Draft and Preliminary
Please do not cite.

Merger Analysis in Geographically Differentiated Industries With Municipal And Private Competitors:

The Case of Solid Waste Disposal

Rene Kamita
Department of Economics
University of California, Berkeley

September 20, 2001

Abstract

Geographic differentiation is an important characteristic for a wide variety of industries ranging from banking services to healthcare provision to food retail. Building on recent advances in demand estimation for differentiated products, this paper examines the impact of mergers in an industry where the primary dimension of differentiation is geographic. In contrast to previous work, this paper also incorporates the presence of municipally-owned firms as competitors. As such, it seeks to answer several questions. First, to what extent does geographic differentiation confer market power? Second, is there evidence suggesting that municipally-owned firms behave differently than private firms? Finally, if municipalities do behave differently, to what extent might these firms mitigate the exercise of post-merger market power?

Using data on solid waste disposal in Illinois, I estimate a discrete choice model of demand in which waste haulers have preferences for landfills based on price and geographic location. The estimates suggest that the average landfill own-price elasticity is almost –4 and that the average price-cost margin for private landfills is 33%. Implied cross-price elasticities suggest that competition in some areas may be regional in nature. Municipal landfills may behave differently than their private counterparts; tests reject profit-maximization but cannot reject municipalities setting prices equal to marginal costs. Finally, results from the simulation of two mergers indicate that, with few exceptions, merging firms' post-merger prices increases would have been fairly modest and that the corresponding price increases of non-merging firms' would have been even lower. In this case, the impact of municipal ownership on post-merger price increases appears to be limited.

I wish to thank my advisors Richard Gilbert, Aviv Nevo and Catherine Wolfram for their guidance and support. I would also like to thank to Karyen Chu, Thomas Hubbard, Theodore Keeler, Paul Ruud, Desiree Schaan, Carl Shapiro, Marta Wosinska and the participants in the Industrial Organization seminar at U.C. Berkeley for their helpful comments and suggestions. Special thanks are due to Chartwell Information Publishers, Inc. and the Illinois Environmental Protection Agency for their data contributions. Financial support from the John M. Olin Foundation is gratefully acknowledged. Address for correspondence: 549 Evans Hall, Department of Economics, U.C. Berkeley, Berkeley, CA 94720-3880; email: rkamita@econ.berkeley.edu.

1. Introduction

Geographic differentiation is an important characteristic for a wide variety of industries. As established long ago by Hotelling (1929), firms distinguished by horizontal differentiation may take advantage of their location by charging prices substantially above marginal costs. If transportation costs are high – that is, consumers are quite sensitive to the distances they must travel – the market power conferred by geographic differentiation will be large. The issue of identifying appropriate geographic markets has arisen in numerous merger analyses: from banking services to healthcare provision, in food retail as well as gasoline refining and marketing.[1] The extent to which geographic differentiation gives rise to market power, however, is an empirical issue. Recent cases such as *FTC v. Staples* highlight the role econometric analysis may play in identifying the price increases resulting from merging local competitors. In many cases, credible analyses of competition and pricing behavior will require the incorporation of distances and the careful estimation of transportation costs.

In this paper, I examine solid waste disposal, an industry in which competitors are principally distinguished by their geographic location. In the disposal industry, however, the exercise of market power may be offset by a second feature: municipally-owned competitors. In this industry, municipalities often run facilities alongside private, profit-maximizing competitors. Moreover, anecdotal evidence indicates that these "municipal facilities" may behave differently than their private counterparts and attempt to set prices equal to marginal costs or average total costs. If the prices set by municipal facilities 1) are lower than those of private firms, and 2) do not respond to an increase in private firms' prices, this could have considerable implications for competition in the industry.

This paper seeks to answer several questions. First, "to what extent does geographic differentiation confer market power in waste disposal?" Second, "Is there evidence suggesting that municipally-owned

---

[1] The list of industries in which geographic differentiation has spurred regulatory concern is large. For example, cases have included those in health care provision (*FTC et al. v. Tenet Health Care Corp., et al.*, *FTC v. Butterworth Health Corp.*), pharmaceutical services and products (*FTC v. McKesson Corp.*, *FTC v. Cardinal Health, Inc.*, *FTC v. Thrifty/Payless*), banking services (*U.S. v. BBT Corp.*, *U.S. v. Wells Fargo and Co.*), wireless

firms behave differently than private firms?” If municipal firms do behave in a different manner, we might further ask, “To what extent do municipal firms mitigate the exercise of market power?” The answers to these questions have implications not only for merger analysis but for concerns regarding privatization as well.

There are distinct advantages to using data from the solid waste disposal industry to address these issues. First, the *primary* source of differentiation in solid waste disposal is geographic – waste haulers base their disposal decisions largely on disposal prices and transportation costs. Second, the recent and unprecedented increase in concentration due to large mergers and the enforcement of stricter environmental regulations in waste disposal has led to heightened policy concerns regarding the exercise of market power. The importance of geographic differentiation in this industry is supported by documents filed by the U.S. Department of Justice (DOJ) in response to merger applications; concerns regarding market power are underscored by the DOJ’s intervention in several of these mergers. Third, one can exploit the role of regulation in this industry to help identify the effect of prices on demand. This allows for the consistent estimation of demand parameters despite limited information regarding firm costs. Finally, the existence of both municipal and private firms in this industry allows me examine the impact of municipalities on competition, contributing to the limited empirical literature regarding mixed oligopoly.

To answer the research questions above, I utilize a unique data set on municipal solid waste (MSW) disposal in the state of Illinois. This data set includes the prices and quantities of landfills accepting Illinois MSW during the period spanning January 1992 through June 1997. This study period is important because it allows for considerable variation in prices and shares. It also covers the enforcement of stricter federal environmental regulations that forced the closure of almost half the landfills in the state. I have extensive data on the location of landfills and the location of residents; the latter is used to proxy for the distribution of solid waste. Knowing the location of landfills and sources of MSW means that distance is generally observable and that transportation costs can be estimated. Finally, I have data on landfill ownership

---

mobile telephone service (*FTC v. SBC and BellSouth*), gasoline marketing and refining (*FTC v. Chevron*) and food throughout this period, including both the name of the landfill owner and whether the owner is a municipality.

The general estimation strategy is as follows. First, I combine the data on prices, quantities, and location to estimate price-elasticities of demand for waste disposal under a discrete choice model of demand. This model builds on recent advances in demand estimation for differentiated products and is grounded in the work of Bresnahan (1981), Berry (1994), and Berry, Levinson and Pakes (1995) (hereinafter BLP (1995)). The own- and cross-price elasticity estimates are then used to discuss geographic market definition for waste disposal in Illinois.

I next combine the estimates of demand parameters with information about landfill ownership to “back out” the implied marginal costs under different models of supply-side conduct. These marginal costs are used to calculate implied market power as in Nevo (2001). However, because there are both municipal and private competitors, I modify the Bertrand-Nash assumption traditionally employed to accommodate “mixed oligopoly”. Tests are run using the implied marginal costs under the mixed oligopoly model of supply and the traditional Bertrand-Nash model to determine whether municipal landfills appear to behave in a profit-maximizing way. Finally, I combine the implied marginal costs from the “appropriate” model of supply to simulate the price increases following two mergers.

Estimates under a model of Logit demand with simulated distances (Distance model) suggest an average landfill own-price elasticity of approximately –3.8. An examination of cross-price elasticities indicate that competition in some areas may be regional in nature. The implied average price-cost margin (PCM) for private landfills is 33%. Tests of municipal firm behavior indicate that municipal firms may not behave as profit-maximizers. However, I could not reject a model in which municipal firms set prices equal to marginal costs. Mergers were both simulated under models in which municipalities acted as profit-maximizers, and continued to set prices equal to marginal costs post-merger. The results suggest that, with a few exceptions, merging firms’ post-merger prices increases

---

marketing (*FTC v. Albertson’s, Inc*., *FTC v. Ahold*).

would have been fairly modest and that the corresponding price increases of non-merging firms would have been even lower. For the most part, municipal landfills are not close competitors to the merging parties and the impact of municipal ownership appears to be limited.

This paper is organized in the following way. Section 2 describes the solid waste disposal industry, including trends in concentration and antitrust concerns. The model of demand and supply is presented in section 3. Section 4 describes the data set and estimation procedure, and includes a discussion of the instruments and identifying assumptions. Results of demand estimation under both a Logit model of demand and a model that incorporates simulated distances are presented in Section 5. Section 6 presents the applications based on these estimates, including demand elasticities, price-cost margins, and merger simulations. The test of supply-side conduct is also described. Section 7 concludes and provides research extensions.

2. Concentration and Mergers in the Solid Waste Disposal Industry

2.1 The Solid Waste Disposal Industry

Municipal solid waste, more commonly known as “trash” or “garbage”, includes solid waste generated by households and commercial establishments.[2] MSW haulers provide waste collection services to residential and commercial areas. Once a hauler collects a truckload of MSW, she may “direct haul” the waste to a landfill or incinerator. If there are no landfills or incinerators nearby, she may decide to dispose of the load at a transfer station. Waste taken to a transfer station is consolidated into a larger vehicle, and hauled in bulk to a more distant facility, usually a landfill. Of the 437 million tons of MSW managed in the U.S. per year, 69 percent were landfilled, 23 percent were recycled, and eight percent were incinerated.[3]

Within the last ten years, concentration in waste disposal has increased dramatically. Nowhere is this trend more pronounced than among landfills. In 1991, the number of landfills in the U.S. numbered 5,726.

---

[2] For example, MSW may include food scraps, clothing, grass clippings, or product packaging. MSW does not include special wastes (e.g. medical or industrial waste), hazardous waste, or construction and demolition debris.

[3] See Repa (2000).

By 1997, this number fell by 56 percent to 2,514. The change in the number of landfills is widely attributed to the promulgation of stricter environmental regulations. Specifically, the U.S. Environmental Protection Agency made effective a set of regulations referred to as "Subtitle D" regulations on October 1991, although various deadlines extended through 1997. The primary impact of these regulations was to increase the fixed costs of operating a landfill, resulting in the closure of many small landfills.

A side effect of Subtitle D enforcement was a reduction in the percent of municipally-owned landfills. Municipal ownership, generally declining since the mid-1980s, dropped sharply between 1996 and 1998.[4] However, municipalities continue to own a substantial number of landfills. In 1998, sixty-four percent of landfills were owned by public agencies.[5] The future of municipal ownership remains uncertain. While some reports have suggested that close to a third of municipalities with populations greater than 100,000 are considering privatization, trade articles have also described a "reverse-privatization" movement.[6]

Exacerbating the trend in concentration has been the rapid pace of mergers and acquisitions in the industry.[7] Most prominent among these are the recent mergers that consolidated the four largest national waste management firms into two. In July 1998, USA Waste Services, Inc. (USA) merged with Waste Management, Inc. (WMI).[8] A year later, Browning-Ferris Industries (BFI) merged with Allied Waste Industries (Allied).[9] The DOJ intervened in both cases, requesting the divestiture of numerous facilities before allowing the mergers to proceed. In its Complaint challenging the Allied-BFI merger, the DOJ wrote:

---

[4] Eighty-three percent of landfills were owned by the public sector in 1984.

[5] Repa, Edward. (2000) "Solid Waste Disposal Trends," *Waste Age*.

[6] See O'Connell, Kim. (2000) "Taking Back the Streets," *Waste Age*, and O'Connell, Kim. (2001) "Back in the Game," *Waste Age*.

[7] See, for example, "Solid Waste Handling Mergers Propel the Industry Toward More Consolidation," *Environment Today*, (January/February 1995) and Jones, Scott. "The Latest Moves in Waste Industry Consolidations," *Waste Age*, (May 1997).

[8] According to the *Wall Street Journal*, "Mr. Drury said he is hoping that, with some weaker companies gone from the industry in recent years and continuing consolidation, disposal prices can be increased without losing customers." John E. Drury is the former CEO of Waste Management, Inc. *Wall Street Journal*, (August 18, 1998).

