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The Impacts of Proposed Landfill Sites on Housing Values

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〈**Abstract**〉

This study utilizes the meta-analysis for the benefits transfer (MA-BT) approach to measure social costs the 7 target sites in the City and County of Honolulu. The estimated MA models (MA-1 and MA-1) were evaluated in terms of validity and reliability criteria. This study utilized a parametric t-test and a non-parametric sign rank test for checking validity. A transfer error measured by an absolute percentage difference was utilized to check reliability their similarity. The GIS was utilized for data collection in order to measure social costs for each target site. The results clearly demonstrated that social costs were substantially higher thant direct costs and varied market conditions and different methods used. In terms of validity and reliability criteria, MA models were preferred to the mean transfer value approach. MA-BT approach is desirable for measuring social costs for a project designed to measure social costs for these 7 proposed landfill sites with inaccessible data, on short time frames, and with little money. If researchers and planners have enough time and money, they can

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implement primary research. If not, the meta-analysis for the benefits transfer approach can be much better than no framework. The use of a GIS can help to identify secondary data within a specific radius of each target site.

Keywords : meta-analysis, benefits transfer, GIS, landfills

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본 연구는 메타분석을 기반으로 한 편익이전 방법과 자료 수집을 위하여 지리정보시스템(GIS: geographic information system)을 활용하여 쓰레기 매립지 선택을 위한 7개 후보지들의 사회적 비용을 추정하였다. 그리고 MA-1, MA-2, 직접편익전달 방법을 타당성(validity), 신뢰성(reliability) 관점에서 검토해 보았다. 타당성(validity)은 메타분석을 기반으로 한 편익이전에 의한 추정치와 원래의 값의 차이의 여부를 통계적으로 검정하는 것이고 신뢰성(reliability)은 추정치와 원래의 값의 % 차이의 절대값을 이용해서 유사성을 검토하는 것이다. 연구 결과는 쓰레기 매립지 선택을 위한 후보지들의 사회적 비용이 직접 비용에 비해서 상당히 크고 주변지역의 경제적 특성에 의해 큰 영향을 받을 수 있음을 보여준다. 그리고 타당성과 신뢰성의 기준으로 메타모형들은 직접적 편익이전에 비해서 선호된다는 것을 보여준다. 메타분석을 기본으로 한 편익이전 방법은 시간, 비용, 혹은 자료부족 때문에 직접적인 방법을 활용하기 어려운 경우 하나의 대안이 될 수 있다. GIS는 각 후보지의 특정 지역 내 자료를 수집하는 데 도움을 줄 수 있다.

주제어 : 메타분석, 편익이전, 지리정보시스템, 쓰레기 매립지

JEL Classification : Q2, Q3

Ⅰ. Introduction

Landfills have the adverse impacts on neighboring communities, surrounding environment, and future generations. These non-market impacts have been estimated by (i) a hedonic price method (HPM), (ii) a contingent valuation method (CVM), and (iii) benefits transfer (BT) methods (Brisson and Pearce, 1995). Using primary HPM and CVM is not desirable for a project which was designed to approximate social costs of the multiple proposed sites for preliminary analysis. Given an example of landfill selection with multiple potential landfill sites, using HPM is difficult to find nonuse values and reliable findings from these target sites without comparisons to the existing landfills. Although using CVM can measure social costs for the target sites, this method requires substantial time and expenses. If researchers and planners have enough time and money, they can implement primary research. If not, BT can provide a reasonable method to approximate the impacts of the potential landfills by utilizing data from other primary studies.

BT is a research method applying data or functions from other primary studies to targeted sites (Desvousges et al., 1998). The location where the primary research was conducted is referred to as the study site, and the location where a new policy is implemented or value measurement is utilized is referred to as the policy or target site (Rosenberger and Loomis, 2003).

There are two approaches to BT utilized: (i) a mean transfer value (MTV) approach to utilize mean values for willingness to pay (WTP) or marginal willingness to pay (MWTP) from primary studies to policy sites and (ii) a transfer function utilizing a function transfer from study sites to policy or target sites (Rosenberger and Loomis, 2003). In order to reflect differences between policy sites and study sites, mean transfer values are adjusted with income or population (Navrud and Ready, 2007). Rosenberg and Loomis(2003) argued that a transfer function is generally considered to perform better than a mean transfer value approach because the transfer function can fit more characteristics of the target sites. However, Lindjem and Navrud(2008) argued that the mean transfer value approach should not be discarded until more empirical findings support the reliability of the function transfer.[1] Utilizing a transfer function from other primary research often fails to find primary research relevant to the target sites. Even the relevant function is inapplicable to the

1) A range of mean values may provide bounds on the probable values for target sites. For example, when multiple study sites exist, a study site with the lowest values becomes the lower bound of the transfer, and a study site with the highest values becomes the upper bound of the transfer. Alternatively, a confidence level represents a simple statistical range in which the true value would fall with some percentage if the mean and standard error of the value is available (Desvousges et al., 1998). These bounds or confidence levels provide additional information regarding the precision of estimates.

target sites if data for target sites are inaccessible. Meta-analysis can be an alternative approach.

