Evaluating Mergers for Antitrust Issues

The Allied Waste and Republic Services Case

An honors thesis for the Department of Economics

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Abstract

Horizontal mergers of actual or potential competitors often raise antitrust concerns. The approach of antitrust enforcement authorities related to such mergers focuses on how the post-merger market will differ from the pre-merger market. Economists have increasingly addressed this question using merger simulation models. These simulations use empirical estimates of key demand and supply parameters, as well as formal economic models of imperfect competition to predict the post-merger market. With these methods, one can analyze quantitatively how a given merger is likely to affect consumers and producers. With the use of a formal model, one can examine how the predictions for the post-merger market vary when key input parameters or behavioral assumptions are changed, providing insight into the robustness of the results. This paper uses merger simulation models to evaluate the recent merger of two of the three largest firms in the U.S. waste disposal industry, Allied Waste and Republic Services. The findings indicate that the merger is likely to be profitable but will lead to a consumer welfare loss if the merged firm's cost savings are about 5% percent or less. However, if cost savings are larger, the simulation results indicate that the merger will increase total surplus, and for cost-savings rates above 12.3%, the industry price will decrease and consumer surplus will rise consistently.

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Table of Contents

I. Introduction

Horizontal mergers of large firms with strong roles in their market often raise antitrust concerns. Authorities such as the Federal Trade Commission (FTC) or the Department of Justice (DOJ) investigate these mergers for potential anticompetitive effects, such as a price increases and consumer welfare losses. Merger reviews focus on predicting how the post-merger market will be affected by the new firm ownership. Authorities have increasingly placed significant weight on merger simulations that are based on an underlying economic model. It is unclear, however, to what extent merger simulations can in fact add useful and reliable evidence to the merger review process. This paper evaluates the 2008 merger of Allied Waste and Republic Services, formerly the second and third largest firms in the U.S. solid waste disposal industry, using merger simulation techniques.

Merger simulations have three key building blocks. The first is a formal model of competition, such as the Cournot or Bertrand oligopoly models for imperfect competition. The second is a demand function for the given market with certain economic parameters that may be estimated econometrically. As illustrated by Crooke et al. (1999), the underlying demand function of a merger simulation may significantly impact its predictions and the conclusions drawn from them. The third building block is an assumption about how costs vary with output. The theoretical frameworks of merger simulation are discussed by Werden (1997). Both Werden et al. (2004) and Walker (2005) emphasize the importance of examining each modeling assumption for consistency with actual observations of the market in the present and the past. Kamita (2001) applies merger simulations in the context of the solid waste disposal industry in the 1990's.

The merger simulations used in this paper are based on Cournot competition, which is generally less common in merger simulations than Bertrand competition. In each case the industry demand curve is assumed to be isoelastic. The key demand and supply parameters needed for the simulations are estimated econometrically using two separate datasets for landfill disposal: one for the national market and one for the state of California. While the simulations focus on modeling the merger on a national level, the California dataset offers additional insight into how the demand and supply for landfill disposal may differ for a specific region. The simulation results are analyzed for their robustness with respect to different parameter estimates. The application of merger simulation techniques to the Allied/Republic case provides insight into 1) the economics of this particular merger and whether it should have been approved by the DOJ, and 2) the key strengths and weaknesses of merger simulation methods in general.

This paper is structured as follows: Section II discusses the solid waste disposal industry and the recent merger case. Section III estimates the demand and supply parameters needed for the simulations. Next, Section IV introduces the merger simulation models and analyzes their results. The paper concludes with a discussion of the main findings in Section V, followed by Tables & Figures, and References.

II. The Solid Waste Disposal Case

i. The Solid Waste Disposal Industry

Solid waste disposal refers to the collection and disposal of municipal solid waste, better known as garbage or trash. The main elements of the disposal process include waste collection, storage in transfer stations, and final waste disposal in sites such as landfills or incinerators.

Although there are many small private and government-owned firms in the U.S. solid waste industry, there were only three major firms with considerable market power in 2008: Waste Management, Allied Waste, and Republic Services. These three firms' combined market share (of revenues) amounted to about 43.4%.[1] The other 56.6% of the market comprised smaller privately held firms and government-controlled operations. In their Annual Reports, both Allied Waste and Republic Services estimated the size of the U.S. solid waste disposal market to be $52 billion in 2007. All three firms offered a variety of services, including waste collection, transfer, landfill disposal, and recycling.