[9] When the USA Waste Services, Inc. and Waste Management, Inc. merger was approved in July 1998, Waste Management was ranked first and USA Waste was ranked third. When Allied Waste Industries, Inc. acquired Browning-Ferris Industries, Inc., the companies were ranked third and second, respectively. These rankings are based on disposal revenues. (Waste News)

> "[A]ccess to a suitable all-purpose MSW landfill at a competitive price is essential. Haulers are often limited to landfills located in close proximity to the areas from which they collect waste because of the high transportation costs. Moreover, natural barriers and congested highways contribute to the substantial travel time in getting to more distant landfills."[10]

According to the DOJ's Complaint, waste disposal tends to occur in "highly localized" markets. In both mergers, the DOJ argued that transportation of waste over significant distances was very costly, leading haulers to "strongly prefer" local disposal sites. Moreover, the agency maintained that entry in waste disposal is costly and slow: "Suitable sanitary landfills are difficult and time-consuming to obtain, and sometimes difficult to expand because of the scarcity of suitable land, local resident opposition, environmental concerns, and government regulation." (USDOJ, 1999) The DOJ has consequently held that it is unlikely for new entry to mitigate an increase in post-merger prices in a timely manner.

This research focuses on *final* disposal. That is, it examines the competition between landfills for truckloads of MSW both from transfer stations and from direct hauls. This focus is due in part to data limitations. However, market power in final disposal is also at the heart of competitive concerns in this industry. If landfills have substantial market power, this raises concern not only for horizontal mergers but for vertical mergers with transfer stations and/or haulers as well. For example, if a firm owns both landfill and hauler operations in an area, it may raise disposal prices in an attempt to "raise rivals' costs." If the only other disposal options non-integrated haulers face are distant landfills, these haulers will effectively face higher costs.

2.2 Solid Waste Disposal in Illinois

The state of Illinois was selected primarily for data reasons that will be discussed a later section. Nevertheless, Illinois trends in consolidation mirror the national trends described above. At the beginning of 1992, there were 104 Illinois landfills accepting MSW; by the end of 1997, the number fell to 59. Forty-five of the landfills that exited indicated they did so in response to the Subtitle D regulations.

---

[10] See U.S. v. Allied Waste Industries, Inc. and Browning-Ferris Industries, Inc. Case No. 1:99 CV 01962, July 20, 1999.

Illinois has historically had less municipal landfill ownership than suggested by the national averages. At the beginning of the study period, twenty-nine landfills, or 28 percent, were municipally owned. Many of these landfills closed under Subtitle D: by the end of June 1997, twelve municipal landfills remained (20 percent of total landfills).

Illinois waste disposal also experienced a number of changes in ownership as a result of merger activity. Between 1992 and 1997, Allied acquired five landfills. USA Waste acquired three landfills, as did Waste Management, and BFI acquired one. Before approving the recent merger between Allied and BFI, the Justice Department directed that BFI sell all four of its landfills in Illinois. (See Final Judgment.)

Landfills play a larger role in MSW disposal in Illinois than national percentages suggest. First, a low percentage of Illinois waste is incinerated, ranging between 0.5 to 1.6 percent over the study period. Precise data on the percent of MSW recycled is unavailable; the IEPA does not require transfer stations to report the quantities of MSW or recyclables accepted. However, survey estimates of the percent of Illinois MSW recycled range from just over 11 percent in 1992 to 19 percent in 1995 to “more than a quarter” in 1997. (IEPA Reports.) Together, these estimates suggest that the percentage of Illinois MSW landfilled ranged between 87 percent in 1992 to a little less than 75 percent in 1997.

3. Theory

3.1 Demand

Demand for waste disposal is modeled using a discrete choice framework. Once a hauler picks up her truckload of waste, she chooses a landfill to frequent. Specifically, $i = 1,\ldots,N$ haulers (consumers) choose one of $j = 1,\ldots,J$ landfills to frequent at time $t = 1,\ldots,T$. Haulers may either “direct haul” their waste – that is, transport waste directly from residences or businesses to the landfill – or take their waste to a transfer station. If the hauler takes her waste to a transfer station, another hauler later takes this waste to a landfill. As such, consumers of waste disposal include both direct and transfer haulers.

From the hauler’s perspective, landfills are principally distinguished by the prices charged for disposal and the transportation costs that must be incurred to get to the landfill’s location. The hauler is interested in minimizing her cost of disposal. The cost (per ton) of disposal for hauler i to dispose of waste at landfill j at time t can be written:

$$h_{ijt} = p_{jt} + g\left(d\left(L_{it}, L_j\right); t\right) + x_{jt} b + x_{jt} + e_{ijt} \qquad (1)$$

where p_{jt} is the price per ton charged by facility j for waste disposal at time t, $g(d(L_{it},L_j);\tau)$ is the transportation cost incurred, x_{jt} includes other observable landfill characteristics, ξ_{jt} reflects factors that affect the hauler's cost of going to landfill j at time t but are unobserved by the researcher, and ε_{ijt} is a mean zero stochastic term.

Distance from the hauler's location L_{it} to the landfill's location L_j is represented as $d(L_{it}, L_j)$.[11] Other observable landfill characteristics include county fixed effects and a dummy variable equal to one if the landfill is owned by a municipality. The county variables may pick up the effects of county taxes as well as potential differences in regulatory stringency. Unobserved landfill characteristics may include differences in landfill road quality or service, controlling for county location. They may also include seasonal effects or changes in the perceived "riskiness" of going to a particular landfill while the status of flow control regulation was uncertain. Finally, the mean zero stochastic term includes unexpected cost shocks such as those stemming from an accident along hauler i's travel to landfill j. I assume that haulers and landfills observe all product characteristics when making decisions.

These J landfills include those within the state of Illinois as well as those in neighboring states near the Illinois border. As such, the J landfills include all landfill disposal alternatives available to Illinois haulers. That is, in this model, there is no "outside option" for haulers to turn to.[12] If the applications included simulating the effects of large changes in price for landfills near the borders of Illinois, this would be a

---

[11] The locations of landfills do not change over time. However, the locations of haulers may do so due to shifts in the distribution of population or seasonal effects.

[12] One could ask why recycling or incineration is not an outside option. While incinerators should technically be included as disposal facilities, they do not play a significant role in this state. Recycling may not be an effective alternative for MSW haulers. Not all MSW is recyclable. In fact, since waste generators typically separate recyclables out for curbside collection, one might expect that the loads MSW haulers collect do not contain large amounts of recyclable material.

problematic assumption. However, for a moderate range of price increases, this impact of this assumption will be limited.

Since haulers go to the landfill that minimizes disposal costs, the set of haulers who choose to frequent landfill j (the market area of landfill j) is given by:

$$A_{jt}(p) = \{(L_i, \varepsilon_{ijt}) : h_{ijt} < h_{ikt}, k = 1,\ldots,\mathrm{K}\} \tag{2}$$

The market share of facility j at time t is:

$$s_{jt}(p) = \int_{A_{jt}} dP(L,\varepsilon) = \int_{A_{jt}} dP(\varepsilon)\,dP(L) \tag{3}$$

where the second equality holds if ε_{ijt} is distributed independent of transportation costs.

If ε_{ijt} follows a Type I extreme value distribution, this corresponds to the Multinomial Logit model. The variance of ε_{ijt}, given by $\mu^2\pi^2/6$, is usually not identified apart from the coefficient estimates and is generally assumed equal to one. Here, however, I assume that the “coefficient” on price in equation (1) is equal to one, so that a \$1 increase in disposal price leads to a \$1 increase in hauler cost. Consequently, I am able to explicitly model the variance of ε_{ijt}. Specifically, if the variance of ε_{ijt} is $\mu^2\pi^2/6$, the probability that hauler i goes to facility j at time t can be expressed as:

$$s_{ijt}(p) = \frac{\exp\left\{\dfrac{-p_{jt} - g(d(L_{it}, L_j);t) - x_{jt}\beta - \xi_{jt}}{\mu}\right\}}{\sum_{k=1,\ldots,J}\exp\left\{\dfrac{-p_{kt} - g(d(L_{it}, L_k);t) - x_{kt}\beta - \xi_{kt}}{\mu}\right\}} \quad \text{or}$$

$$s_{ijt}(p) = \frac{\exp\{-\alpha^* p_{jt} - \alpha^* g(d(L_{it}, L_j);t) - x_{jt}\beta^* - \xi_{jt}^*\}}{\sum_{k=1,\ldots,J}\exp\{-\alpha^* p_{kt} - \alpha^* g(d(L_{it}, L_k);t) - x_{kt}\beta^* - \xi_{kt}^*\}} \tag{4}$$

where $\alpha^* = 1/\mu$, $\beta^* = \beta/\mu$, and $\xi_{jt}^* = \xi_{jt}/\mu$. The higher μ, the higher the variance of the unexpected cost shocks and the lower the sensitivity of haulers to prices, distances, and landfill characteristics.

3.2 Supply

Much of the empirical literature on market power in differentiated products industries assumes that firms set prices to maximize profits through a static Bertrand game.[13] However, the model of supply for waste disposal may differ from the supply-side behavior traditionally assumed. In this industry, both municipalities and private firms may own competing landfills. As a result, competition in waste disposal may be characterized as a "mixed oligopoly."

There is little *empirical* evidence regarding the impact of municipal firms on private firms' behavior.[14] The use of the municipal, or "public", firm as an instrument to increase welfare in markets with few competitors and limited entry, however, is well-documented in the theoretical literature.[15] For the moment, I focus on merger predictions under two scenarios: all firms compete Bertrand-Nash, and private firms compete Bertrand-Nash while municipalities set price equal to marginal cost or average total cost. Articles regarding optimal landfill pricing have suggested that municipalities should set price equal to variable (marginal) cost per ton.[16] Anecdotal evidence suggests that prices at municipal landfills may be set to "break-even", so that tipping fees are equal to average total cost per ton.[17]

---

[13] For example, see BLP (1995), Nevo (2001), and Thomadsen (1999).

[14] There is a growing literature on non-profit and for-profit competition among hospitals. However, the literature has by and large focused on the impact of mergers among *private*, non-profit hospitals; there is little done regarding the role or behavior of public or government-owned hospitals. See Dranove and White (1994); Blackstone and Fuhr (1992); and Keeler, Melnick and Zwanziger (1999). [cable]

[15] Generally speaking, public firms are able to limit the market power of private firms by setting lower prices. The "mixed oligopoly" literature includes work by Merrill and Schneider (1966), Harris and Wiens (1980), De Fraja and Delbono (1990), Cremer et al. (1991), and Anderson et al. (1997). Most studies conclude that public firms are welfare enhancing. However, most studies also assume that the private and public firms are equally efficient (face the same costs) and that there are no principal-agent problems. Not surprisingly, these studies tend to find that welfare is maximized when the industry is nationalized. . In a recent contribution, Anderson, De Palma and Thisse (1997) examine the impact of a municipal firm in a differentiated products industry. In the short-run, the municipal firm enhances welfare because it sets a lower price than a private firm otherwise would. However, in the long-run, lower prices may also deter welfare-enhancing entry.

[16] These articles generally do not consider competing disposal facilities. See, for example, Ready and Ready (1995). This is consistent with a story in which the landfill's objective function is to maximize consumer (but not producer) surplus.

[17] This was suggested by municipal landfill operators in telephone conversations. It was also documented in responses to mailed out surveys.

3.21 All Landfills are Profit-Maximizers.

Let there be f = 1,…,F firms, each of which owns some subset g_f of j = 1,...J landfills at time t. For example, BFI may own both landfill j and landfill m. The profits of firm f are:

$$\Pi_f = \sum_{j \in g_f} (p_j - c_j) s_j(p) Q - C_f$$

where Q is total demand and $s_j(p)$ is the market share of landfill j, which depends on the prices of all facilities. C_f is the fixed cost. Assuming the existence of pure-strategy Bertrand-Nash equilibrium in prices and that the prices supporting it are strictly positive, the profit maximizing price p_j of any landfill j satisfies the following first order condition:

$$s_j(p) + \sum_{r \in gf} (p_r - c_r) \frac{\partial s_r(p)}{\partial p_j} = 0 \tag{5}$$

This set of J equations implies price-cost margins for each landfill. If two (or more) landfills are located close together, there will be a high degree of substitution between them. A firm that owns nearby landfills will have an incentive to keep prices higher than would otherwise prevail if each landfill were owned by a separate firm. The closer the landfills are, the larger the term $\partial s_r(p)/\partial p_j$ will be.

