VALUING PREFERENCES FOR THE REMOVAL OF A DISAMENITY FROM THE PORT ELIZABETH HARBOUR

Mario du Preez *

Nelson Mandela Metropolitan University

Mario.DuPreez@nmmu.ac.za

Deborah Lee #

Nelson Mandela Metropolitan University

Deborah.Lee@nmmu.ac.za

Leann Cloete +

Nelson Mandela Metropolitan University

Leann.Cloete@nmmu.ac.za

October 2011

Abstract

This paper examines the Nelson Mandela Bay public's willingness to pay (WTP) for the removal of a local undesirable land use, the manganese ore dumps and the oil tank farm situated within the boundaries of the Port Elizabeth harbour, Eastern Cape, South Africa, by means of the contingent valuation method. Both a non-parametric and parametric estimate of the WTP is derived. Estimated WTP for the removal of this disamenity ranges from R47.09 to R93.21 per household. The aggregate WTP ranges from R13 489 683 to R26 701 496. Due to the sensitivity of the parametric estimate of WTP to functional form specification and the distribution of the random part of preferences, the less restricted non-parametric WTP estimate (R47.09) is more appropriate. The results of this study show that policy-makers should take heed of the importance communities attach to the location of pollution-creating activities in urban areas.

Keywords

Industry, contingent valuation, willingness to pay, dichotomous choice, parametric estimation, non-parametric estimation, South Africa

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*Dr Mario du Preez is associate professor at the Nelson Mandela Metropolitan University, Summerstrand Campus South, Port Elizabeth, South Africa.

#Ms Deborah Lee is a lecturer at the Nelson Mandela Metropolitan University, Summerstrand Campus South, Port Elizabeth, South Africa.

+Ms Leann Cloete is an associate lecturer at the Nelson Mandela Metropolitan University, Summerstrand Campus South, Port Elizabeth, South Africa.

1. INTRODUCTION

The main objective of this pilot study is to determine Nelson Mandela Bay households' preferences for the immediate removal of the manganese ore dump and oil tank farm from the Port Elizabeth harbour. A manganese ore dump and oil tank farm have been permanent fixtures in the Port Elizabeth harbour since 1950 and 1960, respectively. Increased levels of environmental awareness and monitoring over the last decade have culminated in heightened local opposition to the continued location of the ore dump and tank farm in the harbour. Although the ore dump and oil tank farm are independently managed and operated, they are viewed as one distinct disamenity.

The negative environmental impacts caused by the ore dump and tank farm have been well documented in the local as well as national media (for example, *Carte Blanche*, an actuality television programme aired on DSTV). Examples of these negative impacts include air and water pollution. More specifically, due to the open-air handling and storage structure of the ore dump, ore dust is widely dispersed by the strong prevailing winds in Nelson Mandela Bay – the ore dust is classified mainly as a nuisance pollutant (Erasmus, Strydom, Tipshraeny & Watling, 2003). This has led to an increased incidence of respiratory illnesses in people living in close proximity to the harbour, soiling of personal property, house exteriors and sometimes the interiors of houses and businesses, a decline in the successful hatching of bird eggs (fowl eggs in particular) found near the harbour, and a decline in passive and active use satisfaction associated with the adjacent beach area, that is, Kings Beach (Erasmus et al., 2003; Cull, 2010; MyPE, 2010). Long-term exposure to manganese ore dust could lead to severe respiratory ailments, impotence, muscle pain, nervousness and chronic headaches (Bureau of Environmental Health, 2010).

Oil pollution, due to leakages (the most recent were recorded in 2001 and 2008) experienced at the oil tank farm, has extended far beyond the periphery of the harbour. The pollution has caused the following: whales veering off their natural path of travel past the harbour, the deaths of numerous penguins that were exposed to oil residue in the sea water, a decline in local fish populations, the destruction of turtle nesting grounds, and the cancellation of the national young-lifesavers (Nippers) competition (SABC, 2008; MyPE, 2010). Another major concern is the potential effect that an oil leak could have on the Blue Flag status of Kings Beach, which is located adjacent to the ore dump and oil tank farm, as well as the Blue Flag status of other beaches situated further up the coast (Hayward, 2009; Rogers, 2010). Although the lease agreements for the oil tank farm and manganese ore dump are set to expire within a matter of years (2014 and 2016, respectively), there is, as yet, no consensus as to when these disamenities will be (re)moved. Many of the secondary impacts associated with the operation of the ore dump and oil tank farm involve non-market costs. Avoidance costs, for example the costs of cleaning, give only limited information on the value of the impact of ore dust soiling. Since not all the impacts of the soiling can be mitigated via cleaning, avoidance costs provide a lower bound on values. The only viable way in which these impacts can be mitigated completely is through the removal of the oil tank farm and ore dump from the harbour. Although the impacts associated with the operation of the ore dump and tank farm facilities should be included in public policy debates and cost-benefit assessments, no direct valuation method exists to value the economic cost to affected communities. Instead, non-market valuation methods, such as contingent valuation, are often applied to assign values to these economic costs.

