33	0	0.00	33	1.00
$26*	29	0	0.00	29	1.00
$33*	37	0	0.00	37	1.00
$77	88	35	0.40	53	0.60
$153	98	47	0.48	51	0.52
$195**	16	16	1.00	0	0.00
$230	92	59	0.64	33	0.36
$306	77	46	0.60	31	0.40
$383	89	63	0.71	26	0.29
$391**	20	20	1.00	0	0.00
$586**	9	9	1.00	0	0.00
$782**	14	14	1.00	0	0.00
$977**	12	12	1.00	0	0.00
Total	664	321	0.48	343	0.52

*Taken from Status-Quo WTP question

**Taken from Pre-1900 WTP question

Table 4 shows the bounds on WTP by bid for the Inter-Censored model between the SB method and DB method. It shows how many observations are assigned to each bid, and how many observations are not included in the interval-censored model. The left-censored and right-censored indicate unknown bounds on WTP to the Pre-Camille option. For the left-censored observation between the SB and QDB methods, 56% observations of left-censored are missing by using the SB method, whereas 23% observation of left-censored are missing by using the QDB method. For the right-censored observation between the SB and QDB methods, 44% observations are missing by using the SB method, but 28% observations are missing by using the QDB. These results indicate that total number of observations used in the interval-censored model by using the QDB method is improved over the SB method.

Table 4

Bounds on WTP for the Interval-Censored Model

Bounds on WTP using SB method				
	Lower Bound		Upper Bound	
Bid	N	Proportion	N	Proportion
Left-Censored (-∞)	250	0.56		
$77	53	0.12	35	0.08
$153	51	0.11	47	0.11
$230	33	0.07	59	0.13
$306	31	0.07	46	0.10
$383	26	0.06	63	0.14
Right-Censored (+∞)			194	0.44
Total	444		444	

Table 4 (continued)

Bounds on WTP using QDB method				
	Lower Bound		Upper Bound	
Bid	N	Proportion	N	Proportion
Left-Censored (-∞)	101	0.23		
$7	21	0.05		
$13	29	0.07		
$20	33	0.07		
$26	29	0.07		
$33	37	0.08		
$77	53	0.12	35	0.08
$153	51	0.11	47	0.11
$195			16	0.04
$230	33	0.07	59	0.13
$306	31	0.07	46	0.10
$383	26	0.06	63	0.14
$391			20	0.05
$586			9	0.02
$782			14	0.03
$977			12	0.03
Right-Censored (+∞)			123	0.28
Total	444		444	

Table 5 shows the response to the following question.

"Suppose you could decide how $100 of tax revenue could be divided among the following programs. How would you allocate it?"

The question asks what the most important issues are in terms of improving quality of life in the Mississippi Gulf Coast. The respondents are asked two different questions concerning government programs. The first questions are general government questions, and options to choose include the number of jobs and economic activity; the quality and affordability of healthcare; protection of the Mississippi coast and its residents from hurricanes and other hazards; improving the education system; and an "other" option.

The second question is coast specific government programs related to hurricanes and other hazards, and options to choose include restoration of coastal wetlands, beaches, and other natural habitat; restoration of barrier islands; improvement of hurricane forecast, warning systems and evacuation procedures; improvement of hurricane-protection structure, like seawalls and levies; and an "other" option. According to the result from the Table 5, the respondents allocated their money almost equivalent to various programs except other choice, and it indicates that the respondents think all the government programs are equally important issue in terms of improving quality of the life in the Mississippi Gulf Coast. However, the second question especially, the improvement of hurricane forecast and evacuation procedure and improvement of hurricane-protection structure were combined due to the similarity. Therefore, the respondents think the primary issue related to improving the quality of life in the Mississippi Gulf Coast is the improvement of hurricane forecasts and protection structures.

Table 5

Most Important issue on different government programs

General Government Programs (N=444)	Mean	Std. Dev.
Increasing the number of jobs and economic activity	$25.27	20.29
Improving the quality, availability, and affordability of healthcare	$22.61	18.68
Protection of the Mississippi coast and its residents from hurricanes and other hazards	$22.38	20.01
Improving the education system	$23.07	18.89
Other	$6.67	17.50

Table 5 (Continued)

Coast-Specific Government Programs (N=444)	Mean	Std. Dev.
Restoration of coastal wetlands, beaches, and other natural habitat	$26.76	16.96
Restoration of barrier islands	$24.98	16.31
Improvement of hurricane forecasts, warning systems, and evacuation procedures	$19.07	17.23
Improvement of hurricane-protection structures, like seawalls and levies	$24.57	17.60
Other	$4.62	16.60

The following question was asked to find out how much confidence respondents have that the government agencies are able to accomplish protection efforts from hurricanes and other hazards.

"How much confidence do you have in the ability of government agencies to carry out hurricane and storm surge protection efforts efficiently and in a timely manner?

Table 6 shows the result from this question. The result indicates that more than half of the respondents do not confidence in the ability of government agencies regarding protection efforts against the hurricanes and other hazards.

Table 6

Confidence in government to carry out hurricane protection efforts

	Frequency	Percent
A lot of confidence	123	27.70%
Some confidence	35	7.88%
No confidence	240	54.05%
Not sure	46	10.36%
Total	444	

The following question elicits how important respondents think Mississippi's Barrier Islands are in reducing the damage from storms and hurricanes. Table 7 shows the result from this question.

"How important do you think Mississippi's barrier islands are in reducing storm surge, wave energy, and/or reducing damage from tropical storms and hurricanes on the Mississippi Gulf Coast?"

According to result from Table 7, 91.22% of respondents think the Mississippi barrier islands are important characteristic for reducing damage from storms, hurricanes, and other hazards.

Table 7

Importance on Characteristic of
Mississippi's Barrier Islands

	Frequency	Percent
Not Important	19	4.28%
No Opinion Either way	20	4.50%
Somewhat Important	116	26.13%
Extremely Important	289	65.09%
Total	444	

Table 8 shows the response to the question below

"Overall, were you comfortable with answering the questions contained in this survey?"

The respondents indicated that 96.40% were comfortable answering the questions contained in the survey.