Meta-analysis (MA) is a statistical method used (i) to examine the empirical results from other primary studies, (ii) to analyze factors which affect the differences in the estimates, and (iii) to apply the estimated MA function to measure values for other target sites (Bergstrom and Taylor, 2006).[2] The meta-analysis for the benefits transfer (MA-BT) approach can provide a measure that approximates the impacts of the proposed landfill sites.[3]

Some studies (Brisson and Pearce, 1995; Ready, 2005; Walton et al., 2006) utilized MA based on other HPM studies, which had a slightly different intention. These studies focused on HPM using distance from a landfill site. Brisson and Pearce(1995) did not employ the MA function for BT. They provided a provisional MA function linking a percentage decrease in housing value and distance from the landfill. Their study may suffer from specification bias because of small samples, lack of methodological variables and core economic variables, inclusion of studies using different valuation methods, and inclusion of hazardous waste sites.

2) Although meta-regression analysis is a more precise term, the term meta-analysis is dominant in the literature incorporating meta-regression analysis. Thus, this study will utilize the term meta-analysis. Refer to Stanley and Jarrell(2005) for a general background of meta-regression analysis.

3) Rosenberger and Phipps(2007) showed that inclusion of market characteristics such as income levels and population densities can improve reliability of a meta-analysis for benefits transfer approach (MA-BT).

Ready(2005) included some methodological variables including the amount of transported waste per day, sample size of each study, and distance from landfill sites. These variables adjust differences in MWTP for distance. However, Ready's study did not only obtain statistically significant results for methodological variables due to the use of a small sample size but also explain heteroskedasticity and panel data effects. He did not include core economic variables because he did not intend to utilize MA for the purpose of BT.

Walton et al.(2006) conducted MA on North American hedonic studies. They showed that income levels and methodological variables improved the reliability of MA. They compared the results of MA with those of the primary CVM study and found that MA on HPM studies slightly underestimates externality costs as compared with the original CVM study. However, they did not check statistical tests for equivalence between original values and transfer values of BT results. They could not measure social costs for proposed landfill sites because of data problems.

This study extends previous studies by following the standard for the MA-BT approach suggested by Bergstrom and Taylor(2006). Unlike Brisson and Pearce(1996), Ready(2005), Walton et al.(2006), this study implements equivalence checks as well as statistical tests between original values and transfer values. The MA-BT approach is applied to measure social costs for the 7 proposed landfill sites in the City & County of Honolulu (hereafter "the City"). In this case, a geographic information system (GIS) can assist in data collection within a certain radius of each target site. To my knowledge, this is the first research to apply the MA-BT approach, together with the use of a GIS for data collection, to measure social costs for the proposed landfills.

The primary objective of this study is to apply MA to measure social costs for the 7 proposed landfill sites in the City and to check the estimated MA models in terms of reliability and validity criteria. The MA-BT approach is desirable for this project which measures social costs for the proposed target sites with inaccessible data, a short time frame, and a tight budget. If researchers and planners had enough time and funds, they could implement primary valuation research to measure social costs for each proposed target site. If not, the MA-BT approach provides a reasonable alternative framework. The use of a GIS helps to collect data used for measuring social costs. In ensuing sections, the method and data used is first discussed, and the results and the conclusions are then presented.

II. A proposed method

HPM and CVM have been widely utilized for measuring non-market impacts. Conducting these primary research is not desirable for this project which approximates social costs of the 7 proposed target sites without the existing landfill in the City and County of Honolulu. Conducting HPM is difficult to find nonuse values and reliable findings from multiple proposed landfill sites. Implementing CVM for each target site requires substantial amounts of money and time. The MA-BT approach can be an alternative method by utilizing data from other primary studies. While most studies utilized HPM to examine the impacts of landfills on housing values, a few studies (Roberts et al., 1991; Smith and Desvousges, 1986; Opaluch et al., 1993) employed CVM to examine WTP for avoiding landfills. Thus, HPM studies are suitable for the following MA-BT approach.[4)]

1. A meta-analysis for benefits transfer (MA-BT) approach

This study utilizes a MA-BT approach suggested by Bergstrom & Taylor(2006). The MA-BT method assumes the existence of (i) an underlying valuation function which accounts for target site characteristics and (ii) an envelope function for individual site specific valuation functions estimated from different studies (Rosenberger & Phipps, 2007). An underlying MA valuation function has a relationship between MWTP for distance from landfills and explanatory

4) MA has utilized HPM studies on non-market valuation: Smith and Huang(1995) on air pollution; Nelson(2004) on noise; Brisson and Pearce(1995), Ready(2005), and Walton et al.(2006) on impacts from landfill sites. For technical aspects of meta-analysis, refer to Hedges and Olkin(1985) and Lipsey and Wilson(2001).