Let $S_{rj} = -\partial s_r/\partial p_j$ for j, r = 1,...J. Also define the J x J matrix **Ω*** such that

$$\Omega_{rj}^{\ *} = \begin{cases} 1 \text{ if landfills j and r are owned by the same firm} \\ \qquad\qquad 0 \text{ otherwise} \end{cases}$$

If each landfill is owned by a different firm, **Ω*** = identity matrix; if all the landfills colluded and acted as a monopolist, **Ω*** would be a matrix of ones. Let $\Omega_{rj} = \Omega_{rj}^* \times S_{rj}$. Then s(p) - **Ω** (p-c) = 0, or

$$p - c = \Omega(p)^{-1} s(p) \tag{6}$$

In this way, one can calculate the implied PCM given demand estimates and information on ownership. Moreover, one can use the marginal cost estimates implied by this equation to predict the impact of a proposed merger. That is, equation (6) can be rewritten:

$$\hat{c} = p - \Omega(p)^{-1} s(p)$$

Assuming marginal costs do not change post-merger, the prices predicted to prevail post-merger would solve:

$$p^* = \hat{c} + \Omega_{post}(p^*)^{-1} s(p^*)$$

The post-merger prices (p*) affect post-merger shares as well as the partial derivatives of demand. This amounts to solving a system of J non-linear equations.

3.22 Municipal Landfills Price at Marginal Cost or Average Total Cost

Suppose there are m = 1,…,M municipal landfills, where M ≤ J. If the municipal landfills set prices equal to marginal costs, their prices p_m will be set such that:

$$p_m = c_m \qquad (7)$$

where c_m is muncipal landfill m's marginal cost. If instead the municipal landfills set prices equal to average total costs, the prices would be set such that:

$$p_m = c_m + \frac{C_m}{\overline{Q}_m} \qquad (8)$$

where C_m is the fixed cost of landfill m and $\overline{Q}_m$ is the total capacity of landfill m.

In both cases, the J-M private landfills continue to set prices to maximize profit. Their FOCs remain the same as those given in equation (5).

If municipal landfills set prices equal to marginal costs, their PCM will be zero. If, however, they set prices equal to average fixed costs, their margins will be attributed to fixed costs while those of private landfills may include profit. If landfills are indeed setting prices equal to average total costs, I will not be able to identify the PCM of the municipal landfills without additional information on fixed costs. However, I can still estimate the impact of different ownership structures, including mergers, without this information.

Consider the impact of different pricing strategies by municipal firms on the predicted impact of a merger between two private firms facing municipal "competition." If *all* firms set prices to maximize profit, a merger between the two private firms would lead all other firms (including the municipal ones) to increase their price as well.[18] If municipal firms instead set prices equal to marginal cost or average total cost and these costs do not change post-merger, the municipal firms will keep their prices constant, constraining the ability of other firms to raise their price. The price set by municipal landfill m is assumed to be:

$$p_m{*} = p_m^{pre-merger}$$

Meanwhile the prices prevailing post-merger for private firms j ≠ m solve:

$$p{*} = \hat{c} + \Omega_{post}\left(p{*}\right)^{-1} s\left(p{*}\right)$$

where the vector p* contains both prices set by municipal firms (assumed equal to pre-merger prices) and prices set by private firms. If the prices of municipal firms (p_m*) are lower than they would otherwise be under Bertrand-Nash competition, this will lower the second term. This implies lower post-merger margins for firm j.

4. The Data Set and Preliminary Estimation

4.1 Data

The data set used in demand estimation consists of quarterly average landfill “gate rate” prices (tipping fees) and quantities (intakes) for the period spanning January 1992 through June 1997 for the state of Illinois.[19,20] Price data was provided courtesy of Chartwell Information Publishers, Inc. Quantity and address data were provided by the Illinois Environmental Protection Agency (IEPA); Illinois was selected because the IEPA collects excellent records regarding landfill intake and tons accepted from out-of-state haulers. The data set also includes location variables (latitude and longitude) which were recovered using

---

[18] This assumes that the impact of any post-merger reductions of marginal costs on price will be offset by the increase in market power. It seems unlikely that there would be reductions in marginal costs of due to the merger of two (or more) landfills.

[19] Gate rates are similar to “list” prices.

[20] Quarters are defined on the calendar year. For example, the first quarter includes the months January, February and March. As such, the study spans the first quarter of 1992 through the second quarter of 1997.

ETAK geocoding software.[21] A map of all landfills that accepted Illinois MSW during the study period is provided in Figure 1.

Ownership data includes owner names, dates of ownership changes, and whether the owner is a municipality. This information was gathered from IEPA reports, as well as from the 1992 – 1998 editions of the Merger Yearbooks compiled by Securities Data Corporation. Ownership data was subsequently sent to local IEPA officials for verification.

The total market is defined to include MSW generated within the state of Illinois (IL MSW). Table 1 provides a snapshot of waste generation, average intake, and average tipping fees over the study period. Illinois residents and businesses generate approximately 1 million tons of MSW per month. The average tons disposed per landfill increases dramatically through 1996; by 1996, the mean tons disposed per landfill is 1.7 times the average intake in 1992. This reflects the closure of many small landfills in response to stricter environmental regulations. This fall in the number of landfills also coincides with a general rise in tipping fees over time. See Figures 2a and 2b.

Most of the MSW generated in Illinois is taken to Illinois landfills for final disposal. A fraction of waste, however, is sent to facilities in other states. Most of the waste going to out-of-state facilities is generated in the Chicago-Cook County area and is taken to landfills in Indiana and Wisconsin.[22] The fraction of waste going out-of-state has varied from year to year, dipping to 6 percent in 1994 and climbing to 18 percent in 1997. Dips in out-of-state shipments between 1993 and 1995 may reflect higher out-of-state disposal prices as well as anxiety over pending flow control legislation.[23] While the fraction of waste disposed out of state has varied, the set of landfills receiving IL MSW has remained relatively constant over the study period.

---

[21] If addresses were either not found, or not available, landfills were mapped to the center of their zip code.

[22] CRS reports indicate that approximately two-thirds of Illinois out-of-state waste shipments go to Indiana; the remaining third go to Wisconsin.

[23] Prior to 1994, many states passed flow control restrictions that banned disposal facilities from accepting waste generated outside their state. In June 1994, the Supreme Court issued a ruling stating that such restrictions violated the Interstate Commerce Clause and were, as such, unconstitutional. For the first 8 months of 1995, a Wisconsin statute effectively allowed the state to reject out-of-state waste shipments if Wisconsin did not approve of the recycling program of the originating out-of-state county. This was struck down in August of 1995.

Table 2 provides a further description of the variables used in this analysis. The first table reports summary statistics for all landfills in the sample. The average tipping fee for landfills that accepted IL MSW during the study period is $25.15 per ton; the average intake is 13,523 tons per month.[24] Market shares are calculated by dividing a landfill's intake by the total IL MSW generated. The average market share based on intake is one percent.

Twenty-two percent of landfills during this period are municipally owned. Among the counties in Illinois with at least one landfill, the average number of landfills per county is approximately two. The average number of landfills within 50 miles of a given landfill is almost 20.

The data on landfills was supplemented with U.S. Census data on the population distribution of Illinois over the study period. I use the population distribution to proxy for the location of waste generation. Illinois has a total residential population of approximately 12 million people. Approximately a quarter of the population resides in the city of Chicago; about 40 percent of the total population lives in Cook County.[25] Outside of Chicago, the next largest city is Rockford with approximately 150,000 residents (a little over 1 percent of the total population). The capital of Illinois, Springfield, has about 120,000 residents. While Illinois has witnessed some changes in population distribution during the study period, these have been modest.

---

[24] Sixty-one percent of the reported fees are reported in dollars per cubic yard. These fees were converted to dollars per ton using a standard industry rule of thumb that allocates 3.3 cubic yards to a ton. Thirteen percent of the fees provided by Chartwell were estimated. The estimation procedure used by Chartwell was replaced by one which used linear interpolation to estimate the "missing" fees of a given facility.

4.2 Estimation

This section outlines the estimation procedure used to calculate demand parameters given the data described. Following Berry (1994) and BLP (1995), the Generalized Method of Moments (GMM) estimator is used. The set of moments is defined by the interaction of a set of valid instruments with the "error term" ξ_{jt}* presented in Section 3.1. Estimation is based on the moment condition:

$$E\left[Z \cdot w\left(q^{*}\right)\right] = 0 \tag{9}$$

where Z = [$z_1,\ldots,z_M$] is a set of instruments that are uncorrelated with the unobserved error term ξ_{jt}*, ω is a function of the estimated parameters and is analogous to ξ_{jt}*, and θ* includes the true value of parameters α*, β*, and τ*. The parameter estimates are those that minimize the objective function:

$$\hat{q} = \arg\min_{q} w\left(q\right)' ZA^{-1}Z'w\left(q\right) \tag{10}$$

where A is a consistent estimate of E[Z'ωωZ']. This section describes the computation of the error term. The following section will describe the instruments.

The probability of hauler i going to landfill j at time t was given in Section 3.1 by Equation (4). These individual probabilities are calculated using the data on landfills and the computed distances between landfill locations and draws from the empirical distribution of Illinois residents' locations.[26] It is assumed that transportation costs are linear in distances. Because I have firm level rather than individual level data, however, it is necessary to convert these individual probabilities to aggregate market shares. Aggregate market shares can be computed by numerically integrating over the distances:

$$s_{jt} = \frac{1}{ns}\sum_{i=1}^{ns} s_{ijt} = \frac{1}{ns}\sum_{i=1}^{ns} \frac{\exp\left\{-a^{*} p_{jt} + x_{jt} b^{*} - t^{*} d_{ijt} + x_{jt}^{\ *}\right\}}{\sum_{k=1,\ldots,J} \exp\left\{-a^{*} p_{kt} + x_{kt} b^{*} - t^{*} d_{ikt} + x_{kt}^{\ *}\right\}} \tag{11}$$

where ns is the number of random draws on hauler location, d_{ijt} is the distance between hauler i and landfill j, and τ* = τ/μ. The extreme value distribution is used to integrate the ε's analytically.

---

[25] Approximately 60 percent of the total population lives in Cook County and its suburbs (including the counties of Lake, McHenry, Kane, Dupage, and Will).

One approach to estimation would be to find the parameters that minimize the distance between the observed shares and the predicted shares. This would require non-linear minimization to compute all of the parameters, including the seventy-one county fixed effects. One of the contributions of Berry (1994) is to demonstrate how one can transform what would otherwise be a complicated non-linear minimization problem into one in which some of the parameters enter linearly. Moreover, by isolating the “error term” ξ_{jt}* one can use instrumental variables to deal with endogeneity in the regressors.

It is useful here to recognize that hauler cost can be categorized into two parts: a part that varies with haulers (distance) and a part that does not (prices, landfill characteristics). In particular, the portion of costs that are “hauler invariant” can be expressed as:

$$d_{jt} = -a^* p_{jt} - x_{jt} b^* - x_{jt}^*$$

As can be seen, if one can calculate δ_{jt}, one can back out the implied error term ξ_{jt}*. The δ_{jt}’s are computed by solving the set of implicit equations equating the predicted shares in (11) to the observed shares:

$$s_{jt}\left(d_{jt};t\right) = S_{jt}$$

This requires the inversion of the market share function and is done numerically following the contraction mapping argument in BLP (1995).

Once the δ_{jt}’s are recovered, ω_{jt} is computed using estimated parameters:

$$w_{jt} = \left(-\hat{a} p_{jt} - x_{jt}\hat{b}\right) - d_{jt}\left(S_{jt};\hat{t}\right) \equiv x_{jt}^* \qquad (12)$$

In summary, the estimator takes a given value of τ and computes the value of δ_{jt} that equates the predicted shares to the observed shares. The implied error term is the difference between δ_{jt} and what is predicted by the linear parameters α* and β*.The estimator then takes the implied error term and chooses the parameters that minimize objective function. Because the first order conditions of the minimization problem are linear in α* and β*, the non-linear search is limited to τ*.