Table 8

Comfort with Survey Questions

	Frequency	Percent
No	16	3.60%
Yes	428	96.40%
Total	444	

As mentioned in previous chapter, the sample in the survey was split for testing sample bias by using three different treatments: question order, labeling, and cheap talk. To test and include these treatments in model, this thesis creates dummy variables for each treatment. The question order treatment is 1 if respondents were given restoration option by descending order such as Pre-1900 option, Pre-Camille option, and Status-Quo option and 0 otherwise. For the labeling treatment, it takes value of 1 if respondents were given restoration options with historical reference such as Pre-1900, Pre-Camille, and Status-Quo and 0 otherwise. The cheap talk treatment is 1 if respondents were given additional cheap talk language and 0 otherwise. Table 9 shows the frequency and proportion of each treatment. For the question order, 45% of respondents were given the restoration questions by descending order, whereas 55% were given by accenting order. For the labeling, 52% of respondents were given the restoration options with the historical reference, and 48% were not given the restoration option with the historical reference. 52% of respondents were provided cheap talk language, whereas 48% of respondents were not provided.

Table 9

Proportion of each survey treatment

	Question order		Labeling		Cheap talk	
	Frequency	Proportion	Frequency	Proportion	Frequency	Proportion
0	242	0.55	214	0.48	211	0.48
1	202	0.45	230	0.52	233	0.52
Total	444		444		444	

CHAPTER VI

ECONOMETRIC MODELS

To facilitate comparison, four models of WTP each are estimated using SB and QDB data. This section explains the four model specification: linear (unbounded) probit, bounded probit, unbounded interval-censored, and bounded interval-censored.

This study uses two main approaches to incorporate responses from the Status-Quo and Pre-1900 options as additional information for the Pre-Camille option. The first approach is that this study treats responses as additional independent observations. In this case, the total number of observations increased from 444 to 664. This approach relies on a probit model for comparing WTP under the SB and QDB methods, and this approach results in a binary choice model where the dependent variable is 1 or 0 (yes or no). The second approach is that this study incorporates new information directly into existing observations by updating bounds on WTP. In this case, the total number of observations remains at 444. This approach relies on an interval-censored model, and this approach results. For the interval-censored model, the dependent variable is dollar lower and upper bounds on WTP.

Most models of WTP assume an unbounded WTP range between $-\infty$ and $+\infty$. Haab and McConnell (1998) note that the referendum can sometimes yield either negative or unreasonably large WTP estimates because the admissible range is set arbitrarily between minus infinity and plus infinity. Also, they note that many studies, in an effort to address this apply post-estimation bounds on WTP, which leads to inconsistency between the estimation (unbounded) and calculation of willingness to pay (bounded). To address this issue, they argue that reasonable bounds be placed on the admissible range of WTP: a lower bound on WTP of zero (non-negativity), and an upper bound on WTP of respondent income. Given that there is no consensus on this, this study estimates models under both assumptions: WTP range can be unbounded or bounded.

Table 10 shows the eight different model specifications. The difference between the models by using the SB and the QDB methods is that the latter (potentially) incorporate responses to either the Status-Quo or Pre-1900 restoration options. This thesis estimated models both in which WTP was restricted to be between zero and the respondent's income and models in which WTP was unbounded. Within the SB models, there are two different ways to bound WTP between zero and income. The first is to manually impose the bounds of zero and income, in which the dependent variable specified is the narrowed range of WTP (i.e. for "yes" responses, WTP ranges between the offered bid and income, and for "no" responses, WTP ranges between 0 and the offered bid). The second way is by modeling WTP as a proportion of income, which will be discussed in detail in next section. Within the QDB models, there are two ways to incorporate the responses to the Status-Quo or Pre-Camille options. The first is to treat those responses as independent observations on WTP for the pre-Camille option (e.g. if a person votes "no" to the Pre-1900 option, he is also not willing to pay that much for the

Pre-Camille option, and similarly for “yes” responses to the Status-Quo option). The second way is to recognize that these “follow up” questions come from the same respondent, and to therefore directly update the bounds on the respondent’s willingness to pay for the Pre-Camille option. The bounding of WTP further between zero and income results in the bounded QDB models.

Table 10

Econometric Models Estimated

Model	Data Type	Model Type	QDB Data Interpretation	Admissible WTP Range
1	SB	Binary Probit	N/A	Unbounded $(-\infty,+\infty)$
2	QDB	Binary Probit	Treated as additional independent observations	Unbounded $(-\infty,+\infty)$
3	SB	Interval-Censored	N/A	Unbounded $(-\infty,+\infty)$
4	QDB	Interval-Censored	WTP information incorporated directly into existing observations	Unbounded $(-\infty,+\infty)$
5	SB	Binary Probit	N/A	Bounded (0, Income)
6	QDB	Binary Probit	Treated as additional independent observations	Bounded (0, Income)
7	SB	Interval-Censored	N/A	Bounded (0, Income)
8	QDB	Interval-Censored	WTP information incorporated directly into existing observations	Bounded (0, Income)

Following discussion of each econometric model used in this thesis discusses how WTP can be unbounded and bounded in the probit and interval censored models in detail. Finally, this chapter also describes what variables are used in each different model.

Random Willingness to Pay (RWTP) Model

Following Cameron and James (1987), random willingness to pay model assumes that the respondent's true WTP is unobserved continuous variable. In discrete model, each individual is offered bid, t_i, and by his response his true WTP is either greater than or less than t_i. Then, we assume that

$$Y_i = x_i^{'}\beta + \varepsilon_i$$

where Y_i is unobserved continuous valuation (WTP), x_i is a vector of explanatory variables, and it has some known distribution with a mean of $x_i^{'}\beta$. ε_i is error term. By employing the offered bid as

$$I_i = 1 \text{ if } Y_i > t_i$$

$$= 0 \text{ if } Y_i < t_i$$

where I_i is discrete indicator variable. So probability of "yes" can be written as

$$\Pr(I_i = 1) = \Pr(Y_i > t_i) = \Pr(\varepsilon_i > t_i - x_i^{'}\beta)$$

$$= \Pr\left[\frac{\varepsilon_i}{\sigma} > \frac{(t_i - x_i^{'}\beta)}{\sigma}\right] = 1 - \Phi\left[\frac{(t_i - x_i^{'}\beta)}{\sigma}\right]$$

where Φ is the standard normal cumulative density function, and σ is standard deviation, and assume that the error term is normally distributed. The log-likelihood function becomes

$$\log L = \sum_{i=1}^{N} \left\{ I_i \log\left[1 - \Phi\left(\frac{t_i - x_i^{'}\beta}{\sigma}\right)\right] + (1 - I_i)\log\left[\Phi\left(\frac{t_i - x_i^{'}\beta}{\sigma}\right)\right]\right\}$$

The presence of t_i allows σ to be specified, which is possible to separate β in order to determine the underlying valuation function. This econometric model is used for the unbounded probit model.