variables such as core economic variables and study design variables.[5)] Core economic variables are based on economic theory and represent key factors reflecting characteristics of target sites. Study design variables adjust the differences in MWTP among studies that result from dissimilar research designs (Bergstrom and Taylor, 2006).[6)]

The dataset in this research is similar to unbalanced panel data because 9 studies provide 22 observations:

$$Log(MWTP_{ij}) = \beta + \sum_{k=1}^{K} \beta_k Z_{ijk} + \epsilon_i + u_{ij} \quad (\mathrm{i} = 1, 2, \ldots, \mathrm{L}) \qquad (1)$$

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5) Meta-analysis models employ empirical findings from previous HPM studies. An example of the primary HPM based on Nelson et al.(1992a, b, 1998) is as follows: P (z) = $\beta_0 + \beta_1 z_1 +$, ⋯ $\beta_n z_n + \beta_d$d, where P (z) is the residential property value; z=(z_1, z_2 , ⋯,z_n) represents housing characteristics; d is the distance to a landfill; and β= (β_1,⋯ β_n, β_d) is the vector of estimated coefficients that provides information on the marginal value of characteristics. The parameter β_d reveals the household's the marginal implicit price (MIP) or MWTP for an increase in d. For this study's meta-analysis, a household's MWTP for d is used as a dependent variable and core economic variables and study design variables adjusts for differences in MWTP for d between studies and/or site characteristics.

6) Bergstrom and Taylor(2006) presented three approaches to MA based on an underlying utility theoretic model: (i) the strong structural utility theoretic (SSUT) approach, (ii) the non-structure theoretic utility approach (NSUT), and (iii) the weak structural utility theoretic approach (WSUT). While the SSUT approach involves specifying a structural form of the indirect utility function, the NSUT approach at the other end of the spectrum on the utility theoretic approach does not explicitly specify the connection between variables and an underlying utility function. The WSTU approach is in between the SSUT and NSUT approaches. The WSTU approach approximately specifies the connection between explanatory variables and an underlying utility function. For the WSUT approach for BT, see Smith and Huang(1995) and Walton et al.(1996) that provide examples of consistent economic concepts and benefits transfer consistency.

where i is the i-th study for i=1 to 9, and j is the j-th observation on the i-th study for j =1 to 4. The variable $MWTP_{ij}$ is the i-th study's j-th MWTP for distance obtained by other primary HPM studies, $Z_{ijk} = (z_{ij1}, z_{ij2}, \ldots, z_{ijk})'$ represents core economic variables and study design variables (see Table 1), $\beta_k = (\beta_1, \beta_2, \ldots, \beta_k)'$ is a vector of coefficients, and β is a constant. The variable ϵ_i is a common error across estimates, and μ_{ij} is the panel error that may occur when multiple estimates from the same study incur cross sectional correlation or heterok-

〈Table 1〉 Data Description for MA

Category of Variables	Variables	Description	Expected Sign
Dependent Variable	MWTP	For each mile away from landfill sites, the percentage change in housing values	
Core Economic Variables	Y	Median Household Income	+
	POP	Population density (population per square mile)	+
Study Design Variables	MSW	Dummy variable: 1 if a landfill disposes of MSW, 0 otherwise.	Mixed
	ACTIVE	Dummy variable: 1 if a landfill is active; 0 otherwise	+
	N	The number of observations from each selected study.	Mixed
	SE	Standard error of each selected estimate from primary research	Mixed
	FUNCTION	Dummy variable: 1 if a function is linear; 0 otherwise.	Mixed

* If original studies do not report income and population density, the data are collected at the town levels from US census. Thus, figures may not perfectly match the exact area within 3-mile distance from landfill sites.

sedaticity.

The inclusion of multiple MWTP estimates from a single study is debatable. While a single estimate per primary study can create an independent set of MWTP estimates (recommended by Lipsey and Wilson, 2001), this has a disadvantage of ignoring potential meaningful information and incurs unacceptable small samples for MA (Nelson and Kennedy, 2009).[7] A test for panel effects needs to be implemented because the ordinary least squares(OLS) used with the unbalanced panel data structure would provide biased parameter estimates. Following Rosenberger and Loomis(2000), this study utilized the Breusch -Pagan (BP) Lagrange Multiplier test. However, because statistically significant panel effects were not found, the following OLS was utilized,[8] and the semi-log form adjusted for heteroskedasticity:[9]

$$Log(MWTP_j) = \beta + \sum_{k=1}^{K} \beta_k Z_{jk} + v_j \quad (j = 1, 2, \ldots, L) \qquad (2)$$

where j indicates the j-th observation for j = 1 to 22. The

7) Through the survey of 130 meta-analyses, Nelson and Kennedy(2009) revealed that the median study employs 3 observations per study, and the mean was 6.5.

8) If panel effects exist, a fixed effect model and a random effect model will manage it. While the fixed effect model allows correlation between the unobserved panel effect and the explanatory variables, a random effect model treats as a random variable with zero covariance between explanatory variables (Wooldridge, 2002).