The case of the removal of the manganese ore dump and oil tank farm from the Port Elizabeth harbour was selected since it represents a current public policy debate issue that has not been

resolved. Monetary estimates of people's preferences for the removal of pollution-creating activities can assist policy-makers and other stakeholders when locating industries in an urban setting. These estimates can also be of use in understanding the benefits associated with air and water quality improvement projects.

It should, however, be noted that this is a partial estimation of the social cost associated with the operation of the manganese ore dump and oil tank farm. Ideally, this cost estimate should be added to the private costs of this undesirable land use, and compared to the benefits in a comprehensive social cost-benefit analysis.

This paper is organised as follows: section 2 presents a short overview of the manganese ore dump and oil tank farm. Section 3 describes the methodology used in this study. The empirical results and discussion are presented in section 4. Finally, section 5 concludes this study.

2. THE MANGANESE ORE DUMP AND OIL TANK FARM

The Port Elizabeth harbour is located within Algoa Bay on the south-eastern coast of South Africa, midway between Cape Town and Durban. The harbour has good railway links and the following facilities: a container terminal with three berths and a break terminal with two bulk berths, six normal berths and a tanker berth (Ports and Ships, 2010). Jetties for tug, fishing and trawling purposes and a naval station for the South African Navy are also provided.

Prominent commercial activities in the harbour include the transportation, handling and storage of agricultural produce such as fruit, fish and wool crops. The harbour was recently appointed the alternative port of call for container ships that are unable to dock at the container terminals in Cape Town and Durban. The harbour also has a large open-air motor vehicle terminal to facilitate the transportation and storage of vehicles (Ports and Ships, 2010).

Two additional products which are stored and distributed from the harbour are manganese ore and imported petroleum. The ore is stored and exported from an open-air facility, the ore dumps. The petroleum is stored and distributed from a tank farm facility. Both these facilities are located within the boundaries of the harbour (see **FIGURE 1**).

The land on which the manganese ore dump and oil tank farm is located is currently managed by Transnet, a parastatal of the South African government, which leases the land from the Nelson Mandela Metropolitan Municipality. Transnet sublets parts of the land. The subleases include, among other things, the principle lease of the manganese ore facility to BHP Billiton and the leasing of the tank farm facilities to Shell, Total, Engen and Chevron (Hayward, 2009). Shell is responsible for the management of the oil tank farm on behalf of the other lessees. The leases of the oil tank farm and manganese ore dump are set to expire in 2014 and 2016, respectively (Nelson Mandela Municipality, 2010).