RWTP for Bounded Probit Model

The rationale behind the bounded model comes from Haab and McConnell (1998) who argue for reasonable bounds on the distribution of WTP. They argue that WTP should be bounded from below by zero and from above by respondent income. For the bounded probit model, income and bid information are pooled into a single, joint income-bid variable. Bounded willingness to pay is specified as

$$WTP_i = G(\mathbf{x}_i\boldsymbol{\gamma} + \varepsilon_i) \cdot y_i$$

where $0 \le G(\mathbf{x}_i\boldsymbol{\gamma} + \varepsilon_i) \le 1$ and $G^{'}(\mathbf{x}_i\boldsymbol{\gamma} + \varepsilon_i) \ge 0$. The function $G(\mathbf{x}_i\boldsymbol{\gamma} + \varepsilon_i)$ is willingness to pay as a proportion of income. The specification adopted here is written as

$$WTP_i = \frac{y_i}{1 + \exp(-\boldsymbol{\gamma} - \varepsilon_i)}$$

Note that this specification is necessarily bounded between 0 and income if the error is specified as normal, and the probability of yes is:

$$\Pr(yes) = 1 - F_{WTP}(t) = \Phi\left(\frac{\mathbf{x}_i\boldsymbol{\gamma} + \ln\left(\frac{y_i - t}{t}\right)}{\sigma}\right)$$

It can be seen that numerator on the right is a linear function of $\mathbf{x}_i$ and $\ln\left(\frac{y_i - t}{t}\right)$, so a contribution to the likelihood function for the random willingness to pay model is:

$$\Pr(yes) = 1 - F_{WTP}(t) = \frac{1}{1 + \exp[(-\mathbf{x}_i\boldsymbol{\gamma} - \ln\left(\frac{y_i - t}{t}\right)) / \sigma]}$$

The joint bid-income variable is specified as $\ln\left(\frac{y_i - t}{t}\right)$ for this model.

<u>Interval-Censored Model</u>

The interval censored model is another approach to model WTP, and it was initially implemented by Hanemann *et al*. (1991). The following discussion is based on Stata Manual (2009). If the value of WTP for the i^{th} respondent is observed to be somewhere in the interval $\left[y_{1i}, y_{2i}\right]$, then the respondent's likelihood contribution can be represented as $\Pr(y_{1i} \leq Y_i \leq y_{2i})$. For censored data, respondents' likelihoods include a term of the form $\Pr(Y_i \leq y_i)$ for left-censored data and $\Pr(Y_i \geq y_i)$ for right-censored data, where y_i is the observed censoring value and Y_i indicates the random variable as the dependent variable in the model. In this case, if an observation is left-censored, it will be represented by -∞ as the lower endpoint, and right-censored will be represented by +∞ for the upper endpoint.

The likelihood function for interval regression begins with $Y_i = x_i^{'}\beta + \varepsilon_i$, where Y represents observed or unobserved continuous outcome. This model assumes that error term is normally distributed with mean zero. Observations $i \in L$ represent a left-censored, and unobserved t_i is less than or equal to t_{Li}. Observations $i \in R$ represent a right-censored, and the unobserved t_i is greater than or equal to t_{Ri}. Observations $i \in I$ represent intervals, and the unobserved t_i is in interval $[t_{1i}, t_{2i}]$, then the log likelihood is

$$\log L = \sum_{i \in L} \log \Phi\left(\frac{t_{Li} - \mathbf{X\beta}}{\sigma}\right) + \sum_{i \in R} \log\left\{1 - \Phi\left(\frac{t_{Ri} - \mathbf{X\beta}}{\sigma}\right)\right\}$$

$$+ \sum_{i \in I} \log\left\{\Phi\left(\frac{t_{2i} - \mathbf{X\beta}}{\sigma}\right) - \Phi\left(\frac{t_i - \mathbf{X\beta}}{\sigma}\right)\right\}$$

Where Φ () is the standard cumulative normal.

Application of this method includes that Carson *et al*. (1994) estimate the value for the preservation of Australia's Kakadu conservation zone. They use the double-bounded discrete-choice CV survey to obtain information. The authors define an interval estimate of the WTP by ask questions with two discrete choices, and they analyze the data using survival analysis techniques because of interval-censored data. Then, they estimate the mean WTP using the Turnbull nonparametric approach and parametric approach under Weibull distribution.

<u>Bounded Interval-Censored Model</u>

In the bounded interval-censored model, this study manually constructed an alternative set of bounds such that for left-censored observations, the original lower bound of $-\infty$, is replaced with zero, and for right censored observations, the original upper bound of $+\infty$, is replaced with respondent income. This effectively converted all left-and right-censored observations to interval-censored observations.

Specification of Dependent Variables and Bids

In the previous sections, the unbounded probit model, bounded probit model, unbounded interval censored model, and bounded interval censored model were described as main econometric models used in this thesis for estimating and analyzing data and comparing the SB to the QDB methods. This section discusses how dependent variables and bid are specified in each model.

For the unbounded probit model following the SB method, the dependent variable is respondent response to the referendum question for the Pre-Camille option, where a value of "1" indicates a "yes" vote for the restoration of Mississippi barrier islands, and a value of "0 indicates a "no" vote. The offered bid for the Pre-Camille option and respondent income enters the model as an independent variable (also with other covariates discussed later). For the bounded probit model, the dependent variable is the same as above, an income and bid are, however, merged into a joint variable as described above and enter as a single independent variable.

For the unbounded probit model following the QDB method, the respondents' WTP for the Pre-Camille option was estimated using additional data from other two related Status-Quo and Pre-1900 options. Observations on the dependent variable include responses to the Pre-Camille referendum question as above that the value of "1" indicates a “yes” vote to the Pre-Camille option, and the value of “0” indicates “no” vote. Observations also include “yes” response to the Status-Quo referendum question who responded “no” to the Pre-Camille option, and those “no” response to the Pre-1900 referendum question who responded “yes” to the Pre-Camille option. For the bid used for QDB method in the unbounded probit model, the bid is continuous variable that offered bid for the Pre-Camille option with additional bids offered to other two related options. For the bounded probit model, the dependent variable is same as above, and a joint income variable is used instead of bid and income.

For the interval-censored model using SB method, two dependent variables are specified: the lower and upper bounds that represent either strict bounds for interval-censored observation in the bounded interval-censored mode by restricting the lower bound as zero and upper bound as respondents’ income, or censoring points for left-and right-censored observation without any restrictions on bounds in the unbounded interval-censored model.