9) When researchers use MA, caution should be used for heteroskedasticity. Although explanatory variables adjust for differences in MWTP estimates, heteroskedasticity often persists. See Walton et al.,(2006), Smith and Huang(1995).

variable $MWTP_j$ is the j-th MWTP for distance, $Z_{jk} = (z_{j1}, z_{j2}, \ldots, z_{jk})'$ represents a vector of explanatory variables, β is a constant, $\beta_k = (\beta_1, \beta_2, \ldots, \beta_k)'$ is a vector of coefficients, and v_j is a error term.

Given a small sample size, conducting various diagnostic tests is important for MA. The skewness-kurtosis normality test, the Ramsey's RESET test for the specification error bias, the heteroskedasticity test, and the multicollinearity assessment are reported. Caution should be used for the possibility of multicollinearity between explanatory variables(Walton et al., 2006). High correlation between explanatory variables in small samples can produce possible concerns: (i) substantially higher standard errors with lower t statistics, (ii) unexpected changes in coefficient magnitudes or signs, and (iii) statistically insignificant coefficients despite a high R^2 coefficient (Hamilton, 2004). This study utilized variance inflation factor (VIF) and a correlation matrix between estimated coefficients in order to detect the presence and severity of multicollinearity.

Planners usually consider directs costs, but they did not social costs for the proposed landfills. If social costs are high, they will likely underestimate costs of the proposed landfills. This study utilize the MA functions shown in Table 4 which approximate social costs for the 7 proposed landfill sites in the City. By inserting mean values of N, SE, and FUNCTION, it is assumed to have the same study design variables for the target sites (Rosenberger and Loomis, 2003). The remaining coefficients of Y, POP, MSW, and ACTIVE for MA-1 and Y, POP for MA-2 are multiplied by data for the 7 target sites in the City. The following formula are used for measuring aggregate values (Freeman, 2003).

Aggregate values = B × HN,

where B is the average MWTP for households and HN is the number of households. B is calculated when MWTP per household estimated by MA models is multiplied by average median housing value. Aggregate values for each target site are then calculated when B is multiplied by HN.

The following equivalent annual value (EAV) method is used for comparing the target sites with unequal terminal years (Smith & Desvousges, 1986).

$$EAV = PV/a_i^T ,$$

where PV is the present value of aggregate values, i is the real discount rate, a_i^T is the annuity factor $a_i^T = [1-(1+i)^{-T}]/i$, and T is the terminal year for each target site.

2. Reliability and validity test

A fundamental issue in BT is validity and/or reliability of transfer values. Establishing validity requires statistical tests to examine mean differences or median differences between transfer values and original values. Reliability checks their similarity by using an absolute percentage difference (Navrud and Ready, 2007). Although this reliability check is not a hypothesis test, it is widely utilized for analyzing the similarity between transfer values and original values.

The estimated MA models and the mean transfer value approach can be evaluated in terms of validity and reliability. This study employs the method used by Lindhjem and Navrud(2008). It is assumed that observations are independent since no statistically significant panel effects were not found. N_{-j} observations except for the j-th original value are utilized to estimate the N_{-j} MA functions, where N is the number of observations (22 observations), j is the j-th original value, N_{-j} is the total observations excluding the j-th observation (21 observations).[10] The estimated N_{-j} transfer functions are utilized for measuring the j-th transfer values, which are compared with the j-th original values.

This study utilizes a parametric t-test and a non-parametric test to check for validity between transfer values and original values. A parametric t-test assumes a normal distribution, and the null hypothesis is that the mean difference between the paired values is zero. A non parametric sign rank test does not assume a normal distribution, and the null hypothesis

10) One should caution that the results for MA models may be sensitive to the dropped observation for each target site. Different result could occur if the sample size increases.

is that the median difference between the paired values is zero. In terms of the validity criteria, both tests should not reject the null hypotheses.

An absolute percentage difference is used for checking for reliability, which has the following equation (Lindhjem and Navrud, 2008; Rosenberger and Loomis, 2003)[11)]

$$\delta = \frac{|WTP_T - WTP_O|}{WTP_O} \times 100 \qquad (3)$$

where WTP_T is the transfer value estimated by the N_{-j} transfer functions, WTP_O is the jth original value, and δ is the transfer error (TE) measured by the absolute percentage difference between the transferred value and the original value. In terms of reliability criteria, smaller δ suggests better performance.

III. Data

The data from previous HPM studies are based on a literature review and from several extensive literature reviews

11) Although transfer error (TE) is not a statistical hypothesis test, it is widely used for analyzing the similarity between transfer values and original values (Loomis et al., 1995; Rosenberger and Loomis, 2000; Rosenberger and Loomis, 2003; Shrestha and Loomis, 2003).

by Brisson and Pearce(1995), Ready(2005), and Walton et al.(2006), among others. Following the standards for valid and reliable BT suggested in Bergstrom and Taylor(2006),[12] this study selected observations based on (i) primary HPM studies on the municipal solid waste landfill which utilized distance from landfills and (ii) theoretically consistent positive estimates. Nine HPM studies fulfilling these standards provided a total of 22 MWTP estimates: (i) Nelson et al.(1992a) for 1 observations, (ii) Ready(2003), Lim and Missios(2003), Reichert et al.(1992), Thayer et al.(1992) for 2 observations, (iii) Nelson et al.(1992b), Nelson et al.(1997), and Kiel and McClain (1995) for 3 observations, and (iv) Bouvier et al.(2000) for 4 observations. The 2 of the 6 estimates by Bouvier et al.(2000), and 1 of the 3 estimates by Ready(2005) were excluded because of theoretically inconsistent negative coefficients of landfill distance and 1 of the 3 estimates by Ready(2005).

