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Abstract

The economic advantage of constructing and operating large-scale landfills over small-scale landfills has been used to justify regional landfills as a solution to the municipal waste disposal problem. In addition to the dampening effects on social efforts to divert waste away from landfills, higher external costs of larger landfills may in fact offset the private cost advantages. In this study, the negative effects of a landfill that are capitalized in property values of houses located in the proximity of two landfill sites of significantly different sizes in Toronto, Canada, are examined. The results suggest that larger landfills have greater adverse impacts on property values than smaller landfills, implying consumers perceive (and markets reflect) differences in external costs.

JEL Classifications: Q3, Q38, H41

Keywords: externalities, landfills, hedonic pricing.

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1 Introduction

Landfilling remains the dominant solid waste disposal method. Large-scale engineered regional landfills have replaced small local landfills over the past few decades to deal with two challenges: (1) the increasing difficulty in obtaining governmental approval and public acceptance for any new disposal facilities; and (2) the increased cost pressure caused by stricter landfill construction and operation regulations (Dooley et al., 1993).[1] Landfill cost considerations have previously been addressed by Dooley et al. and Renkow and Keeler (1996). Both articles found that there exist economies of scale over a certain range of landfill sizes. Larger landfills, however, tend to be associated with greater external effects. A higher volume of trucks, a larger parcel of land used, and a longer period of post-closure stabilization are consistent with greater negative impacts of landfills on the natural environment and human health. It is unclear whether all types of landfill externalities are perceived by consumers and reflected in property values.

Risks directly related to humans are more likely to be incorporated than risks to the environment (indirect to humans). Human risks include those from increased traffic, noise, unpleasant odors, aesthetic degradation and limited land utility (Hirshfeld et al. 1992; El-Fadel et al., 1997). Environmental risks include groundwater or surface water contamination, explosions and fires, vegetation damage, air pollution, or global warming arising from landfill leachate and gases. Many studies have tried to assess the impacts of landfills on residential property values in adjacent areas, starting with Havlicek et al. (1971). Although several of these studies have utilized data sets consisting of more than one landfill size, none have specifically estimated the differences in impacts of landfill size. Here we attempt to differentiate the effects of landfill size on property values to determine if consumers account for differences in potential externality impacts.

2 The Data and the Model

Two landfills located in the Greater Toronto Area (GTA) have been selected for the study: the Britannia Landfill (in the west end of the GTA, hereinafter referred to as Britannia), and the significantly larger Keele Valley Landfill (in the north end of the GTA, hereinafter referred to as Keele). Figure 1 shows the relative locations of the Britannia and Keele landfills. The two sites are roughly equidistant from the Toronto central business district (CBD). Figure 2 shows the study area of the Britannia landfill, which is 83 hectares (206 acres) in size, was opened in 1978, and received about 4 million tons of waste before closing in 2001. Figure 3 shows the study area of the Keele landfill, which is approximately 376 hectares (929 acres) in size, was opened in 1983, and received about 28 million tonnes of waste before closing at the end of 2002. Thus, the Keele site is significantly larger in both physical size (4.5 times) and waste volume (7 times).[2] Most existing studies have found that the values of properties are least affected adversely after the landfill is closed (Havlicek et al., Gamble et al., Nelson et al.), and accordingly, the time period selected for the sales was July 01, 1987 to June 30, 1991 to minimize closure issues in the estimation.

The residential district around the Keele site has a very similar development history as the Britannia area. According to 1991 census profiles, age group composition was very similar. For example, the age group, 25 to 44 years old, accounts for 38% in both areas. Median household income was slightly higher for Britannia ($65,252) than Keele ($61,777). Population density was also higher around the Britannia site. Table 1 shows some descriptive statistics for both sites, indicating only minor differences in the structural qualities of houses across the two areas.

[1] O'Leary and Walsh (2002) report that the number of municipal solid waste landfills in the United States has declined from 7,379 in 1989 to 2,216 in 1999. Capacity, however, has remained relatively constant.

[2] Although Britannia was open four years longer than Keele, the annual waste volume at Keele remained substantially higher.