For the interval-censored model using QDB method, the dependent variables are also same as SB method. In the unbounded interval censored model for the QDB, amounts of the lower bound ranges from negative infinity to amounts given for the Pre-Camille option if respondents answer “no” to the Pre-Camille option and “no” to the Status-Quo option, whereas the amounts of the lower bound ranges from Status-Quo option to the Pre-Camille option for “no” responses to the Pre-Camille option and “yes” responses to the Status-Quo option. Similarly, the amounts of the upper bound range from amounts given by the Pre-Camille option to positive infinity if respondents answer “yes” to the Pre-Camille option and “yes” to the Pre-1900 option. Otherwise, amounts of the upper bound ranges between the Pre-Camille option and the Pre-1900 option if the respondents answer “yes” for both options. In the bound interval censored model, the amounts of lower bound when respondents answer “no” to the Pre-Camille option and the Status-Quo option ranges from zero instead of negative infinity to amounts given for the Pre-Camille option. In addition, the amounts of the upper bound for “yes” responses to the Pre-Camille and Pre-1900 options ranges from amounts given by the Pre-Camille option to real income.

Table 11 shows descriptions of dependent variables and bids used in the four different econometrics models, and it also provides how each variable is named in the four different models. For the unbounded interval-censored model, reported number of censored indicates how many observations are $-\infty$ or $+\infty$; in other words, it means omitted observations for which the lower bound is $-\infty$ and $+\infty$ for the upper bounds.

Table 11

Variables and Descriptions of Dependent and Bid Variables for Four Models Estimated

Variables	Type	Description	Mean	Std. Dev	Min	Max	# Obs
		Unbounded Probit Model					
Vote (SB)	Binary	=1 if Yes, =0 if No	0.44	0.50	0	1	444
Vote (QDB)	Binary	=1 if Yes, =0 if No	0.52	0.50	0	1	664
Bid (SB)	Continuous	Offered bid	226.53	107.97	77	383	444
Bid (QDB)	Continuous	Offered bid	214.80	190.91	7	977	664
		Bounded Probit Model					
Vote (SB)	Binary	=1 if Yes, =0 if No	0.44	0.50	0	1	444
Vote (QDB)	Binary	=1 if Yes, =0 if No	0.52	0.50	0	1	664
Income-Bid Term (SB)	Continuous	$\ln\left(\frac{y_i - t}{t}\right)$	5.63	1.04	3.22	8.09	444
Income-Bid Term (QDB)	Continuous	$\ln\left(\frac{y_i - t}{t}\right)$	6.05	1.40	2.78	10.48	664

Table 11 (Continued)

Variables	Type	Description	Mean	Std. Dev	Min	Max	# Censored Obs
		Unbounded Interval Censored Model					
LB (SB)	Continuous	Lower bound on WTP	$200.61	105.86	77	383	250*
LB (QDB)	Continuous	Lower bound on WTP	$122.67	119.55	7	383	101*
UB (SB)	Continuous	Upper bound on WTP	$246.64	105.46	77	383	194*
UB (QDB)	Continuous	Upper bound on WTP	$313.23	203.53	77	977	123*
		Bounded Interval Censored Model					
LB (SB)	Continuous	Lower bound on WTP (bounded at zero)	$87.65	121.68	0	383	250**
LB (QDB)	Continuous	Lower bound on WTP (bounded at zero)	$94.77	116.98	0	383	101**
UB (SB)	Continuous	Upper bound on WTP (bounded at income)	$41,084.82	71101.66	77	250,000	194**
UB (QDB)	Continuous	Upper bound on WTP (bounded at income)	$25,789.52	59831.23	77	250,000	123**

*These means omitted observations for which the lower bound is -∞ and +∞ for upper bound
**These means replaced observations for which the lower bound at 0 and upper bound at income

Specification of Independent Variables

This section discusses what other variables are included in the four models, as mentioned in Chapter IV. The variables are presented in Table 12 with expected signs that provide how each independent variable affects to the dependent variable.

The gender, race, age, residency, and incomes are used as demographic variables in four different models except the bound linear probit model because income and bid are bounded by using log linear income variable. For demographic variables except income, the expected sign can be a positive or negative because it is unknown. However, expected sign of the income variable is positive due to the fact that if people have higher income, their probability of "yes" response for the restoration is also higher than people who have lower income; in other words, if people have more income, there are more willing to pay for the program.

The protection and improvement were used as one of key factors in the models, and expected sign for those variables are positive because if respondents think protection of the Mississippi coast from hurricanes and other hazards, they are more willing to vote for the restoration. In addition, if they want to improve hurricane protection structures, they would be more willing to pay for the restoration.

Government variable was used to measure how WTP will be influenced by if respondents have confidence in the ability of government agencies to carry out hurricane protection efforts in timely manner. The expected sign of the government variable is negative because if respondents have no confidence on government, they would not be willing to pay for proposed program.

Reducing damage is another factor because it is important to determine respondent's decision if they think reducing damage is important characteristic of Mississippi's barrier islands. If the respondents think Mississippi's barrier islands are important on reduction damages, they are more willing to pay for the restoration. Thus, expected sign is positive. Comfort variable is included in model if the respondents are comfortable with all questions contained in survey, they would more willing to pay to the proposed program, so relationship between the comfort variable and WTP is expected as positive.

Three survey treatments are used in the model in order to determine the respondent's decision based on three survey treatments. First one is question order if survey was sent payment question using smallest amount option to largest amount option or largest amount option to smallest amount option. The label is another variable that if each payment option named with historical reference or not. Final treatment is called cheaptalk that if survey version was sent by including uncertainty question otherwise not.

Table 12

Variables and Descriptions of Independent Variables for Four Models Estimated (N=444)

Variables	Type	Description	Mean	Std.Dev	Min	Max	Exp.Sign
Residency	Binary	1 if resident of the Mississippi Gulf Coast; 0 if otherwise	0.62, 0.62*	0.49, 0.49*	0	1	+
Protection	Continuous	Dollar allocation for Protection of the Mississippi coast from hurricanes and other hazards	$22.38, $22.70*	20.02, 19.67*	0	100	+
Improvement	Continuous	Dollar allocation for Improvement of hurricane protection structures	$43.64, $44.14*	25.68, 25.61*	0	100	-
Government	Binary	1 if No confidence; 0 otherwise	0.54, 0.56*	0.50, 0.50*	0	1	-
Reducing Damage	Ordered Categorical	4 if importance of MS Barrier Islands to reduce damages from storms and hurricanes is extremely important; 3 if somewhat important; 2 if no opinion; 1 if not important	3.52, 3.55*	0.77, 0.72*	1	4	+
Male	Binary	1 if male; 0 if female	0.61, 0.60*	0.49, 0.49*	0	1	+/-
White	Binary	1 if white; 0 if otherwise	0.87, 0.87*	0.34, 0.34*	0	1	+/-
Age	Binary	Continuous between 18 - 94	56.45, 56.13*	14.19, 13.77*	18	90	+/-
Income	Ordered Categorical	1 if < $20K; 2 if $20K -$40K; 3 if $40K-$60K; 4 if $60K-$80K; 5 if $80K-$100K; 6 if $100K or more	3.45, 3.43*	1.64, 1.63*	1	6	+