---

[26] Euclidean distances are calculated.

4.3 Instruments

Consistent parameter estimates require a set instruments uncorrelated with the error term ξ_{jt}*. If the regressors themselves are uncorrelated with the error term, they serve as valid instruments.[27] While this argument can be made for "long-term" landfill characteristics such as county location and whether the landfill is municipally-owned, it is difficult make this argument for price. In this section, I discuss how I exploit the role of regulation in this industry to create instruments for price.

It is first worth explicitly discussing what goes into the error term ξ_{jt}*. Broadly speaking, this term encompasses factors that influence the demand for disposal at landfill j at time t controlling for the effects of price, county location, whether the landfill is municipally-owned, and simulated distances. Specifically, ξ_{jt}* might include seasonal or weather related factors that affect demand for disposal at landfills in one area over another.[28] It might also include landfill characteristics such as landfill road conditions or service quality. Finally, ξ_{jt}* might reflect the extent to which certain landfills were perceived as "risky" while the status of flow control and other related regulation was uncertain. Since it is highly plausible that these factors will affect prices, neglecting to instrument for price will result in a price coefficient that is biased towards zero. Indeed, it will be shown in the following section that instrumenting for price makes a substantial difference in the coefficient estimate.

There are generally two types of instruments one might consider: variables that proxy for marginal cost and those that proxy for the degree of competition faced by the firm. In the results that follow, I use both types of variables. To capture potential operating economies of scale, I create a variable based on the average intake over the lifetime of the landfill. The average intake over the lifetime of the landfill is highly correlated with its design capacity, which is determined at the time of siting. In general, landfill size is determined by long-run variables and factors such as zoning restrictions. The overall size of the landfill

---

[27] Or more generally the derivatives of the moment function with respect to the parameters.

[28] For example, if more people tend to travel to the city to shop and eat during the holidays this would affect the distribution of waste.

does not respond to short-run price fluctuations. The categories were based on those used by Chartwell Information Publishers, Inc.[29]

The second category of instruments includes own product and competitors' product characteristics; these proxy for competitive pressure and affect the margins that can be charged. I also create instruments of this type: the number of landfills within a county and number of landfills within 50 miles.[30] Though in most cases the variation in number of landfills over time may itself be endogenous to price changes, this concern is mitigated in this industry. First, the extent to which the number of landfills within a given area responds to certain long-run features (near population centers, low land costs), is captured by the inclusion of county fixed effects in estimation. As such, the remaining variation in the number of landfills variables is over time. And much of the variation over time during the study period was induced by regulatory mandate or capacity constraints. Close to 90 percent of the 51 landfills that exited did so due to Subtitle D regulations; under Subtitle D regulations, landfills were required to comply with more stringent environmental regulations or shut down by certain dates. Compliance involved an increase in fixed costs. For example, landfills were required to install thicker liners. The remaining ten percent of landfills that exited during the study period did so because they ran out of capacity.

Moreover, entry, which occurred on a very limited basis during the study period, is a highly regulated and lengthy process. The developer must obtain several permits before entering.[31] According to IEPA officials, landfills enter soon after they are granted an operating permit; they not do not sit on their permits to wait for a more opportune time. The entire entry process, from siting application to opening date, takes

---

[29] Specifically, the categories are landfills with average intakes 1) less than 25 tons per day, 2) between 20 and 100 tons per day, 3) between 100 and 500 tons per day, 4) between 500 and 1,000 tons per day, and 5) over 1,000 tons.

[30] The quarter of entry is defined as the quarter in which a landfill starts accepting waste. The quarter of exit is the first quarter in which the landfill stops accepting waste.

[31] Landfills must first gain siting approval from local public authorities and go through a public hearing. They may then apply to obtain development and operating permits from the Illinois EPA.

approximately five years. Consequently, the number of landfills in a given area is likely to be due to long-run factors that are picked up by county fixed effects rather than short run price fluctuations.[32]

Under what circumstances might these instruments fail? If overall landfill size is correlated with quality of service or landfill road maintenance, this would violate the identifying assumptions. For example, if small landfills consistently have bad roads or offer better service than large landfills, this would be a problem. However, it is not clear to me that service or road maintenance should necessarily vary with the overall size of the landfill per se.

If the number of landfills within a given area varies with seasonal effects or the weather, or with the status of flow control related legislation, this would also cause the instruments to fail. However, the variation in number of landfills is not seasonal or weather related. Landfills do not “pop up” every spring. For the most part, landfills exited on the dates mandated under federal regulation or when they ran out of capacity. Also, while the long-run probability of entry may have depended on the fate of flow control related legislation, actual entry during this period was pre-determined.

Finally, a natural choice of instruments would be actual cost data. However, it has been extremely difficult to obtain cost data for this industry that exhibits sufficient cross-sectional variation.[33] A related option would be to use prices charged by the same firm for the same product in other markets as a proxy for product or “brand” specific marginal cost. Such instruments would be valid if there is a common “firm” component to the costs of the same product in different markets. They would be invalid in the face of national or regional demand shocks that are specific to the products of certain firms or certain types of firms. As a practical matter, I am precluded from using this type of instrument for two reasons. First, this analysis is not characterized by many distinct markets; while I might consider breaking up the state into

---

[32] To quote an IEPA official, “Landfills are not like oil wells – with oil wells, when the price is high, they produce and when the price is low, they don’t. Or they wait until a competitor goes out and then start producing. Landfills don’t do this.”

[33] For example, data on landfill worker wages is typically available only at the state level. Even if more disaggregate data were available, one suspects there is little variation in this variable across counties or landfills.

several local markets, this would in some sense restrict the exercise I am conducting. Moreover, a number of firms in this sample own just one landfill.

5. Results

Table 3 reports the results of estimation under both a model of Logit demand without distances ("Logit model") and one that incorporates simulated distances ("Distance model"). Column (i) presents the results of an ordinary least squares regression that does not instrument for price and does not include distances. The price coefficient of –0.03 is small and more than half of the implied own-price demand elasticities using this estimate are inelastic (less than one in absolute value). This is consistent with the idea that the coefficient is biased towards zero. When instruments for price are used, the price coefficient is –0.16, substantially larger in magnitude than the OLS estimate. The own-elasticities for all but one of the landfills are now greater than one in absolute value.[34] The instruments for price are those discussed in the previous section: number of landfills within county, number of landfills within 50 miles, and landfill size dummy variables. County and time fixed effects are also included in both stages of the estimation. The R^2 statistic for the first stage regression is 0.6525 and the F-statistic is 414.92. Both measures suggest that the instruments have some power. The Hausman test for over-identifying restrictions (1983) is rejected. It is unclear, however, whether this is due the large sample size or whether the instruments are not valid.

Column (iii) presents the results of estimation when simulated distances are included. The inclusion of distances does not appear to affect the price coefficient much. This is consistent with the idea that distances (and transportation costs) do not change much over time; these effects may already be largely controlled for by county fixed effects. Again, the own-elasticities for all but one landfill are greater than one in absolute value. The implied mean own-price elasticity using estimates from this specification is –3.8. The value of the GMM objective function at the parameter estimates is 305.85.

---

[34] The only landfill with estimated inelastic demand elasticity is Carthage Municipal. This is inconsistent with profit-maximization – under profit-maximization, firms should set prices such that their own-price demand

In all specifications, the coefficient on municipal ownership is negative and significant, implying that municipal landfills are less attractive to haulers (have smaller shares) given the effects of price, county location, and transportation costs. This coefficient may be capturing quality of service differences. It may reflect high taxes charged on tons disposed. Finally, the negative municipal coefficient might also reflect the fact that some municipal landfills may restrict the waste that they accept via contracts or by refusing service. The latter implies that the cost of going to such landfills is prohibitively high.[35]

The estimated coefficient on distance is –0.359, which translates into a transportation cost per ton-mile of $0.23.[36] This is consistent with what limited industry evidence there is regarding hauling transportation costs as well as anecdotal evidence.[37]

6. Applications

The parameters estimated in the previous section will now be used examine geographic market definition for waste disposal in Illinois. When combined with a supply-side model of conduct, they will also be used to calculate implied price-cost margins. Moreover, by assuming that the cost structures of municipal and private landfills should be roughly comparable after controlling for landfill size and county location, I can test to see to whether municipal landfill pricing behavior is consistent with Bertrand-Nash competition. Finally, I will use the demand estimates with an appropriate supply-side model of conduct to predict the impact of two mergers on disposal prices.

---

elasticity is greater than one in absolute value. For reasons which will be discussed later, profit maximization may not be an appropriate assumption for municipal firms.

[35] Only one municipal landfill indicated in the IEPA reports that it restricted intake to local waste flows. This landfill was the only one in its county, so this should have been picked up in its county fixed effect

[36] The transportation cost per ton-mile is calculated by taking the coefficient on distance τ^* and multiplying through by the estimate of $\mu = -1/\alpha$. Because distance is in tens of miles, the result should be divided by 10. (0.359*6.329/10 = 0.23 or 23 cents per ton-mile.)

6.1 Demand Elasticities and Market Definition

The advantage of using the Distance model over the Logit model is that the former allows for more realistic geographic substitution patterns. Specifically, the Distance model allows landfills that are relatively near to a given hauler to be closer substitutes than those that are further away. Under the Distance model, the price elasticities are given by the following:

$$h_{jkt} = \frac{\partial s_{jt}}{\partial p_{kt}} \frac{p_{kt}}{s_{jt}} = \begin{cases} \dfrac{-p_{jt}}{s_{jt}} a \int s_{ijt}(1 - s_{ijt}) d\hat{P}(L) & \text{if } \mathrm{j} = \mathrm{k} \\ \dfrac{p_{kt}}{s_{jt}} a \int s_{ijt} s_{ikt} d\hat{P}(L) & \text{otherwise} \end{cases}$$

where s_{ijt} is the probability that hauler i frequents landfill j, and is given by the expression in equation (4). Under the Logit model, there is no heterogeneity amongst consumers. An increase in the price at one landfill will result in a symmetric increase in shares at all of the other landfills, regardless of where they are located relative to the hauler. The implied elasticities under the Logit model are given by:

$$h_{jkt} = \frac{\partial s_{jt}}{\partial p_{kt}} \frac{p_{kt}}{s_{jt}} = \begin{cases} \dfrac{-p_{jt}}{s_{jt}} a s_{jt}(1 - s_{jt}) & \text{if } \mathrm{j} = \mathrm{k} \\ \dfrac{p_{kt}}{s_{jt}} a s_{jt} s_{kt} & \text{otherwise} \end{cases}$$

Table 4 presents the mean own- and cross-price elasticities computed under Logit demand for the landfills remaining at the end of the study period (June 1997). As indicated above, the cross-price elasticities implied by this model are highly restrictive. Under this model, a one percent price increase at Congress Development Landfill in Cook county results in a 0.23 percent increase in the shares of *all* other landfills, including Landfill 33 approximately 200 miles away in Effingham county. A map of IL MSW landfills by county is provided in Figure 3.

These results can be compared to those computed under the Distance model in Tables 5a and 5b. Table 5a presents the own- and cross-price elasticities computed under the Distance model for select landfills within varying distances of Chicago. Now location matters – under this model, a one percent increase in the

---

[37] [add cites]

price at Congress Development Landfill results in a 0.4 percent increase in shares at the neighboring landfills in the Cook, Dupage and Lake counties. In contrast, landfills that are further away have lower cross-price elasticities: Landfill 33 now receives less than a 0.01 percent increase in share from a one percent increase in the price of Congress Development Landfill.