	Keele Landfill		Britannia Landfill		Total Sample	
Variable	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
#BEDROOM	3.619	0.545	3.814	0.501	3.771	0.518
#BATH_PCS	7.054	2.205	7.690	2.429	7.547	2.395
#GARAGE	1.692	0.599	1.888	0.403	1.844	0.462
BSMT	0.317	0.466	0.202	0.401	0.228	0.420
RERUN	0.547	0.499	0.589	0.492	0.580	0.494
CAC	0.586	0.493	0.495	0.500	0.516	0.500
FIREPLACE	0.858	0.350	0.927	0.260	0.912	0.284
LOTSIZE	5673.595	1636.462	4892.447	1305.142	5068.338	1423.976
DIST_LF	1507.166	490.346	1724.754	688.978	1675.760	655.751
PRICE	238097.0	27913.74	228647.9	47845	230775.6	44316.8

Table 1. Descriptive statistics for Keele landfill area (N=331) and Britannia landfill area (N=1139).

The study area boundary was 3 kilometers from the edges of each landfill. The data set included 1,470 single house sales records for both study areas (1,139 records for Britannia, and 331 for Keele), which were obtained for the four-year study period from the database of the Multiple Listing Service (MLS) in Toronto. All information except distance measurements in the regression model was obtained from the MLS.

Correct estimation of economic prices of housing characteristics depends on appropriate specification of the price and characteristics relationship (Butler, 1982). There are numerous studies that have dealt with, partially or exclusively, the specification of the price-characteristic relationship (Butler, 1982; Kain and Quigley, 1970; Graves et al., 1988; Straszheim, 1974; Cropper et al., 1988; Li and Brown, 1980). Many different functional model types such as linear, log-linear, semilog, quadratic, translog, Box-Cox linear, and Box-Cox quadratic, have been previously employed. Butler suggested that functional forms that are approximate to the correct form have been empirically found to be close substitutes. When all attributes are observed, linear and quadratic Box-Cox forms provide the most accurate estimates of marginal attribute prices, but when certain variables are not observed, a simple linear function consistently outperforms the quadratic Box-Cox function (Cropper et al.). A linear specification is used for this study.

The property prices in the model are hypothesized to be linearly related to twelve independent variables - seven in the physical attribute category, one dummy variable representing the differences in location between the two areas, and four neighborhood characteristics (lot size and distance variables). For the combined sample,

$$\begin{aligned} PRICE &= \beta_0 + \beta_1(\#BEDROOMS) + \beta_2(\#BATH\_PCS) + \beta_3(\#GARAGE) \\ &+\beta_4(BSMT) + \beta_5(RERUN) + \beta_6(CAC) + \beta_7(FIREPLACE) \\ &+\beta_8(LOTSIZE) + \beta_9(DISTLF) + \beta_{10}(LOCATION) \\ &+\beta_{11}(LOC\_DIST) + \beta_{12}(LOC\_LOTSIZE) + \epsilon \end{aligned}$$

and for the individual sites

$$\begin{aligned} PRICE &= \beta_0 + \beta_1(\#BEDROOM) + \beta_2(\#BATH\_PCS) + \beta_3(\#GARAGE) \\ &+\beta_4(BSMT) + \beta_5(RERUN) + \beta_6(CAC) + \beta_7(FIREPLACE) \\ &+\beta_8(LOTSIZE) + \beta_9(DISTLF) + \epsilon \end{aligned}$$

where $PRICE$ is the price of a house sold, in Canadian dollars, as reported in the MLS records, adjusted by the monthly New Homes Price Index[3] (NHPI); $\#BEDROOMS$ is the number of bedrooms; $\#BATH\_PCS$ is the number of bathroom pieces (sinks, tubs, etc.); $\#GARAGE$ is the number of garage spaces available; $BSMT$ is a dummy variable for the status of the basement of a house, equal to one if the basement is finished; $RERUN$ is a dummy variable indicating that the house listing was re-run after 90 days, one if yes; CAC is a dummy variable for the presence of central air conditioning, one if present; $FIREPLACE$ is a dummy variable for the presence of a fireplace, one if present; $LOTSIZE$ is the size of the property in square feet; $DIST\_LF$ is the closest distance from an edge of the landfill to the house in meters (as measured by a GIS system); and ϵ is a random error. For the entire sample, the location dummy variable $LOCATION$ (equal to one if Keele), as well as interaction terms for distance to the landfill (LOC_DIST) and lot size ($LOC\_LOTSIZE$), were used to distinguish these effects across the two sites.