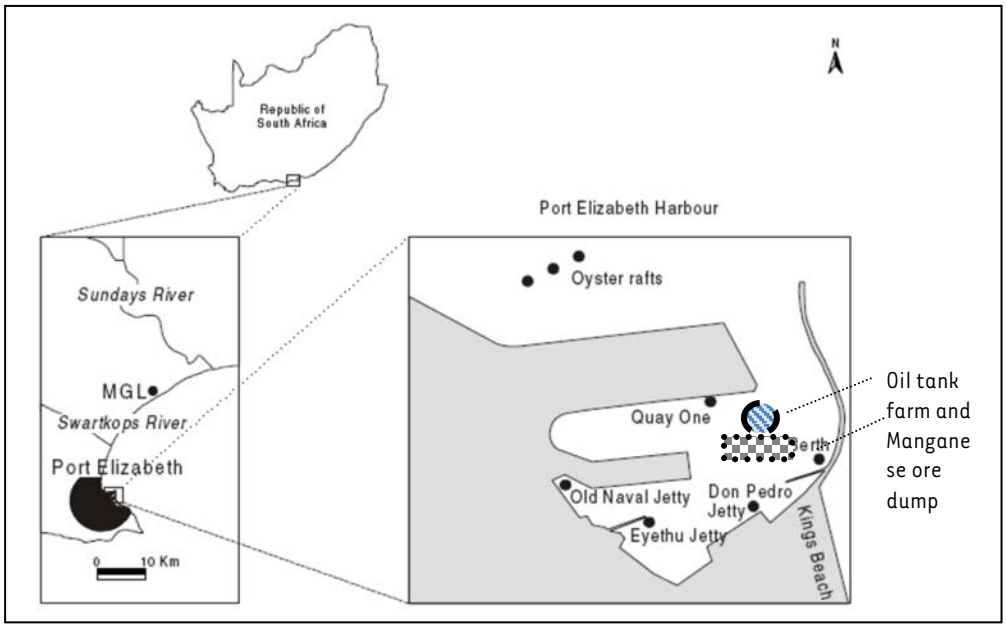

FIGURE 1: The location of the manganese ore dump and oil tank farm

Source: *Shackleton, Schoeman & Newman, 2002*

3. METHODS

3.1 The contingent valuation method

The contingent valuation method (CVM) entails the use of a questionnaire survey to obtain data on the preferences and characteristics of affected parties. The survey allows for the direct elicitation of monetary payments by asking respondents about their willingness to pay (WTP) to secure an improvement of the environmental service flow in question. Guidelines for performing CVM studies are presented in the Report to the NOAA Panel on Contingent Valuation (see Arrow, Solow, Portney, Leamer, Radner & Schuman, 1993).

Although the CVM is now widely accepted as a valuation technique, it does suffer from several biases which have been the focus of a large body of research, namely strategic bias, design bias, mental account bias, hypothetical market bias and non-response bias. These are briefly discussed below.

3.1.1 Strategic bias

Strategic bias refers to a situation where respondents overstate their WTP or understate their WTP if they wish to influence a specific result, such as the amount of the good or service provided, the amount or system of collecting money to provide it, or in damage appraisals, the compensation (Mitchell & Carson, 1989). This type of bias can be reduced or excluded by using referendum formats in the survey (Hanley & Spash, 1993) and avoiding the use of mail surveys (Mitchell & Carson, 1989).

3.1.2 Design bias

When structuring the survey instruments used in CVM studies, certain information has to be relayed to respondents. Concerns have arisen regarding the manner in which this information is relayed to the respondent (for example, its format, the specific order as well as the amount of information) (Hanley & Spash, 1993). These concerns could lead to what is referred to as design bias. Design bias can be broken up into three separate biases, namely (i) the choice of the bid vehicle, (ii) starting point bias and (iii) information bias (Hanley & Spash, 1993).

i) Payment vehicle bias
The choice of payment (bid) vehicle, such as an entry fee, a tax, and a trust fund payment, could have an influence on respondents' WTP. Some respondents may have an adverse feeling towards paying for a public good or service and others may have concerns over the effectiveness of collecting the chosen payment vehicle (Hanley & Spash, 1993). The best way of avoiding this bias is to ensure that any controversial or complicated means of payment is avoided and that the most simple and practical method is chosen (Hanley & Spash, 1993).

ii) Starting point bias
When applying a bidding game in a survey, the actual starting bid can affect the final bid stated by respondents. The starting bid may suggest what the interviewer believes to be the appropriate bid size. This bias could also occur as a result of a lack of interest in the survey by the respondents (Hanley & Spash, 1993). Starting point bias can be avoided by using payment cards or referendum-type elicitation formats (Hanley & Spash, 1993).

iii) Information bias
Information bias can occur whenever respondents are asked for valuations of characteristics with which they have minimal or no experience. In other words, their valuation may be based on a completely false perception. In order for the survey instrument to yield useful information regarding an individual's WTP, the individual must understand what is being valued. If information provided as part of the questionnaire is unclear to the respondents, then doubt arises about the bid amount stated. Another concern regarding the provision of information is whether respondents internalise and accept the information when answering the survey question or if they just hear the information. It is essential that respondents accept the information provided when making their choices (Arrow et al., 1993).

3.1.3 Mental account bias

For individuals to be able to determine their bid for a particular good or service, they should allocate a certain portion of their total time, wealth, and income to the protection and support of the environment. This portion of individuals' total wealth, time and income should then be subdivided into the various initiatives that they deem important (Hanley & Spash, 1993). Mental account bias originates when an individual allocates all of his or her "environmental budget" to the particular good or service under evaluation, thus not making allowances for other environmental initiatives that are of interest to him or her (Hanley & Spash, 1993). Mental account bias can also be as a result of the "warm glow" effect that respondents' project when answering survey questions concerning environmental policies or programmes. The "warm glow" effect refers to the emotional feelings that are attached to contributing to an environmental cause. This effect is likely to result in respondents overstating their bid (Arrow et al., 1993).