Table 12 (Continued)

Variables	Type	Description	Mean	Std.Dev	Min	Max	Exp.Sign
Comfort	Binary	1 if comfortable with survey questions;0 otherwise	0.96, 0.97*	0.19, 0.18*	0	1	+
Cheaptalk	Binary	1 if survey version include uncertainty question; 0 otherwise	0.52, 0.51*	0.50, 0.50*	0	1	+/-
Question Order	Binary	1 if order of restoration question is descending; 0 otherwise	0.45, 0.44*	0.50, 0.50*	0	1	+/-
Label	Binary	1 if survey version came with historical reference; 0 otherwise	0.52, 0.52*	0.50, 0.50*	0	1	+/-

*Number of observation is 644

CHAPTER VII

DISCUSSION OF RESULTS

This section discusses results from the four models presented in the previous chapter. The results from each model provide a comparison between the single-bounded and quasi-double bounded methods. This chapter also presents willingness to pay estimates from each econometric model, as well as Turnbull non-parametric WTP estimates.

Econometric Results

Table 13 shows the estimated parameter coefficients, significance levels, standard deviations, and marginal effects for the unbounded probit model under the SB and QDB methods. Table 13 also provides how well the models are measured. Using value of LR chi2(14) with p-value indicate unbounded probit models using the SB and QDB method found as statistically significant as a whole; in other word, the models statistically better fit than models with no independent variables. Variables significant in both the SB and the QDB include offered bid, protection, improvement, reducing damage, white, income, and question order. The question order variable is not significant using the QDB method only. All signs of estimated parameters are as hypothesized in Table 12.

For the unbounded probit model following the SB method, the estimated coefficients from the probit model give no economic meaning, so the variables are explained using estimated marginal effects presented in Table 13. For binary variable used as dependent variable in the unbounded probit model, the marginal effect (dy/dx) represents the discrete change from the base level; in other words, one unit changes in independent variable affect probability of yes. Bid was significant at 1% level, and it indicates that if the offered bid for the Pre-Camille option increases by $10, the probability of yes decreases by 1percent. The protection variable was found significant at the 1% level, and indicates if respondent allocates their money by 1$ for protecting the Mississippi coast from the hurricanes relative to other pressing issues such as job, healthcare, and education, then the probability of yes increases by 0.3 percent. The improvement variable was also found significant, and it indicates that if respondents allocate their money by $1 in that improvement of hurricane protection, forecast, and evacuation procedures is more important than restoration of coastal wetlands, barrier-island, and other natural habitats, then respondents were 0.2 percent less likely answer "yes" to the Pre-Camille option. For the reducing variable, the probability of yes response increases by 16.6 percent if the respondents think the Mississippi Barrier Islands are important for reducing storm surge, wave energy from storms. If respondents were white, the probability of yes increases by 19.9 percent.

Table 13

Estimated Coefficients, Significance levels, Standard Errors, and Marginal Effects between SB and QDB for the Unbounded Probit Model

	SB			QDB		
Variables	Coef.	Std. Err.	Marginal Effect	Coef.	Std. Err.	Marginal Effect
Bid	-0.003 ***	0.001	-0.001	-0.007 ***	0.001	-0.002
Income	0.169 ***	0.045	0.052	0.156 ***	0.040	0.040
Residency	0.209	0.144	0.065	0.045	0.125	0.012
Protection	0.010 ***	0.004	0.003	0.009 ***	0.003	0.002
Improvement	-0.007 **	0.003	-0.002	-0.005 **	0.003	-0.001
Government	-0.072	0.139	-0.022	-0.150	0.123	-0.039
Reducing Damage	0.538 ***	0.110	0.166	0.476 ***	0.092	0.124
Male	-0.099	0.142	-0.030	-0.114	0.125	-0.029
White	0.661 ***	0.239	0.199	0.362 *	0.191	0.096
Age	-0.004	0.005	-0.001	-0.001	0.005	0.000
Comfort	0.679	0.471	0.196	0.506	0.332	0.133
Cheaptalk	0.195	0.135	0.060	0.124	0.118	0.032
Question Order	0.384 ***	0.135	0.120	0.107	0.123	0.028
Label	-0.042	0.134	-0.013	-0.068	0.118	-0.018
Constant	-3.237	0.797		-1.481	0.615	
Observations		444			664	
Log Likelihood		-240.531			-305.412	
LR chi2(14)		127.370			308.950	
Prob > chi2		0.000			0.000	
Pseudo R2		0.209			0.336	

***,**,* Significant at p = 0.01,0.05, and 0.10 respectively

A one-category increases in income by $20,000 increase probability of yes by 4.5 percent. It is due to the fact that the income was measured in category unit between 1 and 6, thus one unit change represents a change in income of $20,000. Respondents were given restoration scenarios in descending order, their probability of yes increases by 12.0

percent; in other words, if Pre-1900 option is preceded by Pre-Camille option, respondent are more likely answer yes by 12.0 percent.

The question order was found as not significant in QDB, but it was significant in SB. Respondents were 2 percent less likely answer yes to the Pre-Camille option if the offered bid increases by $1. For the protection variable, the probability of yes response to the Pre-Camille options increases by 0.2 percent when the respondents think their prior concern was protection Mississippi coast from the hurricanes rather than jobs, healthcare, and education. Respondents were 0.1 percent less likely answer yes to the Pre-Camille options if they were interested in improvement of hurricane protection and forecast or evacuation procedure. The probability of yes responses to the Pre-Camille option increases by 12.4 percent when they think the characteristic of MS barrier islands is important for reducing storm surge from storms. White respondents were 9.6 percent more likely to answer yes than non-white respondents. The probability of yes to the Pre-Camille options increases by 4 percent if income increases by 1 unit.

Table 14 shows the estimated parameter coefficients, significance levels, standard deviations, and marginal effects for the bounded probit model. It also shows how well the models are measured. In this model, the bid and income variables were replaced with a joint income-bid variable, referred to as the income bound in Table 14. In the SB, the probability of yes response was significantly influenced by protection, improvement, reducing damage, white, income bound, and question order variables. By comparison, the variable male was found significant, and variables of improvement and white were found not significant in the QDB.