Table 5b presents a similar table for select landfills within varying distances from Springfield. The cross-price elasticities exhibit a pattern similar to those in Table 5a: landfills that are relatively close have higher cross-price elasticities than those that are further away. The closest landfill to Springfield is Five Oaks RDF, which is 25 miles away. Notice, however, that Brickyard RDF and Southern Illinois Regional landfill have somewhat larger cross-price elasticities with Five Oaks though they are 110 and 140 miles away from Springfield, respectively. This is because they 1) are closer to Five Oaks RDF than Springfield, and 2) compete with Five Oaks RDF in other markets in southern and southeastern Illinois. Maps illustrating the distance between landfills and the cities of Chicago and Springfield are included in Figures 4 and 5.

I next examine what the computed elasticities imply regarding market definition. Market definition, often critical to merger analysis, is also frequently an issue of contention.[38] When products are differentiated, there are often no clear-cut market boundaries. Products are generally dispersed over a broad and continuous range, rather than clustered in distinct, discrete groupings. Moreover, the degree to which products within a given market compete with one another will depend on not only product characteristics, but the distribution of consumer preferences for those characteristics as well. This is particularly true for geographic differentiation.

As indicated previously, two large mergers occurred in the waste disposal industry since 1997. The first was merger between Waste Management, Inc. (WMI) and USA Waste Services, Inc. (USA) in July 1998. In 1999, Browning-Ferris Industries (BFI) merged with Allied Waste Industries (Allied). In the

---

[38] Carl Shapiro, former Deputy Assistant Attorney General in charge of economics at the U.S. Department of Justice’s Antitrust Division writes, “In my experience, the main battlefield in litigated merger cases is market definition.” (Shapiro, 1996).

WMI-USA merger, no case was brought by the state of Illinois and the merging of IL MSW landfills appears to have gone unexamined. In the Allied-BFI case, the Justice Department required the divestiture of all four BFI landfills in Illinois before allowing the merger to proceed.

Under the Complaint for Injunctive Relief filed by the Justice Department in the Allied-BFI merger, two areas of concern were identified in Illinois. The first was the Chicago area; in the Final Judgment, the Justice Department requested that BFI divest its landfills in Zion, Davis Junction, and Fairview (Fulton county).[39] In examining competitors to the existing Cook County landfills, the cross-price elasticities suggest that one might consider other landfills in the neighboring counties of Kane, Dupage, Lake, DeKalb and Will. The magnitude of the cross-price elasticities for these landfills is close in magnitude to those between the Cook county landfills themselves. Of course, this analysis should be supplemented with information regarding remaining capacity, design capacity, and any restrictions on waste accepted before policy conclusions can be drawn.[40] The permits division should also be contacted regarding potential competitors. Nevertheless, this analysis underscores the idea that waste disposal in certain areas might be considered a “regional” rather than local market.

The other market identified in the Complaint is that in Moline. In the Final Modified Judgment, the Justice Department requested that BFI’s Quad Cities landfill be divested as the number of firms in this area would be reduced from two to one.[41] Results from a full table of cross-price elasticities confirm that the three Rock Island landfills that existed during this period are close substitutes. (One landfill (Watts) closed about a year after the study period.) While no other landfills appear to be comparable substitutes, there appears to be a moderate degree of substitution between the Rock Island county landfills and those in

---

[39] The landfills in Davis Junction and Zion are new and opened after the study period.

[40] For example, Mallard Lake Landfill ran out of capacity shortly after the study period and thus would not served as an effective competitor for very long.

[41] The DOJ noted that a number of municipal landfills lie across the border in Iowa, but maintain that these are generally restricted to local, community waste disposal.

Knox, Whiteside, and McDonough counties. Again, this suggests a regional market where competitors may be as far as 50 miles away.[42]

6.2 Price-Cost Margins (PCM) and a Test of Supply-Side Models of Conduct

The demand estimates may also be combined with a model of supply to estimate predicted price-cost margins under various ownership scenarios.[43] Furthermore, if one is willing to make some assumptions about the cost structure of the industry, one can test whether municipal landfills appear to deviate from profit-maximizing behavior. Specifically, if municipalities and private firms face similar marginal costs given size and county fixed effects, one can reject that municipal landfills set prices to maximize profit. Moreover, given this assumption, one cannot reject that municipal landfills set price equal to marginal cost.

Table 6 presents average PCM under three combinations of demand and supply-side assumptions: 1) the Logit model of demand with firms and municipalities competing Bertrand-Nash, 2) the Distance model with firms and municipalities competing Bertrand-Nash, and 3) the Distance model with firms competing Bertrand-Nash and municipalities setting price equal to marginal cost. Margins for the scenario in which municipalities set price equal to average total cost were not computed due to data limitations.[44] As can be seen, the margins under the Logit Model are slightly lower than those implied by the Distance model. The average PCM for private landfills is approximately 33 percent.

Given prices and the demand parameter estimates, one can back out the marginal costs implied under different supply-side models of conduct. That is, one can take the prices during the study period and subtract the estimated margins implied by each model of conduct to calculate marginal costs. These marginal costs can be regressed on cost-related variables plus a dummy variable for municipal ownership. Under the assumption that the marginal costs faced by municipalities and private firms should be similar

---

[42] The full table of price elasticities is available upon request.

[43] PCM = (price – marginal cost)/price.

[44] This would require me to have information on the fixed costs of the thirty municipal landfills that existed during this period. While this data is technically available, it will require a trip to the IEPA permits office.

after controlling for landfill size and county location, the coefficient on municipal ownership should be not be significantly different from zero.

Tables 7a and 7b report the results of regressions run on marginal cost estimates under models assuming 1) private firms and municipalities compete Bertrand-Nash, and 2) private firms compete Bertrand-Nash while municipalities set price equal to marginal cost. Table 7a examines the former. Once fixed effects are added to control for landfill size and county location, it appears that municipalities face marginal costs that are approximately $8.00 less per ton than those faced by private firms. This suggests that if municipalities set profit-maximizing prices, it must be the case that their marginal costs are considerably lower than those of their private counterparts. While it may be possible that municipal landfills are exempt from certain per-ton taxes or receive some kind of subsidy, it seems implausible that such items are of this order of magnitude. If one instead believes that the marginal costs faced by both municipal and private landfills should be comparable, this would lead to the rejection of a model in which municipalities behaved as private firms.

Table 7b presents the results using the marginal costs implied under a model where private firms set prices to maximize profit while municipalities set prices equal to marginal costs. Here, once landfill size and county location are included in estimation, the difference between municipal and private marginal costs drops to –1.5 and is not significant. If one believes that the marginal costs faced by private firms and municipalities should be comparable, this model of behavior cannot be rejected.

6.3 Merger Analysis

In this section, I use the demand estimates to examine the impact of mergers under different supply-side models of conduct. I should note that while these companies actually did merge, they did so one to two years after the study period. As seen earlier, the competitive landscape changed somewhat in this time – some landfills entered while others closed. Consequently, this analysis may not reflect the competitors that were actually involved in the 1998 and 1999 mergers. It still serves, however, to illustrate the importance of incorporating geographic differentiation into merger analysis.

First, consider merger simulations under the “usual” supply-side assumption of Bertrand-Nash competition. Tables 8a and 8b present the predicted increase in prices for the Allied-BFI and WMI-USA mergers under the Logit model versus the Distance model. In particular, we can see that the merger simulations using the Distance model are considerably more intuitive than those under the Logit model. For example, in the merger between Allied and BFI, the Logit model predicts fairly modest price increases across all merging landfills. The Distance model, however, predicts a considerably larger price increase for the BFI Modern landfill which merges with its two close competitors, Allied’s RCS and Cahokia Road landfills. Similarly, the Logit model “under-predicts” the price increase for BFI’s Quad Cities landfill and Allied’s Upper Rock Island landfill – two landfills which share the same county. In Table 8b, the Logit model predicts a much larger price increases for USA’s Saline and Wayne county landfills, which are relative far from their merging competitors. Meanwhile, it under-predicts the price increase at USA’s Countryside landfill, which merges with its close WMI competitors. Incorporating distance into the model of demand estimation makes a substantive difference in the predicted impact of the mergers.

Now consider the impact of the supply-side model of conduct on the results of merger simulation. All results henceforth are based on the Distance model. Given the results presented in section 6.2, one may believe that the Bertrand-Nash model is inappropriate for this exercise. Tables 9a and 9b examine the impact of assuming all landfills compete Bertrand-Nash (profit maximize) versus assuming that municipal landfills set price equal to marginal cost while private landfills profit-maximize.

The differences in predicted price increases are quite modest – in most cases, they are less than 0.1 percent and do not show up in the tables. This is driven by the fact that even if municipal landfills in this market behaved in a profit-maximizing fashion, they would not increase their prices by much in response to an increase in private landfills’ prices. In most cases, the predicted price increases for “profit-maximizing” municipal landfills is 0.1 percent or less – it is not surprising then that restricting this to zero makes little impact. In fact, it appears that municipal landfills are not close competitors to many of the merging landfills. In the Allied-BFI merger, municipal landfills are located a substantial distance away from the merging firms. In the WMI-USA merger, the Mallard Lake Landfill is fairly close to the WMI landfills in the Chicago metropolitan area. Here, restricting Mallard Lake to pricing at marginal cost reduces the predicted post-merger price increases at the CID #3 and Dekalb County landfills from 1 percent to 0.9 percent and from 1.1 percent to 1.0 percent, respectively. Mallard Lake is still some distance away from USA's Countryside, however, which had a predicted increase in price of almost 8 percent.

7. Conclusion and Research Extensions

This paper examines the extent to which geographic differentiation gives rise to market power in the waste disposal industry. Results using data on Illinois landfills suggest that transportation costs are approximately $0.23 per ton-mile and that competition may be regional in nature. There is also evidence indicating that municipal landfills did not behave in a profit-maximizing manner during the study period, though their behavior may be consistent with setting prices equal to marginal costs. Finally, results from the simulation of two mergers suggest that, with few exceptions, merging firms' post-merger prices increases would have been fairly modest and that the corresponding price increases of non-merging firms' would have been less than one percent. Municipal landfills are not close competitors to the merging firms in these simulations, and the impact of municipal ownership appears to be limited.

This analysis should be supplemented by information regarding landfill capacities to ensure the future existence of current competitors before policy recommendations are made. It should also be supplemented with information from the local and state permitting agencies regarding potential entrants.

The finding that municipal landfills appear to behave in a non-profit-maximizing way has implications not only for merger analysis but also for the issue of privatization. Privatization appears to be a growing trend as municipalities seek ways to improve efficiency, lower costs, or reduce debt. In a related paper, I use demand estimates to examine the impact of privatization for this market. Preliminary results suggest that privatizing municipal landfills may have a considerable impact on overall disposal prices. More information regarding the fixed costs of municipal landfills and the magnitude of potential cost reductions is necessary, however, before conclusions can be drawn.

Bibliography

Anderson, Simon; de Palma, Andre; and Thisse, Jacques-Francois (1997). "Privatization and Efficiency in a Differentiated Industry," *European Economic Review*, vol. 41, pp. 1635-54.

Aquino, John (2000). "A Down-to-Earth Look at Landfill Markets," *Waste Age*, vol. 31(6), pp. 56-62.

Berry, Steven (1994). "Estimating Discrete Choice Models of Product Differentiation," *Rand Journal of Economics*, vol. 25(2), pp. 242-62.

Berry, Steven; Levinsohn, James; and Pakes, Ariel (1995). "Automobile Prices in Market Equilibrium," *Econometrica*, vol. 63(4), pp.841-90.

Blackstone, Erwin and Fuhr Jr., Joseph (1992). "An Antitrust Analysis of Non-Profit Hospital Mergers," *Review of Industrial Organization*, vol. 8, pp. 473-90.

Bresnahan, Timothy (1981). "Departures from Marginal-Cost Pricing in the American Automobile Industry," *Journal of Econometrics*, vol. 17(2), pp. 201-227.

Cremer, Helmuth; Marchand, Maurice; and Thisse, Jacques-Francois (1991). "Mixed Oligopoly with Differentiated Products," *International Journal of Industrial Organization*, vol. 9(1), pp. 43-53.

Davis, Peter (2000). "Spatial Competition in Retail Markets: Movie Theaters," mimeo, MIT Sloan School of Management.