To counter mental account bias, respondents should be reminded of their budget constraints (Arrow et al., 1993). In addition, Arrow et al. (1993) recommend that the WTP responses from a CVM study should be used as indicators of the general approval of the environmental policy under review instead of definite reliable estimates of the value of the policy.

3.1.4 Hypothetical bias

Respondents are presented with a hypothetical market in which they are expected to state a bid value. The hypothetical nature of the market may cause respondents to act differently than they would when faced with a real-life scenario. This could lead to an over- or underestimation of their bid amounts (Hanley & Spash, 1993; Arrow et al., 1993). The best way of preventing this bias is to ensure that the market is presented to respondents in the most realistic manner possible (Hanley & Spash, 1993).

3.1.5 Hypothetical bias

Non-response bias occurs as a result of either unwillingness of respondents to answer certain questions in the survey (that is, item non-response bias) or when respondents refuse to participate in the survey as a whole (that is, unit non-response bias) (Hanley & Spash, 1993). Both item and unit non-response bias can be identified by using follow-up interviews. The follow-up interviews will allow the researcher to compare respondents' initial and later responses and any differences between the two interview sets will be deemed to identify non-response bias (Mitchell & Carson, 1989). Alternatively, the survey results can be compared to demographic profiles of our respondents to those of a reliable external source (for example, the National Census). The probability of non-response bias can be reduced by properly designing the survey; this includes limiting the length of the survey, ensuring that it is simple and clearly presented to respondents (Mitchell & Carson, 1989).

3.2 Dichotomous choice CVM

Several elicitation methods can be used in CVM studies. These include the dichotomous choice method, bidding games and payment cards (Mitchell & Carson, 1989: 99). A bidding game entails the continuous changing of the stated bid amount (by the interviewer) until the highest WTP amount for a respondent is obtained (Haab & McConnell, 2002: 18). Payment card methodology provides respondents with a range of values from which they are asked to select an option which represents their maximum individual WTP amount (Mitchell & Carson, 1989: 100). In this paper, the dichotomous choice (DC) method is used to elicit respondents' WTP. According to the DC method, respondents are asked to accept or reject a specified payment under a hypothetical market situation. This approach was first used by Bishop and Heberlein (1979) to estimate the value of goose hunting. DC questions are easier than open-ended questions to answer, since individuals are familiar with discrete choices when engaged in market transactions (Hanemann, 1984:541).

3.3. Survey design

In terms of questionnaire design, this study attempted to conform to all the guidelines contained in the NOAA Report. The survey questionnaire was constructed carefully in order to provide the respondent with accurate information regarding the local undesirable land use in question. The survey was a personal interview survey. The CVM question was pre-tested as part of

the study. The study adopted a WTP format. As mentioned above, a DC (referendum) format was used to elicit each respondent's WTP amount. Based on a pilot survey, six different bid amounts were established: R5, R10, R18, R40, R75 and R100. The WTP question asked in the survey followed the example of Loomis, Kent, Strange, Fausch and Covich (2000), whereby the question was posed in a referendum format in the context of an election (Haab & McConnell, 2002). The WTP question was stated as follows:

> *If a local government election were being held today and the total cost to your household would be a once-off trust fund payment of Rx, would you vote for the oil tank farm and manganese ore dump removal project or vote against it?*
>
> - *I would vote for it*
> - *I would vote against it*
> - *Don't know*

The R*x* amount was filled in randomly using one of the six bid amounts. A once-off payment was chosen, since the removal of the disamenity is a once-off event. An anonymous referee suggested that a once-off payment is treated more like a donation (introducing a "warm glow" bias) than a real payment for a specific service. As shown above, the questionnaire permitted 'Don't Know' options in the valuation question response. Following the status quo approach as per Groothuis, Groothuis and Whitehead (2008), all 'Don't Know' responses were treated as 'No' responses. If a respondent voted 'No' a follow-up question was included in order to elicit the reason behind this refusal to pay. In order to reduce potential hypothetical bias and mental account bias, the respondents were also reminded that spending more money on this project would mean they would have less to spend on all other goods and services, that is, they faced a budget constraint. More specifically, the budget constraint reminder was stated as follows:

> *Remember that your income is limited and has several uses and that this project is but one of many such projects in South Africa and the world. Before you vote, therefore, we would ask you to be totally sure that you are willing and able to pay the stated sum associated with this project.*

The questionnaire consisted of four major sections. The first section provided the respondent with background information on the local undesirable land use. The second section referred to respondents' general attitudes to the environment as well as their prior knowledge of the land use in question. The third section entailed the WTP referendum. The last section of the questionnaire incorporated questions of a socio-demographic nature, for example, the respondent's age, gender, and race.