Table 14

Estimated Coefficients, Significance levels, Standard Errors, and Marginal Effects between SB and QDB for the Bounded Probit Model

	SB			QDB		
Variables	Coef.	Std. Err.	Marginal Effect	Coef.	Std. Err.	Marginal Effect
Income Bound	0.380 ***	0.073	0.118	0.751 ***	0.057	0.201
Residency	0.231	0.143	0.072	0.121	0.123	0.033
Protection	0.010 ***	0.004	0.003	0.009 ***	0.003	0.002
Improvement	-0.007 **	0.003	-0.002	-0.003	0.002	-0.001
Government	-0.060	0.138	-0.019	-0.086	0.121	-0.023
Reducing Damage	0.563 ***	0.110	0.174	0.543 ***	0.093	0.145
Male	-0.119	0.141	-0.037	-0.226 *	0.122	-0.060
White	0.619 ***	0.238	0.188	0.135	0.189	0.036
Age	-0.005	0.005	-0.002	0.000	0.004	0.000
Comfort	0.650	0.488	0.189	0.506	0.374	0.134
Cheaptalk	0.201	0.135	0.062	0.190	0.117	0.051
Question Order	0.409 ***	0.135	0.128	0.322 ***	0.123	0.086
Label	-0.016	0.133	-0.005	-0.015	0.116	-0.004
Constant	-5.490	0.934		-7.186	0.774	
Observations		444			664	
Log Likelihood		-242.214			-316.099	
LR chi2(14)		124.000			287.570	
Prob > chi2		0.000			0.000	
Pseudo R2		0.204			0.313	

***,**,* Significant at p = 0.01,0.05, and 0.10 respectively

Using the LR chis(14) with p-value, these models also founds as statistically significant as a whole. All coefficient signs were also same as expected signs were hypothesized in Table 12. For the bounded probit model, the variables of improvement, male, and white were different across two different methods of SB and DQB. The improvement variable was significant at 5% level, and the white variable was significant at 1% level in SB method. The improvement variable under the SB method indicates that the probability of a yes response to the Pre-Camille option decreases by 0.2 percent if the respondents wanted more to improve hurricane protection than they wanted to restore other natural habitats. In addition, the white respondents were 18.8 percent more likely to answer yes to restore the Pre-Camille option. The male variable, however, was significant at 10% level in QDB, and it indicates that the respondents were 6 percent less likely answer "yes" to the Pre-Camille if they were male.

Table 15 provides estimated parameter coefficients (marginal WTP), significance levels, and standard deviations for the unbounded interval-censored model. In the interval-censored model, estimated coefficients represent the marginal WTP because the dependent variables used in the interval-censored model are in dollar units.

Based on the results in Table 14, all coefficient signs in both SB and QDB methods show same as expected signs in Table 12. In the unbounded interval-censored model, this study found that the variables of residency, government, male, age, label, and cheaptalk had no impacts on WTP across two methods. The variables of protection, improvement, reducing damage, white, and income significantly impacted on WTP for the Pre-Camille option in both SB and QDB methods. Only question order variable was found as significant in the SB method, and only comfort variable was significant in the QDB method. Under the SB method, the question order variable represented that if respondents were given payment questions ordered by descending in the survey, their WTP was $127.34 more than the respondents who received the payment questions ordered by ascending in the survey.

Table 15

Estimated Coefficients (Marginal WTP), Significance levels, and Standard Errors between SB and QDB for the Unbounded Interval-Censored Model

	SB			QDB		
Variables	Coef. (Marginal WTP)		Std. Err.	Coef. (Marginal WTP)		Std. Err.
Income	$56.242	***	17.540	$22.599	***	4.973
Residency	$69.399		51.505	$6.670		16.168
Protection	$3.446	***	1.317	$1.321	***	0.398
Improvement	-$2.325	**	1.097	-$0.716	**	0.327
Government	-$23.833		45.902	-$23.989		15.706
Reducing Damage	$178.662	***	50.352	$64.644	***	11.916
Male	-$32.907		47.159	-$17.936		15.986
White	$219.424	**	94.031	$49.305	**	25.116
Age	-$1.406		1.756	-$0.013		0.583
Comfort	$225.346		162.024	$73.279	*	43.487
Cheaptalk	$64.741		46.406	$17.770		15.126
Question Order	$127.338	**	54.381	$20.531		15.252
Label	-$13.831		44.477	-$9.363		15.166
Constant	-$1,074.203		359.914	-$205.890		80.085
Sigma	331.888		71.216	122.414		6.799
Observations			444			444
Log Likelihood			-240.531			-328.555
LR chi2(13)			107.190			103.350
Prob > chi2			0.000			0.000

***,**,* Significant at p = 0.01,0.05, and 0.10 respectively

Under the QDB method, the comfort variable can be explained that if respondents were comfortable with given survey questions, their WTP was $73.28 more than respondents who were uncomfortable with the survey questions.

For the protection variable, if respondent indicated a relatively higher priority for protecting the Mississippi coast from the hurricanes relative to other pressing issues such as jobs, healthcare, and education, then they were WTP $3.45 more in the SB method and $1.32 more willing to pay in the QDB method. The respondents stated that if they think improvement of hurricane protection and forecast or evacuation procedure is more interesting than restoration of coastal wetlands, barrier-island, and other natural habitats, then they were $2.33 less willing to pay in the SB method and also $0.72 less willing to pay in the QDB method. The respondents contribute average WTP $178.66 in the SB method and $64.64 in the QDB method if they think the MS barrier islands are important for reducing storm surge, wave energy from storms. White respondents are $219.42 more willing to pay than non-white respondents in the SB method and $49.30 more in the QDB method. For income variable, a one-unit increase in income category adds $56.24 to WTP in the SB method, and $22.60 adds in the QDB method.

Table 16 provides estimated parameter coefficients (marginal WTP), significance levels, and standard deviations for the bounded interval-censored model as well as model fits. Using the LR chi2(13) with p-value, these models found as statistically significant than the model with no variables. All the signs of estimated coefficients between the SB and QDB method show same expected signs presented in Table 12.

For the bounded interval-censored model following the SB method, this study found that WTP to the Pre-Camille option was significantly influenced by the variable of protection, improvement, reducing damage, white, and income. The marginal WTP of those variable can be explained same as above.

