Estimating the willingness-to-pay for the removal of a local undesirable land use: the case of the Manganese ore dump and oil tank farm in the Port Elizabeth harbour

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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 609 010 to R26 937 690. 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: *Contingent valuation, willingness-to-pay, dichotomous choice, parametric estimation, non-parametric estimation*

1. Introduction

A Manganese ore dump and oil tank farm have been permanent fixtures in the Port Elizabeth harbour for well over forty years. Increased levels of environmental awareness and monitoring over the last decade have culminated in heightened local opposition to the ore dump and tank farm's continued location in the harbour. The negative environmental impacts caused by the ore dump and tank farm[2] 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 structure[3] of the ore dump, ore dust is widely dispersed by the strong prevailing winds in Nelson Mandela Bay – the ore dust is mainly classified as a nuisance pollutant (Erasmus, Strydom, Tipshraeny and 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 (i.e. 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,

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[2] Although the ore dump and oil tank farm are independently managed and operated, they are viewed as one distinct disamenity.
[3] The ore dump can be classified as an open air handling and storage facility.

due to leakages[4] 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[5]. The only viable way in which these impacts can be completely mitigated 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 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. This case was selected since it represents a current public policy debate issue that has not been resolved. Monetary estimates of peoples' 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 is presented in Section 4. Finally, Section 5 concludes this study.

[4] The most recent leakages were recorded in 2001 and 2008.

[5] Avoidance costs, for example the costs of cleaning, gives 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.

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 boasts 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 boasts 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 below).

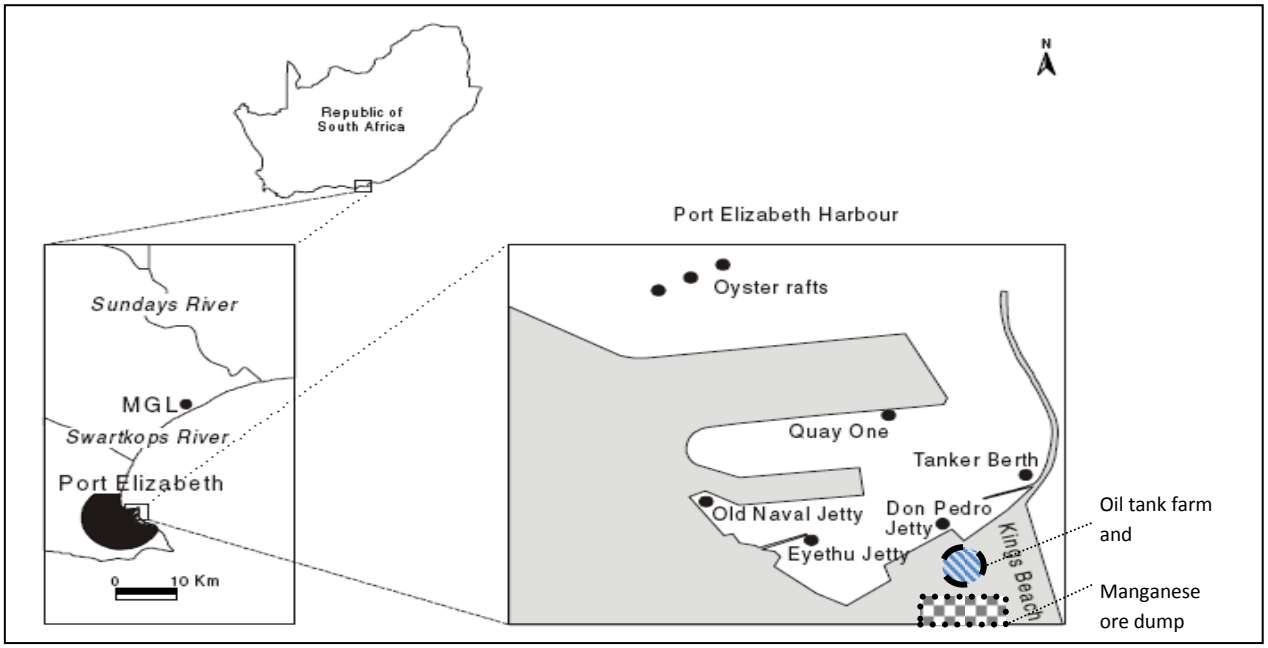

Figure 1: The location of the Manganese ore dump and oil tank farm
Source: Shackleton, Schoeman and Newman (2002)

