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ABSTRACT. Wetlands provide a variety of important environmental services including flood control, wildlife habitat, waste treatment, and recreational opportunities. Because most of these services are public goods, the value of wetland preservation cannot be directly obtained from market prices but may be estimated using revealed-preference or stated-preference methods. We estimate the value to local residents of protecting the Kuantu wetland in Taiwan using contingent valuation. Estimates are sensitive to question format, with estimates using a double-bounded dichotomous-choice format about three times larger than estimates using a single open-ended question. Using the open-ended format, the estimated annual mean household willingness to pay to preserve the Kuantu wetland is about US$21. Using the dichotomous-choice questions, the value is about US$65. These estimates suggest the total present-value willingness to pay to preserve Kuantu wetland is about US$200 million to US$1.2 billion (discounted at 5–10%).

Key words: contingent valuation, willingness to pay, wetlands

1. Introduction

Wetlands are among the most biologically productive and diverse of the Earth's biomes. Because they occur in low-lying, flat, and coastal regions, many wetlands are proximate to human settlements and are threatened by growing demand for agricultural and developed land. The opportunity cost of converting wetlands to other uses includes the loss of some or all of their environmental services, which provide benefits at local, regional, and global scales. Locally, environmental services include the regulation

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of water flows (yielding flood protection and promoting recharge of groundwater aquifers); regulation of nutrient cycles (storing nutrients in vegetation and soils, stabilizing temporal availability); filtering and detoxification of wastes; agricultural production; and recreational amenities including fishing, boating, and bird watching. At the local or regional scale, wetlands provide feeding and nursery habitat for local and migratory aquatic, terrestrial, and avian species, some of which are commercially harvested. At the regional and global scales, wetlands influence the atmospheric concentrations of oxygen, carbon dioxide, methane, and other important gases, with implications for air quality and climate (Pearce and Turner, 1990; Barbier, 1994; Gren *et al*., 1994; Costanza *et al*., 1997).

With a few exceptions (e.g., direct agricultural production), the environmental services provided by wetlands do not usually appear in economic markets. The value of these services may be estimated using a variety of indirect methods, including hedonic pricing, travel cost, analysis of substitute costs, and contingent valuation (Pearce and Turner, 1990). The values of wetlands are dependent on location, type, and other attributes. Existing studies of the value of preserving wetlands are predominantly focused on temperate wetlands in developed countries; there are few studies of the value of tropical wetlands (Barbier, 1994).

We estimate the annual per household value of preserving the Kuantu wetland in Taiwan. Kuantu wetland is located in a northern suburb of Taipei, at the confluence of the Keelung and Tamsui Rivers. Kuantu includes 153 hectares of mangrove swamp, intertidal mud flats, brackish and freshwater marshland, and rice paddies. The climate is tropical with monthly mean temperatures of 15–29°C, annual rainfall of about 2 m, and average relative humidity of 80 per cent (Lin *et al*., 1989).

Kuantu wetland is one of 12 wetlands in Taiwan identified under the Ramsar Convention as being of international importance. Kuantu is considered a particularly good example of a wetland characteristic of its region. It has attracted greatest attention because of its value as a wildlife habitat, particularly for birds. Kuantu is perhaps the most popular bird-watching site on the island due to its proximity to Taipei. More than 200 avian species have been sighted in the wetland, representing 45 per cent of the total sighted in Taiwan. Three of the species are classified as threatened internationally. Kuantu wetland and the surrounding area are important feeding areas for egrets and heron and are the most important wintering grounds in Taiwan for 14 species of duck. The area is also an important feeding ground for birds migrating between the Philippines, Japan, and the Chinese mainland (Lin *et al*., 1989).

Kuantu and other wetlands are threatened by the high population density and rapid economic development in Taiwan. The island is dominated by a central mountain range including 95 peaks of 3,000 m or more. The mountains rise steeply from the eastern coast and the majority of the population and associated development are located on the western coastal plain. Taiwan is densely populated with 20 million inhabitants and a land area of 36,000 km^2, two-thirds of which are mountainous. Of the original 80,000 hectares of intertidal mudflats along the west coast, 11,000 hectares

have been lost and another 15,000 are threatened with conversion to use as fish ponds, industrial, and residential land (Lin *et al*., 1989). Populations of both resident and migratory birds have declined in recent years, apparently due to loss of habitat (Underwood, 1992; Sheng, 1994).