The different estimates from the same source except for Nelson et al.(1997) and Kiel and McClain(1995) attributed to the different landfills. Nelson et al.(1997) provided the 3 estimates given for low, medium, and high property values from one landfill. Kiel and McClain(1995) provided the 3 estimates from the same incinerator over different periods. Although Kiel and McClain(1995) examined the incinerator,

12) Bergstrom and Taylor(2006) suggests the standards for valid and reliable BT: (i) commodity consistency (e.g., the distance to the landfill), (ii) welfare measurement consistency (e.g., HPM studies), and (iii) theoretical consistency (e.g., positive distance effects).

their study were considered in order to reflect different impacts whether the landfill is operating or not. The dummy variable MSW adjusts for differences between MSW landfills and the incinerator.

The dependent variable ($MWTP_j$) is the j-th MWTP for distance drawn from primary HPM studies (Walton et al., 2006; Ready, 2005). The following explanatory variables shown in Table 1 are utilized for explaining differences in MWTP estimates among studies: (i) Y (Smith and Huang, 1995; Walton et al., 2006), POP (Bergstrom et al., 2006; Walton et al., 2006), N, SE (Stanley and Jarrell, 1989), FUNCTION (Smith and Huang 1995), MSW, and ACTIVE (Walton et al., 2005). The data were collected from the primary HPM studies. When these studies provided no Y and POP, supplemental data were collected from the U.S. Census.

Y and POP are expected to have positive signs. High-income households are willing to pay more to avoid landfills than low-income households (Walton et al., 2006; Smith and Huang, 1995), and area with higher population densities are related to higher MWTP (Brander et al., 2006). As shown in Stanley and Jarrell(2005), N, SE, and FUNCTIONS are expected to affect differences in MWTP. The dummy variable MSW was utilized in order to reflect the difference between MSW landfills and the incinerator. The dummy variable ACTIVE was utilized to reflect different landfill impacts on housing values whether the landfill is operating or not.

Table 2 provides data information including mean values, 〈Table 2〉 Data Information

Quantity Variables	Mean	Standard Deviations	Dummy Variables	Frequency = 1
MWTP	0.051323	0.058628	MSW	18
Log(MWTP)	0.012035	0.009860	ACTIVE	15
Y	60823.95	12050.49	FUNCTION	16
POP	1623.75	1662.643		
N	1631.05	3136.189		
SE	2.061	1.077730		

standard deviations for quantity variables, and frequency of dummy variables. The mean value for MWTP is utilized for a comparison with MA models in terms of validity, reliability, and social costs. All studies except for Kiel and MacClain (1995) providing 3 observations are MSW landfills. The majority of research focused on the operating landfills, but Kiel and

〈Table 3〉 Data for Target Sites in the City&County of Honolulu (2008 US dollars)*

Target Sites	Year	HN	Y	MHP	POP
Site A	13	22,774	93,144	463,208	1587.29
Site B	25	12,376	74,400	257,494	606.37
Site C	16	9,600	66,980	215,390	604.75
Site D	20	9,635	74,448	269,558	517.40
Site E	20	8,789	76,988	265,607	513.67
Site F	11	6,960	74,726	363,136	386.83
Site G	25	19,171	88,709	447,726	1911.16

Source: U.S. Census(2000) and City and County of Honolulu(2003).

1) ArcGIS9 identified N, Y, MHP, and POP based on census tract within a 3-mile (4.8 km) distance of each target site. The Honolulu Consumer Price Index (CPI) adjusted money values to 2008 US dollars.
2) POP were people per square mile (2.6 square km).

McClain(1995) and Bouvier et al.(2000) examined the impacts of the closed or proposed landfills.

The data shown in Table 3 are used for measuring social costs for the 7 potential landfill sites in the City.[13] Following Brisson and Pearce(1996), this study assumes that the landfill impacts are within a 3 mile radius of the target sites. The GIS was utilized to collect data HN (the number of households), Y (income levels), MHP (median housing prices), and POP (population densities) based on census tracts within a 3-mile radius of each target site. The life of the landfill was obtained from the City and County of Honolulu(2003).

IV. Results

The results of MA with reasonable diagnostic test results for a wide range of diagnostic tests for heteroskedasticity, multicollinearity, normality, model specificationare shown in Table 4. This study utilized the OLS because no statistically significant panel effects was found. Because the simple linear form was heteroskedastic, the semi-log form was utilized for correcting for this heteroskedasticity.[14]

13) The 7 target sites were selected by the GIS analysis based on the exclusionary criteria (for details, see Jung, 2011).