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, who leases the area of land from the Nelson Mandela Metropolitan Municipality (NMMM). Transnet sublets certain areas of the land. The subleases include, amongst others, the principle lease of the Manganese ore facility to BHP Biliton 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 is set to expire in 2014 and 2016, respectively (Nelson Mandela Municipality, 2010).

3. Methods

3.1 The contingent valuation (CV) method

The contingent valuation (CV) method 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 their willingness to pay (WTP) to secure an improvement of the environmental service flow in question. Guidelines for performing CV studies are presented in the Report to the NOAA Panel on Contingent Valuation (see Arrow, Solow, Portney, Leamer, Radner and Schuman, 1993). Briefly, the NOAA Report guidelines are as follows:

- The CV survey should be designed conservatively;
- The researcher should conduct face-to-face interviews as opposed to mail or telephonic interviews;
- The CV survey should adopt a willingness to pay format as opposed to compensation required;
- The valuation question should be in a referendum type format;
- Adequate and accurate information concerning the environmental program or policy should be provided to all respondents;
- Photographs should be included in the survey only if presentation bias can be avoided;
- Respondents must be reminded of any substitute commodities that are available for the good or policy being evaluated;
- A sufficient time period from the date of environmental damage to the date of the survey must have elapsed;
- Time dependent measurement noise should be kept to a minimum by averaging across independently drawn samples at various points in time;
- A no-answer option should be included in the survey;
- All responses, whether yes or no, should be followed by an open-ended question;
- Questions that will assist in interpreting responses should be included;
- The CV survey should satisfy these requirements, yet be simple enough for respondents to grasp the information (Arrow *et al*., 1993; Haab and McConnell, 2002).

3.2 Dichotomous choice CV

In this paper, the dichotomous choice (DC) method[6] is used to elicit respondents' WTP. This approach was first used by Bishop and Heberlein (1979) to estimate the value of goose hunting. According to the DC method, respondents are asked to accept or reject a specified payment under a hypothetical market situation. DC questions are easier to answer compared to open-ended questions since individuals are familiar with discrete choices when engaged in market transactions (Hanemann, 1984).

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 carefully constructed 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 CV question was pre-tested as part of the study. The study adopted a WTP format. As mentioned above, a DC (i.e. 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 was stated as follows:

> *If a local government election were being held today and the total cost to your household is a once-off trust fund payment of R x , 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 randomly filled in using one of the six bid amounts. 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[7], 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 (i.e. they therefore faced a budget constraint).

[6] Other elicitation methods that are often used in CV studies include bidding games and payment cards (Mitchell and Carson, 1989). 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 and McConnell, 2002). 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 and Carson, 1989).

[7] Mental account bias refers to the fact that respondents allocate a fixed total, comprising of income, wealth and time across all environmental assets they find to be of interest (Hanley and Spash, 1993).

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 method was employed in this pilot study. Three criteria were used in order to find the required cases: race, age and gender. This means that the composition of the sample by race, age and gender was very similar to that of the population. In April 2010, a sample of 192 Nelson Mandela Bay (NMB) households was interviewed face-to-face during an intercept survey. 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 is available via the Community Survey of 2007. This was used to judge the representivity of this sample in the CV survey (see Table 1 below). 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

Characteristics		Population *	Sample
Race	Non-white	84%	83%
	White	16%	17%
Age		26	39
Gender	Male	48%	51%
	Female	52%	49%

*Notes: *Community Survey (2007)*

Both the race and gender structure of the sample of respondents closely corresponded to the Nelson Mandela Bay population. The age structure of the sample, however, was different from the population. The reason for this is twofold: first, respondents less than 18 years of age were deliberately excluded from the sample, and second, household heads were targeted during the survey.