Table 16

Estimated Coefficients (Marginal WTP), Significance levels, and Standard Errors between SB and QDB for the Bounded Interval-Censored Model

	SB		QDB	
Variables	Coef. (Marginal WTP)	Std. Err.	Coef. (Marginal WTP)	Std. Err.
Income	$22.089 ***	4.791	$20.641 ***	4.356
Residency	$11.138	15.261	$5.901	14.045
Protection	$1.323 ***	0.386	$1.129 ***	0.349
Improvement	-$0.600 **	0.299	-$0.543 **	0.277
Government	-$23.632	14.930	-$29.233 **	13.729
Reducing Damage	$45.134 ***	9.533	$43.379 ***	8.854
Male	-$11.490	15.346	-$13.155	14.048
White	$37.487 *	22.403	$32.679	20.817
Age	$0.307	0.545	$0.324	0.501
Comfort	$47.652	35.686	$46.425	33.562
Cheaptalk	$16.095	14.401	$13.827	13.168
Question Order	$22.155	14.617	$15.457	13.315
Label	-$3.965	14.488	-$6.674	13.249
Constant	-$117.019	69.335	-$94.505	63.973
Sigma	117.203	6.087	110.340	5.349
Observations		444		444
Log Likelihood		-324.891		-350.909
LR chi2(13)		88.370		88.720
Prob > chi2		0.000		0.000

***,**,* Significant at p = 0.01,0.05, and 0.10 respectively

For the bounded interval-censored model using the QDB method, the variables of protection, improvement, government, reducing damage, and income were found as significantly impacts on WTP to the Pre-Camille option. Especially, the government variable, which was not significant in previous models, represents that if the respondents had no confident in the ability of government agencies to carry out hurricane and storm surge protection efforts efficiently and in a timely manner, their WTP was \$29.23 less than the base WTP.

Willingness to Pay Estimates

Median WTP for Parametric Estimates

Median willingness to pay estimates as outlined by Haab and McConnell (2002) for the unbounded probit model is defined as:

$$MD(WTP) = \frac{\boldsymbol{\alpha}\bar{\mathbf{x}}}{\beta}$$

where $\boldsymbol{\alpha}$ is a coefficient of each variable except bid, $\bar{\mathbf{x}}$ is mean of each variable, and β is the estimated bid coefficient. The coefficients presented in Table 13 and means presented in Table 12 are used to calculate the median WTP, which is presented in Table 17.

For the bounded probit model where the joint income-bid variable is defined as $\ln\left(\frac{y_i - t}{t}\right)$, median willingness to pay is defined by Haab and McConnell (2002) as:

$$MD(WTP) = \frac{\bar{y}}{1 + \exp(-\bar{\mathbf{x}}\boldsymbol{\gamma})}$$

where $\bar{y}$ is mean of income, $\bar{\mathbf{x}}$ and $\boldsymbol{\gamma}$ are m-dimensional vector of parameters and covariates with respondent *i*. The coefficients were presented in Table 14, and means were presented in Table 12. The calculated median WTP in the bounded probit model is presented in Table 17.

For the interval-censored model, the estimated coefficients give marginal WTP for each variable. Median WTP in the interval-censored model is defined as:

$$MD(WTP) = \boldsymbol{\alpha}\bar{\mathbf{x}}$$

where $\boldsymbol{\alpha}$ is estimated coefficient parameters of each variable, and $\bar{\mathbf{x}}$ is the vector of means. Table 17 shows the results of median WTP from the unbounded and bounded interval-censored models using the coefficients presented in Table 15 and 16 , and the means presented in Table 12.

Krinsky-Robb Confidence Intervals

The Krinsky and Robb (1986) procedure was used to construct confidence intervals on median WTP for each model. The Krinsky and Robb procedure is a method to simulate the distribution of the WTP function (Haab and McConnell, 2002). The first step is to produce $\hat{\mathbf{V}}(\hat{\boldsymbol{\beta}})$ which is the *K* x *K* estimated variance-covariance matrix for the estimated parameter vector $\hat{\boldsymbol{\beta}}$ of column dimension *K*. Second step is to calculate the Cholesky decomposition matrix C. The Cholesky matrix is the *K* x *K* lower diagonal matrix square roof of $\hat{\mathbf{V}}(\hat{\boldsymbol{\beta}})$, so CC' = $\hat{\mathbf{V}}(\hat{\boldsymbol{\beta}})$. Next step is, then, to draw a *K*-dimensional vector of independent standard normal random variables. A new parameter vector, $\boldsymbol{\beta}_d$ is then calculated as $\boldsymbol{\beta}_d = \hat{\boldsymbol{\beta}} + C'x_K$. To produce the simulation of the full distribution of the parameter vector $\hat{\boldsymbol{\beta}}$, it is repeated *N* times, and the produced parameter vector $\hat{\boldsymbol{\beta}}$ is distributed $N(\hat{\boldsymbol{\beta}}, \hat{\mathbf{V}}(\hat{\boldsymbol{\beta}}))$ under ideal asymptotic conditions. Then, the WTP estimate is calculated in *N* times. In this thesis, this study sets *N* = 10,000, and the Krinsky-Robb procedure was repeated for all four models. Simulated WTP estimates were sorted by descending order, and the 95% confidence interval for the median WTP is found between 2500 and 7500 observations from sorted WTP. Table 17 shows the median WTP with 95% confidence intervals for each model under the SB and QDB methods.

For the unbounded probit model, the median WTP from the SB method is $143.65 with a 95% confidence interval between $127.40 and $165.03 whereas the median WTP under the QDB method is $205.33 with 95% confidence intervals between $199.27 and $ 211.27 in the unbounded probit model. The median WTP under the QDB method results $61.68 higher and narrower confidence interval than the SB method.

For the bounded probit model, the median WTP under the SB method is $160.73 with a 95% confidence interval between $137.52 and 183.88, and $214.22 under the QDB method with a 95% confidence interval between $203.21 and $225.79. This results indicate the QDB method yield higher WTP ($53.49 more in this case) with a tighter confidence interval than the SB.

For the unbounded interval-censored model, the median WTP under the QDB yield $56.33 more and narrower a confidence interval than the SB: $148.33 under the SB with a 95% confidence interval between $129.50 and $167.21, whereas the median WTP under the QDB is $204.71 with a 95% confidence interval between $199.56 and $209.88.

For the bounded interval-censored model, the median WTP between the SB and the QDB shows that the median WTP under the SB method yields $7.88 more than the QDB method. However, the QDB method shows a tighter confidence interval than the SB.