3.4 Sample

The non-probability quota sampling technique was employed in this pilot study. The main criterion taken into account to find the required cases was race. Two other criteria were also considered, namely age and gender. In April 2010, a sample of 192 Nelson Mandela Bay households was interviewed face-to-face during an intercept survey. The respondents were interviewed at a public event, namely the annual Splash Festival. The targeted respondents were household heads, aged 18 and older. A household head was deemed to be an individual who is responsible for the primary care of his or her household.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1 Socio-economic characteristics of the respondents

A comprehensive analysis of the characteristics of the Nelson Mandela Bay population of household heads is available via the Labour Force Survey of September 2007. This was used to judge the representivity of this sample in the CVM survey (see **TABLE 1**). If the characteristics of the sample and the population correspond, then reasonable confidence can be placed in estimates of WTP for the project aimed at removing the manganese ore dump and oil tank farm from the Port Elizabeth harbour.

TABLE 1: A comparison of the population and sample statistics for household heads (HHs)

Characteristics		*Population of HHs* *	*Sample of HHs*
Race	Black, coloured and indian	84%	83%
	White	16%	17%
Age (average)		48	39
Gender	Male	65%	51%
	Female	35%	49%

Source: *Labour Force Survey, September 2007*

The race structure of the sample of respondents closely corresponded to the Nelson Mandela Bay population of household heads. The age structure of the sample of respondents broadly corresponded to the general population of household heads. In terms of the gender types, there were a greater proportion of males in the population of household heads compared to the sample. Although not the main sampling criterion, the gender structure of the sample could reflect a gender bias.

The question relating to a household's income level was specified using pre-defined categories. **TABLE 2** presents these categories populated with the relevant percentages of household income. Not unlike the population figures for income levels in Nelson Mandela Bay, the sample figures exhibit a large proportion of low to middle income earners, and small proportion of high income earners.

Average income in Nelson Mandela Bay (taken from the Labour Force Survey of September 2007) equals approximately R50 000. The sample mean income (R139 000) is much higher than the population figure, but the sample median income (R87 000) is more in line with the average income figure for the population.

TABLE 2: Income categories

Income Category		*Percentage of HHs*
R0		7.8
R 1	R 20 000	17.7
R 20 001	R 50 000	8.9
R 50 001	R 75 000	8.3
R 75 001	R100 000	11.5
R100 001	R150 000	13.0
R150 001	R200 000	10.9
R200 001	R300 000	8.9
R300 001	R400 000	5.7
R400 001	R500 000	5.8
R500 001	R750 000	0
R750 001	R1 000 000	1.6
R1 000 001+		0

Source: *Authors*

4.2 Respondents' attitudes and knowledge

The survey questionnaire elicited information on respondents' attitudes to the environment and their prior knowledge of the disamenity in question. The first question simply asked the respondents whether they were aware of the existence of the manganese ore dump and oil tank farm in the Port Elizabeth harbour. The majority of the respondents (55%) indicated that they were familiar with the ore dump and oil tank farm. For the remaining two questions, a scale was used where a rating of 1 indicated that the respondent disagreed completely with the statement made in the question, and a rating of 5 indicated that the respondent agreed completely with the statement made in the question (a 'do not know' option – option 6 – was also included). It was found that respondents felt that the protection of the environment was one of the most important tasks within government policy – this question received an average rating of 4.27. Respondents were indifferent when asked whether the problems associated with the oil tank farm and Manganese ore dump are exaggerated – this question received an average rating of 3.26.

4.3 Empirical estimation

4.3.1 Non-parametric estimates

In this study, a non-parametric model was estimated first. According to Bateman, Carson, Day, Hanemann, Hett, Jones-Lee, Loomes, Mourato, Ozdemiroglu, Pearce, Sugden and Swanson (2002), this type of estimation "is an indispensable step in the analysis of CVM data when the objective is to estimate the mean and median WTP for a sample". Unlike the parametric approaches, conservative (lower-bound) estimates of WTP can be estimated without assuming any distribution for the unobserved elements of preferences (Bateman et al., 2002; Haab &

McConnell 2002). **TABLE 3** shows the number and percentages of all 'yes' responses at each bid amount.