There are seven independent variables representing the physical attributes of a house. The number of bedrooms and the number of bathrooms are positive indicators of house quality and are hypothesized to be positively related to the price of property. The total pieces in all bathrooms were used instead of the number of bathrooms because the former is likely to better represent the luxuries of each bathroom. The dummy variable for the basement status accounts for the differences between unfinished and finished basements. As a finished basement should add a premium to the value of a house, the coefficient is expected to be positive. The variable $RERUN$ is a proxy to indicate the general condition of a house. Other things being equal, a house that is well maintained will sell in a shorter time than an otherwise identical house in poorer condition, so that $RERUN$ is expected to be negatively related to property value. The presence of other amenities such as central air conditioning and fireplaces are expected to add to the value of a house, as indicated in several other studies.

There are five neighborhood factors included in the combined model (two in the individual site regressions): the distance to the respective landfill, the land area of the property (or lot size), a location indicator, and two interaction variables. A larger lot size will provide not only an extended area for living space but also an aesthetic value to the neighborhood, and accordingly, the lot size of a house is hypothesized to be positively related to the price of property. Other neighborhood characteristics, including the distance to the CBD and the distance to the nearest highway, did not significantly affect the house price and were removed from the estimation. The distance of a house from the landfill was measured by geo-coding the addresses of homes in the study area, using GIS software. As the distance was not measured from the centre of the landfill, but instead from the edges of the landfill, the distance of each house to a multitude of points along the edges of the landfill and the shortest distance among them was used for the analysis. Interaction terms were included for the two continuous neighborhood variables, lot size and distance to the landfill, to examine differences between the two sites.

3 Regression Results

The combined regression results are presented in Table 2. Individual site estimation results are presented in Table 3. As expected from the importance of many of the included variables, most coefficients are significant at the 1% confidence level. Structural characteristics such as bedrooms and bathroom pieces were highly significant and important determinants of the sales price. The value of central air conditioning and fireplaces in each case far outweighs their respective costs and may be proxies for some omitted positive characteristic(s). The signs of these coefficients are as postulated and are the same as those found by past studies. The RERUN proxy variable has a negative relationship with property value - that is, houses that had not been sold within 90 days after the first listing were sold at lower prices than the houses sold within 90 days, other things being equal.

[3] The New Housing Price Index is a monthly series that measures changes over time in the contractors' selling prices of new residential houses, where detailed specifications pertaining to each house remain the same between two consecutive periods. The base period was 1992.

Variable	Keele and Britannia Combined Sample
#BEDROOMS	24607.52 (1737.506)***
#BATH_PCS	4872.222 (348.4904)***
#GARAGE	3206.826 (1905.109)*
BSMT	5022.119 (1916.029)***
CAC	13805.91 (1613.339)***
FIREPLACE	23944.53 (3063.421)***
RERUN	-3875.2 (1566.519)**
LOCATION	-58295.2 (8877.734)***
LOTSIZE	3.136083 (1.028337)***
LOC_LOTSIZE	10.73134 (1.292233)***
DIST_LF	9.799031 (3.433441)***
LOC_DIST	-6.686303 (3.638447)*
CONSTANT	48566.31 (10868.69)***
R^2	0.5609

Table 2. Regression results for combined sample. Standard errors in parentheses. * denotes significance at 1%, ** denotes significance at 5%, and * denotes significance at 10% level.**