4.2 Respondents' attitudes and knowledge

Section two of the survey questionnaire elicited information on respondents' attitudes towards 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 is 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 CV 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 2 shows the number and percentages of all "yes" responses at each bid amount.

Table 2: 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%

The data indicates that, generally[8], the higher the bid, the lower is 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 (i.e. the CV referendum responses) was used in this study (Turnbull, 1974; Bateman *et al*., 2002; Haab and McConnell, 2002). 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 (i.e. bid amount j). The lower bound of the WTP for a sample of referendum responses can formally be expressed as follows:

$$WTP = \sum_{j=0}^{K^*} p_j \times f^*_{j+1} \quad \ldots\ldots(1)$$

where:

f^*_{j+1} = F^*_{j+1} - F^*_j (i.e. the probability that WTP lies between bid j and bid j+1)

F^*_j = the fraction of respondents that will pay less than p_j (i.e. the proportion of no votes to each bid amount presented to respondents)

K= the number of bids (Turnbull 1974; Haab and McConnell, 2002)

The values for p_j, f^*_j and F^*_j are shown in Table 3 below.

Table 3: 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

[8] With the exception of one bid amount (R10), the percentages of "yes" responses decrease as the bid increases, reflecting that the distribution is imperfectly monotonic.

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.

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 and McConnell, 2002). The variance of the lower bound WTP (i.e. V(WTP)) can be calculated as follows:

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

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 ± (1.96 * 4.65), which gives a range of R37. 98 to R56. 20.

In most situations, CV practitioners would like to estimate the effects of covariates (i.e. explanatory variables) on WTP. Because the non-parametric technique only accommodates 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 and McConnell, 2002). Hanemann's (1984) random utility maximisation model forms the basis of the standard DC method. The logit model provides the fundamental relationship:

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

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 (Bateman *et al*., 2002). The operational definitions of the explanatory variables are shown in Table 4 below.

Table 4: 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).

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 percent level in the complete model: aware, bid, age, income and education. For the sake of parsimony, only the results of the reduced logit model are reported here[9] (see Table 5).

[9] 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:

Likelihood ratio = $-2(L_R - L_c)$

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 percent level of significance is given as:

Likelihood ratio $\geq X^2_{0.05}(v)$

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

Table 5: 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

Notes: Z –statistics in parentheses:

-Significant at 10%, ** - Significant at 5%' *- Significant at 1%*

As shown in Table 5, 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 percent level. This result supports the hypothesis that the probability of an individual answering "yes" to the referendum question increases with household income. 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. Finally, the "Age" variable's coefficient is negative and highly statistically significant. This means that older respondents would be less willing to pay.

value, corresponding to the upper five percent 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.

4.3.3 Measuring mean individual WTP

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

$$\text{Mean WTP} = (1/\beta_1)^* \ln(1 + e^{\beta_0}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where: β_1 refers to the estimated coefficient of the bid and β_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. This is almost double the amount derived from the non-parametric estimation (i.e. R47.09).

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 (Bateman *et al*., 2002). The most recent estimate of the number of households in the Nelson Mandela Bay area equals 289 000 (Community Survey, 2007). The results are shown in Table 6 below.

Table 6: Aggregate WTP estimates: parametric vs. non-parametric

Model	**Household WTP (rand)**	**Total WTP (rand)**
Non-parametric	47.09	13 609 010
Parametric	93.21	26 937 690

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. 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 completely mitigate 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 609 010 and R26 937 690. The logit model's results 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 CV 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 two 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 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.

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