TABLE 3: Bid responses at each bid amount and probabilities of a 'yes' response

0	*R5*	*R10*	*R18*	*R40*	*R75*	*R100*
Yes	19	19	29	19	12	12
No	6	11	12	18	17	18
% Yes	76%	63%	71%	51%	41%	40%

Source: *Authors' calculations*

The data indicates that, generally, the higher the bid, the lower the probability of a 'yes' answer. More specifically, at the lowest bid amount, 76% of the respondents indicated that they would vote yes, whereas at the highest amount only 40% indicated that they would vote yes – this is in line with the economic theory of demand. The Turnbull estimator for interval-censored data (that is, the CVM referendum responses) was used in this study (Turnbull, 1974:345; Haab & McConnell, 2002:74). This estimator utilises individuals' choices to create an interval estimate for the latent WTP suggested by each individual's choice (Bateman et al., 2002). In this case, it is assumed that the respondents' lower bound of his or her WTP is the choice p_j (that is, bid amount j). The lower bound of the WTP for a sample of referendum responses can be expressed formally as follows:

$$WTP = \sum_{j=0}^{K} p_j \times f_{j+1}^{*} \qquad \textbf{(1)}$$

where:

$$f_{j+1}^{*} = F_{j+1}^{*} + F_j^{*}$$

that is, the probability that WTP lies between bid j and bid $j+1$;

F_j^{*} = the fraction of respondents who will pay less than p_j–that is, the proportion of no votes to each bid amount presented to respondents; and

$\boldsymbol{K}$ = the number of bids (Haab & McConnell, 2002)

The values for p_j, f_j^{*} and F_j^{*} are shown in **TABLE 4**.

By multiplying each bid amount offered (p_j) by the probability that WTP lies between it and the next bid (p_{j+1}) and summing the quantities obtained over all bid amounts, an estimate of the lower bound on WTP is obtained (Turnbull, 1974; Haab & McConnell, 2002). The variance of the lower-bound WTP, that is, V (WTP), can be calculated as follows:

$$\mathrm{V(WTP)} = \sum_{j=1}^{K} \frac{F*_j\left(1-F*_j\right)}{P*_j}\left(P_j - P_{j-1}\right)^2 \qquad \textbf{(2)}$$

TABLE 4: Turnbull estimates with pooling

p_j	N_j^1	P_j^1	*Turnbull* F_j^*	f_j^*
5	6	25	0.240	0.240
10	11	30	0.324	0.084
18	12	41	Pooled back[2]	Pooled back[2]
40	18	37	0.486	0.162
75	17	29	0.586	0.100
100	18	30	0.600	0.014
100+	-	-	1	0.400

Source: *Authors' calculations*

Notes:
1) N_j represents the number of 'no' votes at each bid amount and P_j represents the total number of offered bids.
2) The data for the R10 and R18 bid levels were pooled because the probability estimate for the higher bid level was greater than that for the lower bid level.

The lower-bound WTP was estimated at R47.09, with an estimated standard error of R4.65. The 95% confidence interval for lower-bound WTP is $47.09 \pm (1.96 \times 4.65)$, which gives a range of R37.98 to R56.20.

The follow-up question to the WTP question presented three reasons for voting against the project, namely (1) It is not worth it, (2) I do not know, and (3) Government should pay. Of all the respondents who voted against the project, 67% indicated that the government should pay for the project, 27% indicated that the project was not worth it, and 6% indicated that they did not know.

In most situations, CVM practitioners would like to estimate the effects of covariates (explanatory variables) on WTP. Because the non-parametric technique allows for only limited exploration of the effects of independent variables, a parametric model (a logit model) was estimated. This model is presented below.

4.3.2 Parametric estimates

As part of the parametric estimation, several covariates, in addition to the bid amount, were included in the logit model to account for the possible effects of socio-economic and attitudinal factors (Haab & McConnell, 2002). Hanemann's (1984) random utility maximisation model forms the basis of the standard DC method. The logit model provides the fundamental relationship:

$$\text{Probability (Yes)} = 1 - \{1 + \exp[\beta_0 - \beta_1(\text{RX})]\}^{-1} \qquad \textbf{(3)}$$

where: the β's refer to coefficients estimates of the logit model. RX is the rand amount that respondents were asked to pay for the removal of the manganese ore dump and oil tank farm (Haab & McConnell, 2002:28). The operational definitions of the explanatory variables are shown in **TABLE 5**.