The Kuantu wetland has been threatened by proposed development into an industrial and commercial park, by the dumping of municipal waste, soil, and other materials from the Taipei region, and from disturbances by boating and other human intrusion. In 1983, the Taipei city government established a 117-hectare bird sanctuary in the area, of which 60 hectares were privately owned and used for rice cultivation. In 1985, 57 hectares of mangrove swamp and marsh were designated a Natural Preservation Area to be administered by the Council of Agriculture (Lin *et al*., 1989).[1] Although entry into the protected areas was restricted, staffing was limited and the wetlands suffered from human disturbance (Sheng, 1994). Finally, under pressure from environmental groups, the Taipei government purchased the additional land for NT$15 billion and began to set up a natural park in 1997.[2]

We use contingent valuation to estimate the value to local households of preserving Kuantu wetland. Data were collected in December 1993, several years before the Taipei government decided to acquire the wetland. Estimates of willingness to pay (WTP) can be used to evaluate whether the benefits of public ownership exceed the cost to the government. We compare estimates of WTP elicited using dichotomous-choice and open-ended questions obtained from independent samples of respondents. We also estimate WTP for a program to expand the wetland by 10 per cent to provide evidence about the extent to which respondents' answers reflect their economic preferences for the wetland, as contrasted with general support for environmental protection or other benefits they may perceive from endorsing the wetland in our survey (Arrow *et al*., 1993; Smith and Osborne, 1996).

The paper is organized as follows. Section 2 outlines our survey procedures and data sources. Section 3 describes econometric models for the two formats and discusses the empirical results. The final section aggregates WTP over the local population and offers concluding remarks.

2. Survey Procedures and Data Sources

The design of our contingent valuation survey began with a review of previous studies of the value of wetlands. Using this information, we developed an initial draft questionnaire, similar to those of Hanemann, Loomis, and Kanninen (1991) and Desvousges *et al*. (1993). The draft questionnaire was tested and refined using one focus group and two pretests.

[1] The most important legislation for protecting Taiwanese wetlands are the Enforcement Rules of the National Park Law (1972), the Cultural Assets Preservation Law (1982), and the Wildlife Conservation Law (1989). The Council of Agriculture oversees farming, forestry, fishery, and wildlife protection in Taiwan. Conservation represents only a small fraction of the Council's responsibilities.

[2] The 1993 exchange rate was US$1 = NT$26.63 (New Taiwan Dollars).

The focus group was used to assess the public's general knowledge of wetlands and to select photographs of the Kuantu wetland for use in the survey. Focus group participants were instructed to choose photographs to identify related environmental goods to be used in the personal survey. Two reference photographs of the wetland were chosen based on the characteristics of the scenes. The focus group also suggested a number of wording changes to the draft questionnaire to make it more understandable to the public. Two pretests were conducted to further test respondent comprehension and revise question wording. Open-ended maximum WTP values were elicited and used to establish the bid vectors for the dichotomous-choice questions.

A probability sample of local residents was drawn from government household-registration records. Two geographical areas were chosen: Taipei City and Taipei County, which are neighboring areas along the Tamsui River. The sample was stratified by residence (city versus county) and by age to ensure it is representative of the population. Respondents were interviewed in December 1993 by the Survey Research Office, Academia Sinica. The survey office initially contacted 800 households containing an eligible respondent by mailing a postcard to the targeted individual.[3] In the postcard, the purpose of the survey was described. Subsequently, an interviewer visited the respondent's home. Each respondent received a randomly assigned survey version containing only open-ended (OE) or only double-bounded dichotomous-choice (DC) questions (400 respondents for each version). A total of 709 respondents completed interviews, 352 with OE questions and 357 with DC questions. The response rates were nearly equal in the two formats (88 per cent and 89 per cent, respectively).