De Fraja, Giovanni and Delbono, Flavio (1990). "Game Theoretic Models of Mixed Oligopoly," *Journal of Economic Surveys*, vol. 4(1), pp. 1-17.

Dranove, David and William,White (1994). "Recent Theory and Evidence on Competition in Hospital Markets", *Journal of Economics and Management Strategy*, vol. 3(1), pp. 169-209.

Feldman, Roger (1994). "The Welfare Economics of a Health Plan Merger," *Journal of Regulatory Economics*, vol. 6(1), pp. 67-86.

Harris, Richard and Wiens, Elmer (1980). "Government Enterprise: An Instrument for the Internal Regulation of Industry," *Canadian Journal of Economics*, vol. 13(1), pp. 125-32.

Hausman, Jerry (1996). "Valuation of New Goods under Perfect and Imperfect Competition," in *The Economics of New Goods*, eds. Timothy Bresnahan and Robert Gordon, University of Chicago Press.

Hausman, Jerry; Leonard, Gregory; and Zona, Douglas (1994). "Competitive Analysis with Differentiated Products," *Annales D'Economie et de Statistique*, vol. 34(2), pp. 159-80.

Hotelling, Harold (1929). "Stability in Competition," *Economic Journal*, vol. 39, pp. 41-57.

Illinois Environmental Protection Agency (1999) *Nonhazardous Solid Waste Management and Landfill Capacity in Illinois*, 1998 Annual Report. (cite goes back for reports through 1991).

Jones, Scott (1997). "The Latest Moves in Waste Industry Consolidation," Waste Age, vol. 28(5).

Keeler, Emmet; Melnick, Glenn; and Zwanziger, Jack (1999). "The Changing Effects of Competition on Non-Profit and For-Profit Hospital Pricing Behavior," *Journal of Health Economics*, vol. 18 pp. 69-86.

Merrill, William and Schneider, Norman (1966). "Government Firms in Oligopoly Industries: A Short-Run Analysis," *Quarterly Journal of Economics*, vol. 80(3) pp. 400-12.

Nevo, Aviv (2001). "Measuring Market Power in the Ready-to-Eat Cereal Industry," Econometrica, vol. 69(2), pp.307-42.

Nevo, Aviv (2000a). "Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry," *Rand Journal of Economics*, vol. 31(3), pp. 395-421.

Nevo, Aviv (2000b). "A Practitioner's Guide to Estimation of Random Coefficients Logit Models of Demand," *Journal of Economics and Management Strategy*, vol. 9(4), pp.513-48.

Perloff, Jeffrey; Suslow, Valerie; and Seguin, Paul (1996). "Higher Prices from Entry: the Pricing of Brand-Name Drugs," mimeo, University of California,Berkeley.

Ready, Mark and Ready, Richard (1995). "Optimal Pricing of Depletable, Replaceable Resources: The Case of Landfill Tipping Fees," Journal of Environmental Economics and Management, vol. 28(3) pp. 307-23.

Repa, Edward (2000). "Solid Waste Disposal Trends," *Waste Age*, vol 31(4), pp.262-5.

Securities Data Corporation (1999). *The Merger Yearbook*, (cite goes back through 1993).

Shapiro, Carl (1996). "Mergers with Differentiated Products," *Antitrust*, vol. 10, pp. 23-30.

Slade, Margaret and Pinske, Joris (2000). "Mergers, Brand Competition, and the Price of a Pint," mimeo, University of British Columbia.

Thomadsen, Raphael (1999). "Price Competition in Industries with Geographic Differentiation: The Case of Fast Food," mimeo, Stanford University.

U.S. v. Allied Waste Industries, Inc. and Browning-Ferris Waste Industries, Inc. (1999) *Complaint for Injunctive Relief*, Case No. 1:99 CV 01962.

U.S. v. Allied Waste Industries, Inc. and Browning-Ferris Waste Industries, Inc. (1999) *Modified Final Judgment*, Case No. 1:99 CV 01962.

U.S. Department of Justice and the Federal Trade Commission (1992). *Horizontal Merger Guidelines*.

USA Waste Services (1998). *Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934*, Form 10-K, for the Fiscal Year ended December 31, 1997.

Werden, Gregory and Froeb, Luke (1994). "The Effects of Mergers in Differentiated Products Industries: Logit Demand and Merger Policy," *The Journal of Law, Economics, and Organization*, vol. 10(2), pp. 407-426.

Werden, Gregory and Froeb, Luke (1996). “Simulation as an Alternative to Structural Merger Policy in Differentiated Products Industries,” in *The Economics of the Antitrust Process*, eds. Coate, Malcolm and Kleit, Andrew, (Kluwer Academic Publishers: Norwell, MA), pp. 65-88.

Werden, Gregory; Froeb, Luke; and Tardiff, Timothy. (1996) “The Use of the Logit Model in Applied Industrial Organization,” *International Journal of Business Economics*, vol. 3(1), pp. 83-105.

additional cases to be added

Table 1. Waste Generation, Average Intake, and Average Tipping Fees.

	1992	**1993**	**1994**	**1995**	**1996**	**1997**
Total IL MSW (tons/month)	944,551	1,010,567	1,027,551	1,018,304	1,034,449	923,111
Mean intake per landfill	9,520	11,982	15,194	16,283	16,410	15,528
Mean number of landfills accepting IL MSW	100	84	68	63	63	60
% IL MSW disposed out-of-state	0.14	0.07	0.06	0.07	0.13	0.18
Mean tipping fee at landfills accepting IL MSW ($/ton)	22.87	24.42	25.37	26.00	27.64	27.20
Illinois landfills	22.52	23.85	24.70	25.70	27.07	26.52
Out-of-state landfills	25.76	28.70	30.01	27.84	30.30	30.59

Table 2. Summary Statistics
Number of Observations: 1,626

Variable	Mean	Std. Dev.	Min	Max
price	25.15	10.05	5.84	81.92
intake	13,523	24,870	1	237,471
share	0.014	0.024	0.000002	0.214
pub	0.22	0.42	0	1
no. of LFs w/in county	1.96	1.27	0.33	8
no. of LFs w/in 50 mi.	19.64	3.21	14	25
county population (100,000)	4.93	12.79	0.07	51.90

Summary Statistics for the Normalizing Landfill
Number of Observations: 22

Variable	Mean	Std. Dev.	Min	Max
price	33.59	3.61	28.90	38.10
intake	13,029	4,065	7,685	19,461
share	0.013	0.004	0.007	0.019
pub	0	0	0	0
no. of LFs w/in county	4.92	1.23	4	8
no. of LFs w/in 50 mi.	19.06	3.17	14	25
county population (100,000)	51.77	0.13	51.48	51.90

Summary Statistics for All Other Landfills
Number of Observations: 1,604

Variable	Mean	Std. Dev.	Min	Max
price	25.03	10.06	5.84	81.92
intake	13,530	25,035	1	237,471
share	0.0135	0.0246	0.000002	0.2144
public landfill	0.23	0.42	0	1
no. of LFs w/in county	1.92	1.22	0.33	8
no. of LFs w/in 50 mi.	11.96	5.77	2	30
county population (100,000)	4.29	11.63	0.07	51.90

Summary Statistics in Regression (Normalized Variables)
Number of Observations: 1,604

Variable	Mean	Std. Dev.	Min	Max
price_jt - price_1t	-7.97	10.19	-28.55	52.78
ln(share_jt) - ln(share_1t)	-0.8743	1.6005	-9.1307	3.2820
pub	0.23	0.42	0	1
#lfwco_jt - #lfwco_1t	-3.23	1.60	-7	0.67
#lfw50_jt - #lfw50_1t	-7.69	5.54	-19	5
county pop_jt - county pop_1t	-47.46	11.63	-51.73	0

Table 3: Estimation Results Under Logit Model and Distance Model

Dependent Variable: ln(share_jt) - ln(share_1t)

1,604 observations

	Logit Model		Distance Model
	OLS	IV	IV
	(i)	(ii)	(iii)
price_jt - price_1t	-0.029 **	-0.163 **	-0.158 **
	(0.005)	(0.020)	(0.020)
municipal	-1.520 **	-2.275 **	-2.123 **
	(0.147)	(0.264)	(0.290)
distance			-0.359 **
			(0.137)
Measures of fit:[1]	0.5625	333.52	305.85
		(11.07)	(11.07)
First Stage			
Instruments			
No. of landfills w/in county		x	x
No. of landfills w/in 50 miles		x	x
landfill size		x	x
R^2		0.6525	
F-statistic		414.92	
transportation cost per ton-mile			-0.228
Own-Price Elasticity			
Mean	*-0.725*	*-4.031*	*-3.754*
Std. Deviation	*0.291*	*1.619*	*1.596*
Median	*-0.658*	*-3.659*	*-3.414*

All regressions include time and county dummy variables. Robust standard errors are given in parentheses.

[1] Measures of fit include the adjusted R^2 for column (i); a test of over-identification for column (ii), with the 95 percent critical value in parentheses; and a test of the moment restrictions in column (iii), with the 95 percent critical value in parentheses.

Table 4. Mean Own- and Cross-Price Elasticities Under Logit Demand
Illinois MSW Landfills Remaining in June 1997

Name	County	Own-price	Cross-price[1]
Five Oaks RDF	Christian	-3.3292	0.0600
CID #3	Cook	-5.5498	0.1047
Congress Development Landfill	Cook	-5.3306	0.2307
Land & Lakes Dolton	Cook	-5.5520	0.0406
Land & Lakes Harbor View	Cook	-5.3815	0.0699
Clinton Landfill	De Witt	-3.0690	0.0452
DeKalb County Landfill	DeKalb	-4.6261	0.0302
Mallard Lake Landfill	Dupage	-3.9004	0.4658
Landfill 33	Effingham	-3.4287	0.0085
Gallatin National Landfill	Fulton	-3.5583	0.0196
Environtech Landfill	Grundy	-4.0339	0.0518
Morris Community Landfill	Grundy	-4.0259	0.0326
Southern Illinois Regional	Jackson	-3.5225	0.0347
RCS Landfill	Jersey	-3.5415	0.0143
Settler's Hill RDF	Kane	-5.0153	0.1866
Woodland RDF	Kane	-5.1236	0.1617
Kankakee RDF	Kankakee	-5.1801	0.0455
Knox Landfill	Knox	-3.2472	0.0122
States Land Improvement	La Salle	-4.1361	0.0168
Countryside Landfill	Lake	-5.3425	0.1552
Dixon GROP Landfill	Lee	-3.2089	0.0417
Livingston Landfill	Livingston	-3.0484	0.1228
Streator Area Landfill	Livingston	-3.3398	0.0270
Macon County Landfill	Macon	-2.3305	0.0392
Cahokia Road Landfill	Madison	-3.7264	0.0321
South Chain of Rocks Landfill	Madison	-3.6385	0.0454
Salem Municipal	Marion	-2.4929	0.0021
Envirofil of Illinois	McDonough	-3.7414	0.0213
American Disposal of Bloomington	McLean	-2.8798	0.0105
Litchfield - Hillsboro Landfill	Montgomery	-3.0832	0.0159
Rochelle Municipal	Ogle	-4.6179	0.0223
Peoria City/County	Peoria	-2.2656	0.0319
Pike County Landfill	Pike	-3.0318	0.0161
Quad Cities Landfill	Rock Island	-3.2422	0.0190
Upper Rock Island County Landfill	Rock Island	-2.9863	0.0295
Watts Landfill	Rock Island	-3.6040	0.0253
Saline County Landfill	Saline	-3.4678	0.0223
BFI Modern Landfill	St. Clair	-4.3982	0.0480
Milam RDF	St. Clair	-3.9693	0.0715
Freeport Municipal	Stephenson	-5.3136	0.0172
Pekin Landfill	Tazewell	-3.1071	0.0094
Tazewell RDF	Tazewell	-2.4588	0.0725
Brickyard RDF	Vermillion	-3.5632	0.0461
Illinois Landfill	Vermillion	-3.9166	0.0144
Wayne County Landfill	Wayne	-3.2247	0.0244
Prairie Hill RDF	Whiteside	-3.2548	0.0491
Laraway RDF	Will	-11.7993	0.0122
CDT Landfill	Will	-4.4354	0.0922
Winnebago Reclamation	Winnebago	-7.7536	0.1308

[1] This provides the percentage change in the market share of any landfill j should landfill k increase its price by one percent, where k indexes row and j≠k.