TABLE 5: Operational definitions of explanatory variables included in the logit model

Variables	*Operational definitions*
Awareness	Is the respondent aware of the existence of the manganese ore dump and oil tank farm? Dummy variable, 1 if yes; 0 otherwise.
Live	Does the respondent live in close proximity to the harbour? Dummy variable, 1 if yes; 0 otherwise.
Recreate	Does the respondent recreate in close proximity to the harbour? Dummy variable, 1 if yes; 0 otherwise.
Protection	How strongly does the respondent agree with environmental protection being an important task of governmental policy? A six-point scale, 1 if completely disagrees, 5 if completely agrees, 6 if do not know.
Problems	How strongly does the respondent agree with whether the problems associated with the facility are exaggerated? A six-point scale, 1 if completely disagrees, 5 if completely agrees, 6 if do not know.
Bid	The amount an individual is willing to pay for the removal of the manganese ore dump and oil tank farm (in rand).
Gender	Dummy variable, 1 if the respondent is male; 0 otherwise
Race	Dummy variable, 1 if the respondent is white; 0 otherwise
Age	Continuous variable (years)
Education	Continuous variable (number of years of schooling completed)
Income	Continuous variable (gross annual household income in rand).

Source: *Authors' calculations*

A log-likelihood ratio test showed that the reduced logit model is preferred to the complete logit model. This test is based on the difference in the log-likelihood functions for the complete and reduced models. The log-likelihood ratio test is given as: A two-stage process was followed in estimating the logit model. First, a logit model that contained all the explanatory variables was estimated (the complete model). Then, a reduced logit model was estimated, which included only those covariates whose coefficients were significant in the complete model. The following independent variables were statistically significant at the 10% level in the complete model: aware, bid, age, income and education.

$$\text{Likelihood ratio} = -2(\text{LR} - \text{Lc}) \qquad \textbf{(4)}$$

where:

L_R represents the log-likelihood value of the reduced logit model; and

L_c represents the log-likelihood value of the complete logit model.

The rejection region at the 5% level of significance is given as:

$$\text{Likelihood ratio} \geq \text{X}20.05(\text{v})(5) \qquad \textbf{(5)}$$

where:

v represents the number of parameters tested.

The complete and reduced logit models yielded log-likelihood values equal to -110.85354 and -110.55922, respectively. The log-likelihood test ratio statistic was calculated to be 0.58864, and the chi-square (χ^2) critical value, corresponding to the upper five % significance level with four degrees of freedom, was 9.490. The log-likelihood ratio test statistic does not exceed the χ^2 critical value. The reduced logit model was thus preferred, as the null hypothesis could not be rejected. There is sufficient evidence to infer that none of the explanatory variables omitted from the reduced logit model contributes significant information for the prediction of WTP. In the interests of parsimony, only the results of the reduced logit model are reported here (see **TABLE 6**).

As shown in **TABLE 6**, the 'Bid' variable's coefficient is negative and highly statistically significant. This indicates that the probability of answering 'yes' to the referendum question declines as the bid level increases. This result mirrors the findings of the non-parametric estimation with sound statistical significance. As far as the included attitudinal and socio-economic characteristics are concerned, all the coefficients are significant and have the correct sign. More specifically, the coefficient on 'Income' is positive and significant at the 10% level. This result supports the hypothesis that the probability of an individual answering 'yes' to the referendum question increases with household income.

TABLE 6: Coefficient estimates for the multivariate logit model– a reduced model

Variables	*Coefficient*
Aware	0.8810624 (2.59)***
Bid	-0.0131391 -2.67)***
Age	-0.0459567 (-2.58)***
Education	0.1261068 (2.20)**
Income	2.30 (1.77)*
Constant	-0.2500157
χ^2	40.36
Log likelihood	-110.85354
Observations	192

Source: *Results from Stata estimates*

Notes:
Z –statistics in parentheses:
*-Significant at 10%,
** - Significant at 5%'
***- Significant at 1%

The 'Awareness' coefficient is positive and highly statistically significant. This result is in line with *a priori* expectations, since those individuals who are more aware of the disamenity would

in all likelihood be more prepared to pay for its removal. The 'Education' coefficient is positive and significant. This result indicates that those individuals with a higher level of education would be more willing to pay. A test for collinearity between education and income was conducted at the behest of an anonymous referee. This test revealed no collinearity Finally, the coefficient of the 'Age' variable is negative and highly statistically significant. This means that older respondents would be less willing to pay.