The questionnaire was divided into three parts: (1) household information, (2) the respondent's knowledge, attitudes, and behavior about wetlands and recreation, and (3) WTP. Household information included age, sex, household size, individual and family income. The second section dealt with the respondent's wetland knowledge, environmental attitude, and recreational behavior along Tamsui River. The knowledge variable is a crude measure equal to the number of ecological functions of wetlands the respondent correctly selected from a list.[4] A dummy variable for visiting the Kuantu wetland in the current year is used as a proxy for the respondent's recreational preferences and attitude toward wetlands. Table 1 reports descriptive statistics for the two samples. There are no significant differences between the samples.

The final set of questions dealt with household willingness to pay for wetland preservation. Color photographs and a map of the Kuantu wetland were included with the survey instrument to facilitate the forma-

[3] Respondents were required to be head of household, 20–70 years old, with some earned income.

[4] The functional services of the wetlands are: (1) providing bird-watching sites; (2) flood protection; (3) reduction of water erosion impacts; (3) purification of air pollution; (5) water pollution assimilation; (6) prevention of the destruction of underground water system; (7) providing wildlife habitats.

Table 1. *Variable definitions and sample statistics*

Variable	*Definition*	*Open-ended*	*Dichotomous choice*	*t-statistic*
MALE	1 if male, 0 if female	0.595 (0.493)	0.652 (0.476)	−1.583
AGE	Respondent's age in years	40.733 (13.272)	40.392 (13.093)	0.679
FSIZE	Number of persons in family	4.567 (2.229)	4.798 (2.001)	−1.452
KNOW	Knowledge of wetlands (1–7 scale)	2.716 (2.148)	2.758 (2.087)	−0.264
VISIT	1 if respondent visited Kuantu wetland in 1993, 0 otherwise	0.304 (0.460)	0.327 (0.469)	−0.661
INCOME	Monthly household income (NT$)	74,013 (41,210)	77,773 (41,416)	−1.212
CITY	1 if respondent lives in Taipei city, 0 if in Taipei county	0.502 (0.500)	0.473 (0.499)	0.773
SCOPE	1 if offered wetland 10% larger than present area, 0 otherwise			
N	Sample Size	352	357	

Notes: Standard deviations are in parentheses. t-statistic is used to test for differences between sample means.

tion of willingness to pay statements. The valuation question asked respondents about their annual WTP for each of two programs: (1) a maintenance program that would preserve the environmental quality and waterfowl at current levels, and (2) an improvement program that would expand the wetland area by 10 per cent and improve the numbers of migratory waterfowl by about 10 per cent. Both the current protected area and the expanded area were identified on the map. In each case, the alternative to the specified program is the situation existing at the time of the survey, in which the Kuantu wetland is not well protected and is threatened by pressures for development.

The payment vehicle is a hypothetical 'Natural Resource Preservation Fund' to which households can donate money for the preservation and management of natural wetlands. Respondents are informed that it has been proposed that the Kuantu wetland be acquired through the fund. This payment vehicle was used because the Taiwan government had proposed establishing such a fund to acquire wetlands in the country, and this proposal had been announced in the news media. Although the trust fund was perceived as a highly credible payment vehicle, its use may yield less accurate estimates of individuals' WTP than would alternatives (such as increased taxes) if it invites free-riding and emphasizes the symbolic and 'warm glow' aspects of voluntary contributions (Diamond and Hausman, 1994).

For the OE questions, 207 of the 352 individuals asked (59 per cent) gave a positive WTP to preserve the area and 145 (41 per cent) gave a zero bid. To distinguish respondents who do not value the wetland from those having some objection to the question, we offered alternative explanations for a zero WTP response and asked the respondent to pick the explanation giving the most important reason for his or her answer. If the respondent's answer was, 'My household should not have to pay for wetland preservation', or 'The environmental quality of this wetland is too poor, it is impossible to improve it', then it was classified as a protest response.[5] In the regression analysis, the 44 observations with protest responses are eliminated.