Table 5a. Own- and Cross-Price Elasticities for Selected IL MSW Landfills Remaining as of June 1997
By Distance from Chicago, IL

Name	County	Approx. Distance from Chicago	County									
		(miles)	*Cook*	*Cook*	*Cook*	*Dupage*	*Lake*	*Grundy*	*Vermillion*	*Rock Island*	*McDonough*	*Effingham*
Congress Development Landfill	Cook	10	**-5.3244**	0.1467	0.0701	0.5636	0.3109	0.0688	0.0058	0.0053	0.0043	0.0003
Land & Lakes Harbor View	Cook	14	0.4120	**-5.8022**	0.0842	0.5002	0.2732	0.0704	0.0069	0.0046	0.0041	0.0003
CID #3	Cook	20	0.4069	0.1740	**-5.2917**	0.4941	0.2685	0.0708	0.0071	0.0047	0.0041	0.0004
Mallard Lake Landfill	Dupage	30	0.3834	0.1212	0.0579	**-4.0196**	0.3313	0.0667	0.0050	0.0064	0.0047	0.0002
Countryside Landfill	Lake	40	0.3760	0.1176	0.0560	0.5891	**-6.8841**	0.0617	0.0046	0.0063	0.0045	0.0002
Environtech Landfill	Grundy	50	0.3479	0.1267	0.0617	0.4957	0.2578	**-4.1743**	0.0065	0.0078	0.0072	0.0009
Illinois Landfill	Vermillion	100	0.2015	0.0860	0.0429	0.2560	0.1336	0.0453	**-4.0836**	0.0046	0.0123	0.0193
Quad Cities Landfill	Rock Island	150	0.0900	0.0282	0.0137	0.1599	0.0895	0.0264	0.0022	**-3.4368**	0.1501	0.0018
Envirofil of Illinois	McDonough	180	0.0296	0.0101	0.0050	0.0483	0.0256	0.0100	0.0025	0.0612	**-3.3180**	0.0100
Landfill 33	Effingham	200	0.0055	0.0025	0.0013	0.0074	0.0035	0.0035	0.0114	0.0021	0.0296	**-3.9451**

Table 5b. Own- and Cross-Price Elasticities for Selected IL MSW Landfills Remaining as of June 1997
By Distance from Springfield, IL

Name	County	Approx. Distance from Springfield	County									
		(miles)	*Christian*	*Macon*	*Montgomery*	*Tazewell*	*Fulton*	*Livingston*	*Vermillion*	*Jackson*	*Winnebago*	*Lake*
Five Oaks RDF	*Christian*	25	**-3.4504**	0.2927	0.1783	0.0305	0.0141	0.0096	0.0882	0.1035	0.0092	0.0069
Macon County Landfill	*Macon*	37	0.5398	**-2.7839**	0.1099	0.0307	0.0127	0.0180	0.1878	0.0744	0.0246	0.0222
Litchfield - Hillsboro Landfill	*Montgomery*	44	0.6111	0.2042	**-3.0889**	0.0210	0.0106	0.0049	0.0451	0.1532	0.0029	0.0018
Pekin Landfill	*Tazewell*	49	0.2233	0.1221	0.0449	**-2.8912**	0.0302	0.0330	0.0714	0.0203	0.0986	0.0685
Gallatin National Landfill	*Fulton*	65	0.1853	0.0907	0.0407	0.0541	**-3.0370**	0.0282	0.0378	0.0159	0.1116	0.0590
Streator Area Landfill	*Livingston*	100	0.0237	0.0240	0.0035	0.0111	0.0053	**-3.2056**	0.0421	0.0018	0.2347	0.2132
Brickyard RDF	*Vermillion*	110	0.1426	0.1646	0.0213	0.0157	0.0047	0.0276	**-2.6584**	0.0222	0.0486	0.0620
Southern Illinois Regional	*Jackson*	140	0.1846	0.0720	0.0797	0.0049	0.0022	0.0013	0.0245	**-2.2726**	0.0004	0.0002
Winnebago Reclamation	*Winnebago*	164	0.0042	0.0061	0.0004	0.0061	0.0039	0.0433	0.0137	0.0001	**-7.5932**	0.2807
Countryside Landfill	*Lake*	198	0.0030	0.0052	0.0002	0.0041	0.0020	0.0376	0.0167	0.0000	0.2685	**-6.8841**

Each cell represents η_{jk} where j indexes the row and k indexes the column.

Table 6. Implied Price-Cost Margins for IL MSW Landfills

	No. of Obs.	Mean	Std. Dev.	Median
Logit Demand and Bertrand-Nash	1,410	30%	11%	29%
Private Landfills' PCM	1,088	29%	10%	29%
Municipal Landfills' PCM	322	32%	15%	29%
Distance Model				
Bertrand-Nash	1,410	33%	13%	32%
Private Landfills' PCM	1,088	33%	12%	32%
Municipal Landfills' PCM	322	35%	17%	31%
Municipal Landfills set P=MC	1,410	25%	17%	27%
Private Landfills' PCM	1,088	33%	12%	32%
Municipal Landfills' PCM	322	0%	0%	0%

Table 7a: Estimation Results for Predicted Marginal Costs under Bertrand-Nash Model

Dependent Variable: mc_jt
1,626 observations

	(i)	(ii)	(iii)	(iv)
municipal	-2.443 **	-2.721 **	-7.889 **	-7.829 **
	(0.539)	(0.566)	(1.119)	(1.115)
landfill size fixed effects	N	Y	Y	Y
county fixed effects	N	N	Y	Y
time effects	N	N	N	Y
R^2	0.0101	0.0532	0.6072	0.6272

Table 7b: Estimation Results for Predicted Marginal Costs under Municipalities setting P=MC

Dependent Variable: mc_jt
1,626 observations

	(i)	(ii)	(iii)	(iv)
municipal	4.547 **	4.173 **	-1.425	-1.368
	(0.533)	(0.557)	(1.113)	(1.108)
landfill size fixed effects	N	Y	Y	Y
county fixed effects	N	N	Y	Y
time effects	N	N	N	Y
R^2	0.0343	0.0817	0.6150	0.6408

Table 8a. Percent Increase in Prices Following a Merger Between Allied and BFI

Comparison of computed equilibrium under Logit model vs. Distance model

Owner - Name	County	Logit Model	Distance Model
WMI - Five Oaks RDF	Christian	0.0%	0.3%
BFI/JS - Congress Development Landfill	Cook	0.0%	0.0%
Land & Lakes - Dolton	Cook	0.0%	0.0%
Land & Lakes - Harbor View	Cook	0.0%	0.0%
WMI - CID #3	Cook	0.0%	0.0%
Peoria Disposal - Clinton Landfill	De Witt	0.0%	0.0%
WMI - DeKalb County Landfill	DeKalb	0.0%	0.0%
Forest Preserve - Mallard Lake Landfill	Dupage	0.0%	0.0%
Landfill 33	Effingham	0.0%	0.0%
BFI - Gallatin National Landfill	**Fulton**	**3.0%**	**6.5%**
City of Morris - Morris Community Landfill	Grundy	0.0%	0.0%
Environtech Landfill	Grundy	0.0%	0.0%
Republic - Southern Illinois Regional	Jackson	0.0%	0.7%
Allied - RCS Landfill	**Jersey**	**0.5%**	**2.9%**
Kane County - Settler's Hill RDF	Kane	0.0%	0.0%
WMI - Woodland RDF	Kane	0.0%	0.0%
WMI - Kankakee RDF	Kankakee	0.0%	0.0%
Knox County - Knox Landfill	Knox	0.0%	0.1%
Groot - States Land Improvement	La Salle	0.0%	0.0%
USA - Countryside Landfill	Lake	0.0%	0.0%
City of Dixon - Dixon GROP Landfill	Lee	0.0%	0.0%
Allied - Streator Area Landfill	**Livingston**	**0.5%**	**0.4%**
Am. Disposal - Livingston Landfill	Livingston	0.0%	0.0%
Macon County - Macon County Landfill	Macon	0.0%	0.1%
Allied - Cahokia Road Landfill	**Madison**	**0.6%**	**3.8%**
WMI - South Chain of Rocks Landfill	Madison	0.0%	0.8%
City of Salem - Salem Municipal	Marion	0.0%	0.1%
Envirofil of Illinois	McDonough	0.0%	0.2%
Sexton - American Disposal of Bloomington	McLean	0.0%	0.0%
Liberty - Litchfield - Hillsboro Landfill	Montgomery	0.0%	0.2%
City of Rochelle - Rochelle Municipal	Ogle	0.0%	0.0%
Peoria City/County	Peoria	0.0%	0.1%
Peoria Disposal - Pike County Landfill	Pike	0.0%	0.1%
Allied - Upper Rock Island County Landfill	**Rock Island**	**0.6%**	**3.6%**
BFI - Quad Cities Landfill	**Rock Island**	**2.6%**	**7.4%**
Watts - Watts Landfill	Rock Island	0.0%	0.4%
USA - Saline County Landfill	Saline	0.0%	0.2%
BFI - Modern Landfill	**St. Clair**	**2.2%**	**11.9%**
WMI - Milam RDF	St. Clair	0.0%	0.9%
City of Freeport - Freeport Municipal	Stephenson	0.0%	0.0%
Waste Professionals - Pekin Landfill	Tazewell	0.0%	0.0%
WMI - Tazewell RDF	Tazewell	0.1%	0.2%
Allied - Brickyard RDF	**Vermillion**	**0.5%**	**0.3%**
Allied - Illinois Landfill	**Vermillion**	**0.4%**	**0.2%**
USA - Wayne County Landfill	Wayne	0.0%	0.3%
Whiteside County - Prairie Hill RDF	Whiteside	0.0%	0.1%
CDT - CDT Landfill	Will	0.0%	0.0%
WMI - Laraway RDF	Will	0.0%	0.0%
Winnebago Reclamation	Winnebago	0.0%	0.0%