The significant coefficients of the logit model can be interpreted by estimating their odds ratios. This is done by calculating the antilog of the various coefficients. Odds interpretation indicates how the probability of being willing to pay increases (decreases) as the explanatory variables' values increase (decrease). The 'Awareness' coefficient can be interpreted as follows: an increase in awareness will result in an increase in the probability of a respondent being willing to pay by 7.6%. An increase in age will result in a decrease in the probability of a respondent being willing to pay by 1.1%. An increase in the level of education will result in an increase in the probability of a respondent being willing to pay by 1.3%.

4.3.3 Measuring mean individual WTP

Hanemann (1989: 1059) established a formula to estimate the mean individual WTP (assuming the WTP is greater than or equal to zero):

$$\text{Mean WTP} = (1/\beta 1)^* \ln(1 + e\beta o) \qquad \textbf{(6)}$$

where:

$\beta 1$ refers to the estimated coefficient of the bid; and

$\beta 0$ can be either the estimated constant (in the case where no other explanatory variables are included) or alternatively the grand constant, which is calculated as the sum of the estimated constant added to the product of the other independent variables times their respective means.

Based on the estimation results, the mean WTP was estimated at R 93.21 per household. The mean WTP expressed as a percentage of the mean income for the sample is 0.1%. The mean WTP estimated here appears to be an overestimate, since 25% of the respondents had indicated that they would not pay anything, and, of the remainder, half made bids below R50, and 40% just offered more than R100. This result may be due to the underlying distribution selected for the unobserved random component of preferences, or the functional form chosen for the preference function (Haab & McConnell, 2002:84).

4.3.4 Aggregate WTP

To estimate a total WTP value, the mean WTP value was aggregated across the total number of households in the Nelson Mandela Bay area. Both the non-parametric and parametric estimates of the mean WTP were used. The non-parametric estimate provides the minimum value for the mean WTP that is consistent with the sample data (Haab & McConnell, 2002:74). The most recent estimate of the number of households in the Nelson Mandela Bay area equals 286 466 (Labour Force Survey, September 2007). The results are shown in **TABLE 7**.

TABLE 7: Aggregate WTP estimates: parametric vs. non-parametric

Model	*Household WTP (Rand)*	*Total WTP (Rand)*
Non-parametric	47.09	13 489 683
Parametric	93.21	26 701 496

Source: *Authors' calculations*

The non-parametric estimate of WTP (household and total) is about half of the parametric estimate. This result is not surprising, since the Turnbull non-parametric estimate is a lower-bound one. Since the mean WTP estimated via the parametric model appears to be an overestimate, the more conservative non-parametric estimate is the more appropriate WTP measure to use. The total WTP derived here is, however, only a partial estimation of the social cost that can be associated with the operation of the Manganese ore dump and oil tank farm. Ideally, this cost estimate should be added to the private costs of operating these facilities, and compared to the benefits, in a comprehensive social cost-benefit analysis.

5. CONCLUSION

The objective of this pilot study was to estimate the Nelson Mandela Bay public's willingness to pay (WTP) for a project entailing the immediate removal of the manganese ore dump and oil tank farm from the Port Elizabeth harbour. The removal of these facilities was assumed to be the only viable way to mitigate completely the negative impacts caused by the facilities as a result of air and water pollution. Both a non-parametric and parametric estimate of mean WTP was derived – on average a respondent was willing to pay a once-off amount of between R47.09 (non-parametric estimate) and R93.21 (parametric estimate). Total WTP varies between R13 489 683 and R26 701 496. The results of the logit model showed that the probability of a 'yes' answer to the referendum question varies with a number of covariates in a realistic and expected way, which offers some support for the construct validity of this CVM study. Household income, education, age, and disamenity awareness were significant determinants of individuals' responses to the WTP question. The results of this study are subject to three qualifications. First, a relatively small sample size was used in this pilot study and although the estimates appear to be plausible in terms of their size, they are indicative rather than precise estimations of the WTP for the removal of the disamenity. Future research into this issue should aim for a much larger sample size to ensure more precise estimates. Second, the mean WTP estimated via the parametric model appears to be an overestimate and, as such, the more conservative non-parametric estimate is the more appropriate WTP measure to use. Third, the aggregate WTP estimation constitutes only a partial analysis of cost. A number of other factors and value streams need to be analysed and compared with the cost estimates generated by this study if adequate holistic decision-making is to take place with regard to the removal of the manganese ore dump and oil tank farm. More specifically, the total WTP estimated in this study should be viewed as only one input into a comprehensive social cost-benefit analysis to determine the desirability of the removal of this disamenity for wider society.

Acknowledgements

The authors gratefully acknowledge the comments and suggestions made by an anonymous ERSA referee.

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