For the DC questions, initial bids for the maintenance program were NT$50, 100, 200, 400, 700, 1,000, 1,700, 3,000, 5,000, and 7,000. The initial bids for the improvement program were NT$100, 150, 250, 500, 800, 1,200, 2,000, 3,500, 6,000, and 7,500. The questionnaires were designed so that a respondent was presented with the nth initial bid for both programs; consequently the initial bid for the improvement program always exceeded the initial bid for the maintenance program. In the DC format, we asked whether respondents would agree to pay a specified amount for the resource. We did not explore respondents' reasons for their responses. Therefore, protest responses cannot be identified.

3. Empirical Models and Results

3.1 Willingness to Pay

Household WTP is estimated as a linear function of respondent characteristics including household income, wetland knowledge, and recreational experience. OE responses are analyzed using a tobit model to account for non-protest zeros. DC responses are analyzed using the maximum-likelihood method under the assumption that WTP is lognormally distributed (which implies $WTP > 0$).[6] We estimate WTP for both maintenance and improvement programs in a single model, using the dummy variable SCOPE to distinguish the larger program. OE and DC models estimated separately for the maintenance and improvement programs yield similar results.

Table 2 shows the estimated models. For the OE responses, WTP is positively related to income and knowledge about the wetland. The estimated income elasticity is 0.22.[7] The positive coefficient on the knowledge vari-

[5] Five explanations for zero bids are offered in the questionnaire: (1) I cannot afford to pay; (2) This wetland is not worth anything to me; (3) This wetland should be converted to urban and commercial uses; (4) My household should not have to pay for wetland preservation; (5) The environmental quality is too poor to be improved.

[6] Using a χ^2 test we found that the lognormal model provides a better fit than the Weibull, exponential, and log-logistic models. The estimated coefficients using alternative distributions have the same signs.

[7] Since the tobit model is nonlinear in parameters, we compute the partial derivative of expected WTP at the sample mean of the independent variables (Maddala, 1983).

Table 2. *Regression results*

Variable	*Open-ended*	*Dichotomous-choice*
INTERCEPT	3.085	3.085
	(1.838)	(0.306)
MALE	−0.661	0.439
	(−1.857)	(2.319)
AGE	−0.066	0.026
	(−4.238)	(3.319)
FSIZE	−0.032	−0.166
	(−0.368)	(−3.279)
KNOW	0.648	0.103
	(7.121)	(2.040)
VISIT	−0.126	0.062
	(−0.317)	(0.311)
LOG(INCOME)	0.252	0.546
	(2.035)	(2.779)
CITY	−1.517	−0.298
	(−4.281)	(−1.605)
SCOPE	0.224	0.117
	(0.646)	(0.645)
σ	3.954	1.358
Log-Likelihood	−1254.54	−435.15

Note: t statistics in parentheses. The OE regression is estimated using a tobit model and the DC regression is estimated assuming a lognormal distribution. σ is the estimated residual standard deviation on the logarithmic scale.

able is consistent with previous studies (Whitehead and Blomquist, 1991; Epp and Griffith, 1993). The coefficient on age is significantly negative but those on sex and family size are not significant. The coefficient for Taipei city is significantly less than zero, suggesting that city residents have lower WTP than county residents. The coefficient on previous visits to the wetland is insignificant.

Results from the DC sample are somewhat different. The coefficients on knowledge and income are both positive and significant, as in the OE sample. The income elasticity is about 0.5, higher than the OE estimate. The estimated coefficients of sex and age are positive, unlike the estimates in the OE sample. Family size is negative and significant and the city dummy variable is insignificant.

The coefficients on SCOPE suggest that estimated WTP is somewhat larger for the improvement program than for the maintenance program in both OE and DC samples (about 20 per cent and 10 per cent, respectively). It is not clear how large an increase in WTP one should expect for a 10 per cent increase in the protected area, but differences exceeding 10 per cent seem large. However, our study has inadequate power to detect differences of this magnitude and so we cannot reject the hypothesis that WTP is insensitive to this difference in scope.