14) In order to identify suitable functions, this study specified different MA models: (i) different functional forms, (ii) a fully specified model including all variables versus a restricted model excluding some variables based on statistical significance and

〈Table 4〉 MA Results (Semi-Log Form)

	Dependent variable: Log (MWTP)	
Independent Variables	MA-1	MA-2
C (constant)	-3.011537*	-2.81639**
	(1.423797)	(1.226508)
Y	0.0000454**	0.0000455**
	(0.0000188)	(0.0000165)
POP	0.0000143	0.0000306
	(0.0001632)	(0.000145)
N	0.0001193°	0.00013016*
	(0.0000818)	(0.0000717)
SE	0.3567514°	0.4041681**
	(0.2188691)	(0.1691612)
FUNCTION	0.4325731	0.5742518°
	(0.5735238)	(0.4114403)
MSW	0.2992723	Omitted
	(0.7962355)	
ACTIVE	0.1702279	Omitted
	(0.6252988)	
Observations	22	22
R square	0.5208	0.5157
F test (p-value)	0.1024	0.0276
Normality (p-value)	0.9820	0.9706
Heteroskedasticity	0.8424	0.8609
Ramsey RESET test (p-value)	0.5383	0.4791
Multicollinearity (VIF)	MSW(2.29), POP(2.21), ACTIVE(2.10), FUNCTION(2.05), N(1.98), SE(1.67), Y(1.54)	POP(1.97), N(1.72), Y(1.72), FUNCTION(1.20), SE(1.13)

1) The 1,5, 10, and 20% statistically significance levels are respectively shown as ***, **, *, and °. All values in parentheses () under the estimated coefficients are p-values.

The results confirm previous findings: (i) Y had a statistically significant and positive effect on MWTP at the 5% level i.e.,

multicollinearity.

higher income levels were related to higher MWTP (Nelson et al., 1997 and Walton et al., 1996), and (ii) N and SE had statistically significant effects on MWTP at the 5% or 10 % level. Although POP was statistically insignificant at the 10% level, the positive sign was consistent with priori expectations (see Brander et al., 2006).[15]

While MA-2 had similar explanatory power to MA-1, MA-2 had more variables with equal or higher statistical significance. However, MA-1 with Y, POP, MSW, and ACTIVE is more desirable for BT than MA-2 with Y and POP. These two models were used for measuring social costs for the 7 target sites in the City.

1. Social costs for the 7 proposed target sites in the City and County of Honolulu

Study Area: As one of the Hawaiian Islands, the island of Oahu is the most populated island in the State of Hawaii. As a jurisdictional unit, the entire Island of Oahu is in the City and County of Honolulu administrated by a mayor and nine council members. The City has a total land area of 596.7 square miles (1545.45 square km). According to the U.S.

15) Although most studies use a 1% or 5% significant level, for BT retaining significant variables at the 20% level is often recommended since this optimization can perform the better model specification (Rosenberger and Loomis, 2000, 2003). However, retaining core economic variables at the 20% level avoids miss-pecification that can occur when relevant core variables are omitted from the model.

Census, population of the City is about 0.95 million people (70.1% of the State's population) in 2010. Average temperature ranges from 69.4 - 80.6 (°F).

The City employs an integrated waste management system incorporating source reduction, recycling, a waste-to-energy recovery plant, and landfill disposal. The existing public Waimanalo Gulch Sanitary Landfill (WGSL) site has been a major disposal facility in the City's waste management system. Because of the political promise of its closure, the City started the process of landfill selection. However, the City did not consider social costs for the proposed target sites because (i) they lacked confidence in applying an economic analysis to measure social costs, (ii) the primary valuation method required substantial amounts of time and money for data collection, and (iii) the valuation method could be difficult to measure social costs for each target site in the City. The MA-BT can be an alternative method for planners to approximate the social costs for each target site.

The estimated MA functions shown in Table 4 were utilized to measure social costs for these target sites in the City. For the procedure, see pp. 5-7 of this paper. Following Rosenberger and Loomis(2003), mean values of N, SE, and FUNCTION were inserted into the MA functions by assuming the same values for the target sites, and the remaining coefficients of Y, POP, MSW, and ACTIVE for MA-1 and Y, POP for MA-2 are multiplied by data for the 7 target sites in the City. The aggregate values were calculated when the estimated MWTP for households was multiplied by the number of households and the average housing values. The equivalent annual value method was then used for calculating annual values in 2008. GIS was utilized for data collection within a 3 mile radius of the target sites (see Table 3).