From the combined sample results of Table 2, two landfill-related variables are notable. First, the location dummy variable for Keele is very large (negative $58,295) and highly significant. Therefore, the same house placed at the same distance from the landfill would be worth substantially less near the large landfill than it would be worth the same distance from the small landfill. This suggests that large landfills have a significant lump-sum impact on property values relative to small landfills (although there may also be other factors present as well). If attributable to landfill size, this difference would be consistent with the assumption that larger landfills have greater negative externalities capitalized in sales prices. Second, the distance to the landfill variables, *DIST_LF* and *LOC_DIST* are both significantly different from zero, the former positive and the latter negative. The magnitudes of these coefficients suggest that prices rise more quickly with distance as one moves farther away from the small landfill site than from the large landfill site. Moving one kilometer farther away from the Britannia site yields an estimated $9,799 larger property price, while moving the same distance farther away from the Keele site would yield only an estimated $3,112, after accounting for the lump-sum difference between the two sites and the variation in the desirability of lot sizes.

Variable	Keele	Britannia
$\#BEDROOMS$	16528.5 (2460.471)***	26684.68 (2141.238)***
$\#BATH\_PCS$	3317.137 (565.8469)***	5231.155 (412.525)***
$\#GARAGE$	9292.217 (2274.202)***	869.5343 (2543.359)
$BSMT$	-1691.735 (2672.903)	7814.621 (2369.367)***
CAC	12257.07 (2535.022)***	14589.47 (1948.26)***
$FIREPLACE$	15403.31 (3869.535)***	28483.39 (3988.792)***
$RERUN$	-4400.198 (2310.933)*	-3516.373 (1898.048)*
$LOTSIZE$	2.8636 (0.7754732)***	13.35631 (0.7854782)***
$DIST\_LF$	5.399013 (2.708442)**	3.147045 (1.360428)**
CONSTANT	97312.22 (12205.15)***	-18928.99 (8200.973)**
R^2	0.4569	0.5759

Table 3. Regression results for individual sites. Standard errors in parentheses. * denotes significance at 1%, ** denotes significance at 5%, and * denotes significance at 10% level.**

In the separate site regressions of Table 3, the coefficient of $DIST\_LF$ for houses in Keele is greater than that in Britannia by $2.25 per meter. In these regressions, the same model is fitted to each site, differing from the model in Table 2 in that the coefficients on structural characteristics are not necessarily equal across the two sites. In this case, the value placed on the number of bedrooms, number of bathroom pieces, finished basements, central air, fireplaces, and lot sizes tend to be larger at the Britannia location. This may indicate that these characteristics are in fact more valuable (suggesting the two markets are not one single market) or that the landfill scale effects spill over into other factors affecting the purchase decision. Regardless, when incorporating all factors, this does not imply that two structurally identical houses, one a kilometer away from the larger Keele landfill and the other one kilometer from the smaller Britannia landfill, would have the same value. The above mentioned lump-sum effects imply that the two houses would have the same value only if the Keele house was located farther away from the landfill than the Britannia house. From that point, a one kilometer move farther from the respective landfill would be worth $2,252 more at Keele. It is interesting to note that the sizes of the distance coefficients found in this study, CDN$3.15 per meter for Britannia (equivalent to approximately US$2.26) and $5.40 per meter at Keele (approximately US$3.89), are similar to those figures obtained by previous studies (after inflation). For example, the distance coefficients were found to be the equivalent of US$1.80 per meter in the 1960s from Havlicek et al. and US$3 per meter in the 1980s from Nelson et al.

4 Conclusion

The empirical study results have shown that the regression coefficients for the distance to the landfill and location vary depending on a landfill size (or, alternately, depending on the volume of waste a landfill handles daily). These results suggest that people perceive the nuisances or disamenities from a large landfill as being greater than those from a small landfill. The implication of a greater impact of a large landfill on property values is that a smaller landfill may be less costly in terms of total social costs associated with waste disposal, diminishing the economic advantages a large landfill possesses over a small landfill. When combined with the incentive effects of less landfill availability, small landfills may in fact be superior to large landfills overall.

The negative costs of a landfill incorporated in property values capture only a certain portion of the total external costs of a landfill. However, it does appear that consumers recognize the relative differences in external effects, and accordingly landfill siting should be considerate of scale effects. Further, given that a large-scale landfill may also be operational for a longer period, the results of this study suggest that residential development would be hindered more significantly by a large landfill area than a small landfill.

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