3.2 Comparison of Open-Ended and Closed-Ended Formats

As questionnaires are identical across the two formats (with the exception of the WTP question), comparable estimates from the two formats would provide evidence of convergent validity. We present two tests for the comparability of estimates: a test for differences in the distribution of responses to the two formats and a test for differences in the estimates of mean WTP.

Following Kristrom (1993) and Desvousges *et al*. (1993), we use a Kolmogorov–Smirnov (K–S) statistic to test for differences in the distribution of responses. We construct a synthetic single-bounded DC data set from the OE responses. We define the expected number of 'no' responses using the percentage of OE respondents giving a response less than each of the ten initial DC bids and compare the observed number of 'no' responses obtained from the first question in the DC sample. The largest difference is at the lowest bid (NT$50 for the maintenance program). About 35 per cent of the OE respondents reported a WTP in the range of zero to less than NT$50. In contrast, only 19 per cent of DC respondents rejected an initial bid of NT$50 and 27 per cent rejected an initial bid of NT$100. A similar condition exists for the improvement program. We reject the hypothesis that the OE and DC WTP values are generated from the same distribution and conclude that the question format affects estimated WTP.[8]

To compare the estimated mean WTP from the two formats, we use a bootstrap resampling procedure (Efron and Tibshirani, 1986) to estimate the standard errors of the estimated means. The estimated mean WTP from the DC sample is about three times larger than the estimated mean from the OE sample. For the maintenance program, the estimated means (standard errors) are NT$549 (NT$147) using the OE results and NT$1,721 (NT$249) using the DC results.[9] The difference between formats is highly significant. Adjusting the DC estimate downward to account for the possibility that some DC respondents have zero WTP does not alter this conclusion. After removing protest zeros, 22 per cent of OE respondents report zero WTP for the maintenance program. Reducing the estimated mean WTP from the DC sample by 22 per cent leaves it about two and a half times as large as the corresponding OE estimate.[10]

The larger estimates from the DC sample are consistent with previous studies. Brown *et al*. (1996) reviewed eleven studies that compared WTP in the two formats and found that the ratio of DC to OE mean WTP ranged from 1.1 to 4.8.

[8] The K–S values are 473 for the maintenance program and 431 for the improvement program. The corresponding 95% critical value for a χ^2 distribution with eight degrees of freedom is 15.5.

[9] The estimates for the improvement program are NT$757 (NT$171) and NT$2,062 (NT$365) for the OE and DC samples, respectively.

[10] If respondents having zero WTP are more likely than others to respond 'no' to the DC question, reducing the mean DC estimate by 22% will overestimate the bias induced by treating these respondents as if they have positive WTP.

4. Conclusion

The estimated value of preserving the Kuantu wetland is substantial. Consistent with other results in the literature, we find that OE measures are substantially smaller than DC measures. Mean annual WTP to preserve the wetland is estimated as NT$549 (US$20.60) and NT$1,721 (US$64.60) using OE and DC formats, respectively.

Taipei city and county (the population from which our sample was drawn) contain about 900,000 households (with an average household size of 4.5, these households include about 4 million people). Multiplying the number of households by the lower (OE) and upper (DC) estimates of mean WTP for the maintenance program yields a range of roughly NT$500 million to NT$1,500 million per year (US$20 million to US$60 million). If these annual values continue in perpetuity, the present value WTP is NT$5 billion to NT$30 billion (US$200 million to US$1.2 billion) using discount rates of 5–10 per cent. The amount spent by the Taipei government to purchase the wetland, NT$15 billion, is in the middle of this range. Within the limits of accuracy of our study, the government expenditure to purchase this land appears comparable to the benefits to the local population of public ownership; thus, we cannot judge whether the benefits exceed the costs of acquisition. Future operation and maintenance expenses will increase the public costs of ownership. However, the benefits of preservation may be underestimated because we do not incorporate benefits to Taiwan residents outside the local area or to residents of other countries. The benefits of preservation may also be underestimated to the extent that ecosystem services of Kuantu and other wetlands are inadequately appreciated.

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