Table 5 summarizes annual aggregate values (in 2008 US dollars) for the 7 target sites in the City using three methods: (i) the direct mean transfer value approach, (ii) MA-1, and (iv) MA-2. Estimated social costs are $7 million to $143 million on an annual basis. These annual social costs are substantially higher than the direct costs (0.87 million to 8.87 million per year) which the City and County of Honolulu (2003) estimated. Because planners did not consider social costs, they likely underestimated costs of the proposed landfill

〈Table 5〉 Annual Aggregate Values for Target Sites

(Unit: $million)

Target Sites	Direct Mean Transfer for MWTP (i)	MA-1 (ii)	MA-2 (iii)
Site A	$50,908 (7)	$131,824 (7)	$143,643 (7)
Site B	$9,392 (4)	$11,756 (4)	$12,586 (4)
Site C	$8,448 (2)	$6,576 (1)	$7,034 (1)
Site D	$8,959 (3)	$11,591 (3)	$10,450 (2)
Site E	$8,053 (1)	$9,861 (2)	$10,542 (3)
Site F	$14,019 (5)	$15,464 (5)	$16,493 (5)
Site G	$25,298 (6)	$53,810 (6)	$58,919 (6)

1) The Honolulu Consumer Price Index adjusted money values to 2008 US dollars. An equivalent annual value method was utilized for calculating annual values The length of life for each target site was used as the time horizon, and the 3% real discount rate was used (Freeman, 2003).

2) Numbers in parenthesis () next to the aggregated values indicate rank order.

sites and possibly located the landfill in a higher overall cost location.

Social costs varied by target sites due to market conditions, and different methods, and differences in landfill life years. While most sites had relatively consistent and stable annual aggregate values, Sites A and G located near highly populated residential areas, exhibited extremely large variability in annual aggregate values. These sites with higher social costs are unsuitable for a new landfill site compared with other target sites.

A sensitivity analysis on MA models was implemented when the impacted area increased from a 3-mile radius to a 5-mile

〈Table 6〉 Sensitivity Analysis Results (Unit: $ million)

		Distance		
	Target Sites	1 mile	3 miles (base)	5 miles
MA-1	Site A	$65.227 (7)	$131.824 (7)	$304.652 (7)
	Site B	$6.043 (3)	$11.756 (4)	$21.037 (4)
	Site C	$2.276 (1)	$6.576 (1)	$8.438 (1)
	Site D	$6.432 (4)	$11.591 (3)	$19.363 (3)
	Site E	$7.0709 (5)	$9.861 (2)	$19.060 (2)
	Site F	$4.717 (2)	$15.464 (5)	$44.376 (5)
	Site G	$39.996 (6)	$53.810 (6)	$140.575(6)
MA-2	Site A	$70.580 (7)	$143.643 (7)	$334.007 (7)
	Site B	$6.447 (4)	$12.586 (4)	$22.651 (4)
	Site C	$2.439 (1)	$7.034 (1)	$9.008 (1)
	Site D	$5.787 (3)	$10.450 (2)	$17.532 (2)
	Site E	$7.552 (5)	$10.542 (3)	$20.467 (3)
	Site F	$5.014 (2)	$16.493 (5)	$47.302 (5)
	Site G	$44.161 (6)	$58.919 (6)	$154.143 (6)

radius or decreased from a 3-mile radius to a 1-mile radius with respect to the base model (a 3-mile radius) ceteris paribus. This type of analysis will indicate the robustness and credibility of MA models. A GIS was utilized for obtaining data for the sensitivity analysis by identifying census tract data within a 1-, 3-, or 5-mile radius of each target site. The results show that the greater the impact on an area, the higher the social cost is since an increase in the radius to the impacted area results in the size or the number of the affected households. Social costs ranges \$2.2 millions to \$65.2 millions within a 1-mile radius, \$6.5 millions to \$143.6 millions within a 3-mile radius, and \$8.4 millions to \$334 millions.

2. Validity and reliability test results

The N_{-j} MA function method suggested by Lindhjem and Navrud(2007) was utilized in order to check validity and reliability criteria. See pp 7-8 of this study for the procedure. Tables 7 shows the results of the parametric t test and the non-parametric Wilcoxon sign rank test for (i) the direct

〈Table 7〉 Validity Tests

Test	Mean MWTP**	MA-1	MA-2
Paired t-statistics	0.5000	0.9105	0.8865
Sign rank test statistics	0.1485	0.9612	0.8838

1) All values are p-values.

2) Mean values used in meta-analysis (MA) was utilized.

Table 8. Reliability Checks (1)

	Mean MWTP	$MA-1_{-j}$	$MA-2_{-j}$
Low POP	127.72	64.64	61.47
	[13.32, 722.42]	[3.08, 287.66]	[2.73, 293.79]
High POP	238.13	186.54	155.02
	[19.69, 1687.46]	[33.94, 651.31]	[10.56, 522.17]
Low Y	291.73	182.09	155.99
	[13.32, 1687.46]	[11.87, 651.31]	[10.85, 522.17]
High Y	73.1	69.09	55.61
	[18.04,211.51]	[3.08, 193.82]	[2.73, 192.58]
Mean δ (n-j)	193.74	125.59	107.45
	[13.32, 1687.46]	[3.08, 651.31]	[2.72, 522.17]

1) Eleven observations for each subgroup were selected for sensitivity testing
2) Numbers indicates the mean transfer error in percentage terms (%), and numbers in the bracket indicate the range of transfer errors.

mean value for MWTP approach, (ii) MA-1, and (iii) MA-2. The mean and median differences between transfer values and original values for these methods were not found.