Table 8b. Percent Increase in Prices Following a Merger Between WMI and USA

Comparison of computed equilibrium under Logit model vs. Distance model

Owner - Name	County	Logit Model	Distance Model
WMI - Five Oaks RDF	**Christian**	**1.2%**	**1.4%**
BFI/JS - Congress Development Landfill	Cook	0.0%	0.0%
Land & Lakes - Dolton	Cook	0.0%	0.0%
Land & Lakes - Harbor View	Cook	0.0%	0.0%
WMI - CID #3	**Cook**	**1.0%**	**1.0%**
Peoria Disposal - Clinton Landfill	De Witt	0.0%	0.0%
WMI - DeKalb County Landfill	**DeKalb**	**1.0%**	**1.1%**
Forest Preserve - Mallard Lake Landfill	Dupage	0.2%	0.3%
Landfill 33	Effingham	0.0%	0.1%
BFI - Gallatin National Landfill	Fulton	0.0%	0.0%
City of Morris - Morris Community Landfill	Grundy	0.0%	0.0%
Environtech Landfill	Grundy	0.0%	0.0%
Republic - Southern Illinois Regional	Jackson	0.0%	0.7%
Allied - RCS Landfill	Jersey	0.1%	0.4%
Kane County - Settler's Hill RDF	Kane	0.0%	0.0%
WMI - Woodland RDF	**Kane**	**1.1%**	**1.2%**
WMI - Kankakee RDF	**Kankakee**	**1.0%**	**0.8%**
Knox County - Knox Landfill	Knox	0.0%	0.0%
Groot - States Land Improvement	La Salle	0.0%	0.0%
USA - Countryside Landfill	**Lake**	**6.4%**	**7.9%**
City of Dixon - Dixon GROP Landfill	Lee	0.0%	0.0%
Allied - Streator Area Landfill	Livingston	0.1%	0.0%
Am. Disposal - Livingston Landfill	Livingston	0.0%	0.0%
Macon County - Macon County Landfill	Macon	0.0%	0.1%
Allied - Cahokia Road Landfill	Madison	0.1%	0.4%
WMI - South Chain of Rocks Landfill	**Madison**	**1.2%**	**1.4%**
City of Salem - Salem Municipal	Marion	0.1%	0.1%
Envirofil of Illinois	McDonough	0.0%	0.0%
Sexton - American Disposal of Bloomington	McLean	0.1%	0.0%
Liberty - Litchfield - Hillsboro Landfill	Montgomery	0.0%	0.1%
City of Rochelle - Rochelle Municipal	Ogle	0.0%	0.0%
Peoria City/County	Peoria	0.0%	0.0%
Peoria Disposal - Pike County Landfill	Pike	0.0%	0.0%
Allied - Upper Rock Island County Landfill	Rock Island	0.1%	0.0%
BFI - Quad Cities Landfill	Rock Island	0.0%	0.0%
Watts - Watts Landfill	Rock Island	0.0%	0.0%
USA - Saline County Landfill	**Saline**	**9.8%**	**3.8%**
BFI - Modern Landfill	St. Clair	0.0%	0.1%
WMI - Milam RDF	**St. Clair**	**1.2%**	**1.5%**
City of Freeport - Freeport Municipal	Stephenson	0.0%	0.0%
Waste Professionals - Pekin Landfill	Tazewell	0.0%	0.0%
WMI - Tazewell RDF	**Tazewell**	**2.0%**	**0.8%**
Allied - Brickyard RDF	Vermillion	0.1%	0.1%
Allied - Illinois Landfill	Vermillion	0.1%	0.0%
USA - Wayne County Landfill	**Wayne**	**12.2%**	**5.6%**
Whiteside County - Prairie Hill RDF	Whiteside	0.0%	0.0%
CDT - CDT Landfill	Will	0.1%	0.1%
WMI - Laraway RDF	**Will**	**0.4%**	**0.5%**
Winnebago Reclamation	Winnebago	0.0%	0.0%

Table 9a. Percent Increase in Prices Following a Merger Between Allied and BFI

Based on results from Distance model

			Municipal landfill behavior	
Owner - Name	**County**	**Muni?**	**Profit Max.**	**P = MC**
WMI - Five Oaks RDF	Christian		0.3%	0.3%
BFI/JS - Congress Development Landfill	Cook		0.0%	0.0%
Land & Lakes - Dolton	Cook		0.0%	0.0%
Land & Lakes - Harbor View	Cook		0.0%	0.0%
WMI - CID #3	Cook		0.0%	0.0%
Peoria Disposal - Clinton Landfill	De Witt		0.0%	0.0%
WMI - DeKalb County Landfill	DeKalb		0.0%	0.0%
Forest Preserve - Mallard Lake Landfill	Dupage	x	0.0%	0.0%
Landfill 33	Effingham		0.0%	0.0%
BFI - Gallatin National Landfill	**Fulton**		**6.5%**	**6.5%**
City of Morris - Morris Community Landfill	Grundy	x	0.0%	0.0%
Environtech Landfill	Grundy		0.0%	0.0%
Republic - Southern Illinois Regional	Jackson		0.7%	0.7%
Allied - RCS Landfill	**Jersey**		**2.9%**	**2.9%**
Kane County - Settler's Hill RDF	Kane	x	0.0%	0.0%
WMI - Woodland RDF	Kane		0.0%	0.0%
WMI - Kankakee RDF	Kankakee		0.0%	0.0%
Knox County - Knox Landfill	Knox	x	0.1%	0.0%
Groot - States Land Improvement	La Salle		0.0%	0.0%
USA - Countryside Landfill	Lake		0.0%	0.0%
City of Dixon - Dixon GROP Landfill	Lee	x	0.0%	0.0%
Allied - Streator Area Landfill	**Livingston**		**0.4%**	**0.4%**
Am. Disposal - Livingston Landfill	Livingston		0.0%	0.0%
Macon County - Macon County Landfill	Macon		0.1%	0.1%
Allied - Cahokia Road Landfill	**Madison**		**3.8%**	**3.8%**
WMI - South Chain of Rocks Landfill	Madison		0.8%	0.8%
City of Salem - Salem Municipal	Marion	x	0.1%	0.0%
Envirofil of Illinois	McDonough		0.2%	0.2%
Sexton - American Disposal of Bloomington	McLean		0.0%	0.0%
Liberty - Litchfield - Hillsboro Landfill	Montgomery		0.2%	0.2%
City of Rochelle - Rochelle Municipal	Ogle	x	0.0%	0.0%
Peoria City/County	Peoria	x	0.1%	0.0%
Peoria Disposal - Pike County Landfill	Pike		0.1%	0.1%
Allied - Upper Rock Island County Landfill	**Rock Island**		**3.6%**	**3.6%**
BFI - Quad Cities Landfill	**Rock Island**		**7.4%**	**7.4%**
Watts - Watts Landfill	Rock Island		0.4%	0.4%
USA - Saline County Landfill	Saline		0.2%	0.2%
BFI - Modern Landfill	**St. Clair**		**11.9%**	**11.9%**
WMI - Milam RDF	St. Clair		0.9%	0.9%
City of Freeport - Freeport Municipal	Stephenson	x	0.0%	0.0%
Waste Professionals - Pekin Landfill	Tazewell		0.0%	0.0%
WMI - Tazewell RDF	Tazewell		0.2%	0.2%
Allied - Brickyard RDF	**Vermillion**		**0.3%**	**0.3%**
Allied - Illinois Landfill	**Vermillion**		**0.2%**	**0.2%**
USA - Wayne County Landfill	Wayne		0.3%	0.3%
Whiteside County - Prairie Hill RDF	Whiteside	x	0.1%	0.0%
CDT - CDT Landfill	Will		0.0%	0.0%
WMI - Laraway RDF	Will		0.0%	0.0%
Winnebago Reclamation	Winnebago		0.0%	0.0%

Table 9b. Percent Increase in Prices Following a Merger Between WMI and USA
Based on results from Distance model

			Municipal landfill behavior	
Owner - Name	**County**	**Muni?**	**Profit Max.**	**P = MC**
WMI - Five Oaks RDF	**Christian**		**1.4%**	**1.4%**
BFI/JS - Congress Development Landfill	Cook		0.0%	0.0%
Land & Lakes - Dolton	Cook		0.0%	0.0%
Land & Lakes - Harbor View	Cook		0.0%	0.0%
WMI - CID #3	**Cook**		**1.0%**	**0.9%**
Peoria Disposal - Clinton Landfill	De Witt		0.0%	0.0%
WMI - DeKalb County Landfill	**DeKalb**		**1.1%**	**1.0%**
Forest Preserve - Mallard Lake Landfill	Dupage	x	0.3%	0.0%
Landfill 33	Effingham		0.1%	0.1%
BFI - Gallatin National Landfill	Fulton		0.0%	0.0%
City of Morris - Morris Community Landfill	Grundy	x	0.0%	0.0%
Environtech Landfill	Grundy		0.0%	0.0%
Republic - Southern Illinois Regional	Jackson		0.7%	0.7%
Allied - RCS Landfill	Jersey		0.4%	0.4%
Kane County - Settler's Hill RDF	Kane	x	0.0%	0.0%
WMI - Woodland RDF	**Kane**		**1.2%**	**1.2%**
WMI - Kankakee RDF	**Kankakee**		**0.8%**	**0.8%**
Knox County - Knox Landfill	Knox	x	0.0%	0.0%
Groot - States Land Improvement	La Salle		0.0%	0.0%
USA - Countryside Landfill	**Lake**		**7.9%**	**7.9%**
City of Dixon - Dixon GROP Landfill	Lee	x	0.0%	0.0%
Allied - Streator Area Landfill	Livingston		0.0%	0.0%
Am. Disposal - Livingston Landfill	Livingston		0.0%	0.0%
Macon County - Macon County Landfill	Macon		0.1%	0.1%
Allied - Cahokia Road Landfill	Madison		0.4%	0.4%
WMI - South Chain of Rocks Landfill	**Madison**		**1.4%**	**1.4%**
City of Salem - Salem Municipal	Marion	x	0.1%	0.0%
Envirofil of Illinois	McDonough		0.0%	0.0%
Sexton - American Disposal of Bloomington	McLean		0.0%	0.0%
Liberty - Litchfield - Hillsboro Landfill	Montgomery		0.1%	0.1%
City of Rochelle - Rochelle Municipal	Ogle	x	0.0%	0.0%
Peoria City/County	Peoria	x	0.0%	0.0%
Peoria Disposal - Pike County Landfill	Pike		0.0%	0.0%
Allied - Upper Rock Island County Landfill	Rock Island		0.0%	0.0%
BFI - Quad Cities Landfill	Rock Island		0.0%	0.0%
Watts - Watts Landfill	Rock Island		0.0%	0.0%
USA - Saline County Landfill	**Saline**		**3.8%**	**3.8%**
BFI - Modern Landfill	St. Clair		0.1%	0.1%
WMI - Milam RDF	**St. Clair**		**1.5%**	**1.5%**
City of Freeport - Freeport Municipal	Stephenson	x	0.0%	0.0%
Waste Professionals - Pekin Landfill	Tazewell		0.0%	0.0%
WMI - Tazewell RDF	**Tazewell**		**0.8%**	**0.8%**
Allied - Brickyard RDF	Vermillion		0.1%	0.1%
Allied - Illinois Landfill	Vermillion		0.0%	0.0%
USA - Wayne County Landfill	**Wayne**		**5.6%**	**5.6%**
Whiteside County - Prairie Hill RDF	Whiteside	x	0.0%	0.0%
CDT - CDT Landfill	Will		0.1%	0.1%
WMI - Laraway RDF	**Will**		**0.5%**	**0.4%**
Winnebago Reclamation	Winnebago		0.0%	0.0%

Figure 2a.

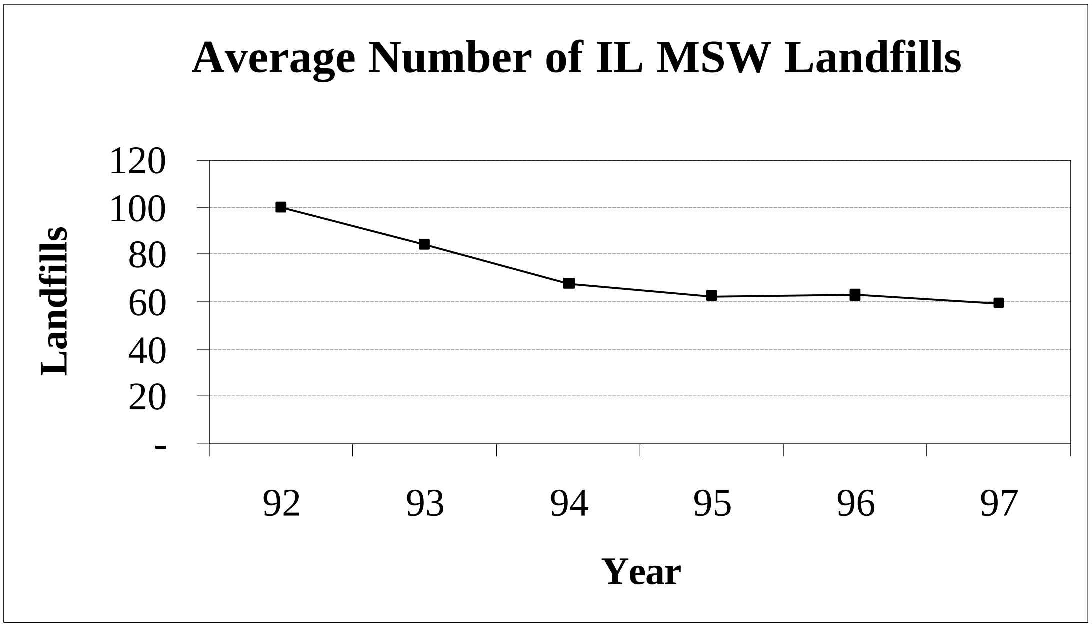

Figure 2b.