Table 17

Median WTP with 95% Confidence Interval for Four Models

Models	Unbounded Probit*	Bounded Probit*	Unbounded I.C*	Bounded I.C*
SB	$144	$161	$148	$221
C.I	$127-$165	$138-$184	$130-$167	$216-$226
QDB	$205	$214	$205	$213
C.I	$199-$211	$203-$226	$200-$210	$208-$218

*Means and Variance between SB and QDB method were statistically difference at 5% significant level for all models

Based on discussions above using results from the table 17, the QDB method produces narrower confidence interval than the SB, and the median WTP under the QDB produces higher WTP than the SB except the bounded interval censored model. Therefore, the QDB method gains statistical efficiency over the SB method by comparing the median WTP with confidence interval between the two methods.

Non-Parametric Turnbull WTP Estimates

Another method to estimate WTP is the Turnbull distribution free estimator. This method is a non-parametric method in that it can be can be applied where there is no assumption about distribution of WTP. It is also called the lower bound method due to the fact that it produces lower bound WTP estimate by restricting the upper bound as highest bid and the lower bound as non-negative. The Turnbull distribution free estimator was introduced by Turnbull (1976), Cosslett (1982), and Ayer *et al*. (1995). Carson, Hanemann *et al*. (1994) and Haab and McConnell (1997) used this method in CV studies for the first time. Haab and McConnell (2002) provide a procedure for calculating the Turnbull Distribution-Free estimator. Turnbull lower bound WTP, E_{LB}, is defined as:

$$E_{LB}(WTP) = \sum_{i=0}^{M*} t_i \cdot f*_{i+1.}$$

where $M*$ is the number of bids that in pooled price range, t_i is offered bid, and $f*_{i+1.}$ is consistent estimates of the probability that WTP falls between bid *i* and *i*+1.

The variance of the expected lower bound is

$$V(E_{LB}(WTP)) = \sum_{i=1}^{M*} \frac{F_i^*(1-F_i^*)}{T_i^*}(t_i - t_{i-1})^2$$

$$= \sum_{i=1}^{M*} V(F_i^*)(t_i - t_{i-1})^2$$

The Offered bids and responses to the Pre-Camille option were used for the SBDB and offered bids and responses to the Pre-Camille option with two relative options of Status-Quo and Pre-1900 were used for the QDB. Table 18 shows the Turnbull WTP and standard deviation of WTP with confidence interval between the SB and QDB.

WTP under the SB method is $150.12 and $148.89 under the QDB method. Compared to WTP estimates by using parametric method, the turn-bull estimates yield lower WTP as expected. The results in Table 18 also indicate that the SB method produce higher WTP, and smaller standard deviation, and narrower confidence interval than the QDB method.

Table 18

Turnbull Distribution-Free Estimates for the SB and QDB

	SB	QDB
MDWTP	$150	$149
Std.Dev	$7.77	$8.72
C.I	$135-$165	$132-$166

<u>T-test and F-test for Comparison of SB and QDB</u>

For comparison of mean and variance between the SB and QDB methods, T-test and F-test were used for all econometric models except Turnbull distribution-free estimates, which did not test in this study due to the no observations on this. The null hypothesis for the T-test is that the mean between the SB and the QDB is same. Result from T-test shows that the means using the QDB method were higher than the SB method in three of four models excluding bounded interval-censored model, but the means between SB and QDB were statistically difference at 5% significant level for all four models. For the F-test, the null hypothesis is that variance between the SB and the QDB is same. The result from the F-test shows that the variances using the QDB method were significantly lower than the SB method for all four econometric models, but the variances between the SB and the QDB were statistically difference at 5% significant level for all four models.

CHAPTER VIII

CONCLUSION

This study proposes a novel variant of the double-bound (DB) method for non-market valuation, referred to as the "quasi-double-bound" (QDB) method, applied to the case of barrier-island restoration in Mississippi. The QDB method works by having respondents evaluate, in the same survey instrument, three different programs that differ only in the quantity of the good provided. This information is then used to estimate WTP for the program of intermediate quantity by incorporating data from the questions pertaining to the relatively smaller and larger quantity programs. It was hypothesized that the QDB method would increase the efficiency of welfare estimates while simultaneously mitigating the potential for biases prevalent in DB method. To test the QDB method, several models were estimated to derive a variety of welfare estimates for comparison to the estimates derived from the SB method.

For all econometric models, all estimated coefficient signs were found to have the hypothesized signs, and the damage variable was found as the primary factor for all econometric models. There were some differences in significance of individual variables across SB and QDB methods.

Median WTP estimates were calculated, and the Krinsky-Robb procedure was used to produce a confidence interval on WTP for each model, as well as Turnbull non-parametric WTP estimates. Of the five models estimated, three resulted in higher WTP estimates using the QDB method, and two resulted in lower WTP using the QDB method relative to SB estimates. Of the five models estimated, four resulted in lower variances (i.e., confidence interval) estimates using the QDB method, and one resulted in higher variance using the QDB method relative to SB method.

This study had some caveats. This study made two assumptions to apply the QDB method. The first assumption is that only fundamental difference between the three scenarios is quantity. This implies that quantity is the main determining factor in the decision process. However, it may not always hold because people may mot always make their decision based on quantity. When amount of quantity changes, other things also changes; in other words, it is difficult to hold other factors constant. The second assumption is that utility is non-decreasing in quantity, which means the utility is increasing over quantity or at least non-decreasing. For example, if a person is provided more quantities, additional quantities provided either increase utility or at worst do not decrease it. However, it may not be true always because there are some exceptions. For instance, it a person is provided a million acres of land, his perception on that amount of land may make his utility decrease.

This study also hypothesized that use of the QDB method should mitigate the issues of the starting point, shifting effect, and strategic bias by providing explicit survey questions with brief information about the WTP question beforehand, and by providing distinct stated price and quantity for each program. On the starting point bias, this study found that the question order variable was statistically significant in some cases; in other words, the respondents were significantly influenced by the question order, but this study at least controlled for the ordering effect. On the shifting effect, the QDB method requires explicitly different programs with explicitly stated prices and quantities, and this should minimize the likelihood of respondents substituting their own perceived notions of quantity. On the strategic bias, even though use of the explicitly different programs, price, and quantities reduces the likelihood of bargaining behavior, the QDB method may encourage some other form of strategic bias, reducing the incentive compatibility of the method. For example, respondents may perceive the options as competing, and so vote a certain way on one option in an effort to influence the likelihood of success of another option. Moreover, the QDB requires three referendum questions, whereas DB requires two questions, so the use of the QDB may increase respondents' fatigue.

The main contribution of this study is that the QDB method has not been used in previous CV studies, so findings from this study will provide new information regarding the merits of this new method to economists who conduct non-market valuation research. Further, this study provides more precise estimates of WTP to policymakers considering Mississippi barrier islands restoration.

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