Table 8 shows the reliability test results: (i) the direct mean value for MWTP approach, (ii) MA-1, and (iii) MA-2. TEs were sorted with Y and POP respectively, and each subgroup for high Y versus low Y or high POP versus low POP had 11 TEs. Mean TEs and the range of TE for each subgroup were then calculated. In terms of the mean TE, MA models are preferred to the direct mean transfer approach. Even though the TE were highly sensitive to the methods used, population densities, and income levels, mean TE for target sites with higher Y was relatively smaller than other

〈Table 9〉 Reliability Checks (2)

Primary HPM Research	Target Sites (j)	j-th original value	$Mean\,MWTP\_$	$MA-1_{-j}$	$MA-2_{-j}$
Nelson et al. (1992a)	Ramsey, MN (j=1)	6.20	5.09 (18.04)**	3.56 (42.97)	3.38 (45.08)
Nelson et al. (1998)	Eden Prairie, MN (j=2)	4.32	5.17 (19.70)	5.79 (33.98)	5.40 (25.00)
Ready (2005)	Oakgrove, MN (j=3)	2.46	4.88 (113.80)	2.17 (11.87)	2.19 (10.85)
Mean TE			50.51	29.60	26.98

1) Values are MWTP estimates in percentage terms.
2) Numbers in parenthesis () indicates transfer errors in percentage terms

subgroups.

A comparison between original values based on primary HPM research checks reliability (Rosenberger and Loomis, 2003; Lindhjem and Navrud, 2008; Navrud and Ready, 2007). Ramsey, Eden Prairie, and Oakgrove in Minnesota were chosen following the criteria for valid and reliable BT (Bergstrom and Taylor, 2006). These 3 target sites have relatively lower TE since the target sites in state have similar income levels and population densities. Generally, in-state transfer values with similar characteristics perform better than those of across states (Rosenberger and Phipps, 2007).

Table 9 summarizes original values, transfer values, TE, and average TE for the three target sites. TE for the direct mean transfer value approach ranges from 18.04 % to 113.80% (mean TE = 50.51%). The TE for MA-1 ranges from 11.87% to

42.97% (mean TE = 29.60%), and the TE error for MA-2 ranges from 10.85% to 45.08% (mean TE = 26.98%). MA models have lower mean TE than the direct mean transfer value for the MWTP approach.

Overall, the MA models (MA-1 and MA-2) are preferred to the direct mean transfer value approach in terms of validity and reliability.

V. Conclusions

This study applied the MA-BT approach to measure social costs for the 7 proposed landfill sites in the City and County of Honolulu. The GIS was employed for data collection within a 3-mile radius of each target site. The results clearly demonstrated that social costs were substantially higher than the City's direct costs and varied by target sites due to different market conditions, different methods used, and differences in lengths of landfill life in years. In terms of reliability and validity criteria, MA models were preferred to the direct mean transfer value approach. TE and mean TE for target sites with higher income levels become decrease.

This study provides several policy implications. First, planners should consider direct costs as well as social costs. If planners do not consider the substantial social costs, they likely underestimate costs of the proposed landfill sites and possibly located the landfill in a higher overall cost location, which results in society's burdens. In order to reduce society's burden, a proposed landfill site should not be located in or near highly populated residential areas.

Second, market conditions are important factors that affect differences in social costs. For example, higher income levels are positively related to higher social costs. High income residents tend to be more sensitive to landfill location than low-income levels. Residents with higher income levels may have greater substitution for landfill location or react to the proposed landfill than residents with lower income levels. Compensation for affected residents and providing legal advice and information for low-income households may reduce inequity related to landfill sites.

Third, landfill life lengths affect differences in social costs. Planners need to examine the equivalent annual value method in order to compare sites or projects with unequal time lengths, which transforms the present value to an annual basis.

Forth, a use of a GIS can be a useful tool to measure social costs for the proposed landfills. For example, a GIS can assist in data collection by identifying income levels, population densities, the number of households, and housing values within a 1-mile, 3-mile, 5-mile radius of each target site. By processing a large amount of data in a short time, the use of a GIS will reduce the effort required for information collection and process.

The MA-BT approach is desirable for measuring social costs for the multiple proposed target sites with inaccessible data, a short time frame, and a tight budget. If researchers and planners had enough time and funds, they could implement primary valuation research to measure social costs for each target site. If not, the MA-BT approach provides a reasonable alternative framework. The MA-BT approach can be extended to measure social costs for other unwanted sites such as hazardous waste sites, incinerators, and nuclear plants. The use of a GIS can help secondary data collection. This study provides a possibility of measuring social costs for the multiple proposed target sites and utilizing a GIS for secondary data collection.

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