Waste Management earned total revenues of $13.31 billion in 2007 and had a market share of 25.6%.[2] In the same year, the firm owned or operated 341 transfer stations, 277 landfill disposal sites, 105 recycling plants, as well as 108 landfill gas-projects.[3] Through its many subsidiaries, Waste Management owned more landfills than Allied Waste and Republic Services combined, and processed more than 116 million tons of solid waste in 2007.[4] The company's

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[1] Market share was calculated as the proportion of the firms' reported yearly revenues for 2007 relative to total sales in the industry, which Republic Services and Allied Waste both estimated to be approximately $52 billion.
[2] See Waste Management's Annual Report for 2007. Market share was calculated as proportion of $52 billion market.
[3] See Waste Management's Annual Report for 2007.
[4] See Waste Management's Annual Report for 2007.

revenues from solid and hazardous waste landfills alone amounted to $3.05 billion in 2007.[5] According to the firm's Annual Report, competition in the industry is based mainly on tipping fees, geographic location and the individual operation's quality. Operating and disposal costs, as well as tipping fees, tend to vary greatly from region to region.

The second largest firm in the market, Allied Waste, earned revenues of $6.1 billion in 2007, $0.8 billion of which came from landfill operations. With a market share of approximately 11.7%, the firm owned or operated 291 collection companies, 161 transfer stations, 161 landfills and 53 recycling facilities.[6]

Republic Services, which had emerged out of Republic Industries in a 1998 Initial Public Offering (IPO), earned revenues of $3.18 billion in 2007. The firm had a market share of roughly 6.1%, and owned or operated 94 transfer stations, 58 solid waste landfills, and 33 recycling facilities.[7] According to the company's Annual Report, its key growth markets with above-average population growth included the states of California, Florida, and North Carolina, among others. Over 57% of the total volume of waste collected by Republic Services was processed in landfill disposal sites owned or operated by the firm. An overview of the three firms and some key information is shown in Table 1.[8]

The solid waste disposal industry underwent substantial consolidation in the 1990's. There were multiple mergers in the market, two of which are of particular importance, because they resulted in a market with three large dominant firms. One of these mergers was the acquisition of Browning-Ferris Industries by Allied Waste in 1999. The other was the merger between Waste Management and USA Waste in 1998. The final stage of disposal, particularly in

[5] See Waste Management's Annual Report for 2007.
[6] See Allied Waste's Annual Report for 2007. Market share was calculated as proportion of $52 billion market.
[7] See Republic Services' Annual Report for 2007. Market share was calculated as proportion of $52 billion market.
[8] This paper uses market information from 2007 instead of 2008, because Republic Services includes Allied Waste in its reporting for 2008, and does not publish separate financial data for the two firms.

landfills, has been a major source of antitrust concerns with past merger cases in the industry, as discussed by Kamita (2001). Therefore, the demand and supply estimations presented in this paper are based on this market segment of landfill disposal.

According to the U.S. Environmental Protection Agency (EPA), the number of landfill disposal sites in the U.S. has been decreasing since 1988.[9] However, at the same time, the typical size of a landfill site has increased. According to the EPA's report, the amount of solid waste disposed of in landfills fell from 142.3 million tons in 1990 to 137.2 million tons in 2007, a drop of about 5 million tons. This decrease can be explained largely by stricter environmental regulations and a general increase in the level of recycling. The prices charged for landfill disposal are called tipping fees and are usually measured in dollars per ton or dollars per cubic yard. According to Waste Management, tipping fees are determined mainly based on competition and the amount of solid waste being deposited.[10] In 2008, landfill disposal was once again an area of concern in face of the merger of the second and third largest firms in the industry.

ii. Merger of Allied Waste and Republic Services

In 2008, the solid waste disposal industry witnessed two merger proposals, one for a merger of Allied Waste and Republic Services, and another for a merger of Waste Management and Republic Services. Waste Management eventually withdrew its $6.2 billion bid for Republic Services. On December 5, 2008 Republic Services and Allied Waste Industries declared that they had completed the proposed merger between their firms, and that the combined company would be named Republic Services, Inc. with headquarters in Phoenix, Arizona.[11] According to Republic Services' 2008 Annual Report, the merger is expected to result in over $150 million in

[9] See Report: *Municipal Solid Waste in the United States: 2007 Facts and Figures* published by the EPA.
[10] See Waste Management's Annual Report for 2007.
[11] See http://www.republicservices.com/

pre-tax annual synergies by 2011. Although the merger itself may not be a cause for concern in terms of national market share, competition in the industry varies greatly by region, and Waste Management, Allied Waste, and Republic Services together controlled 496 of the 1754 landfills in the United States, as shown in Table 1.

In a previous study of mergers in the solid waste industry, Kamita (2001) concentrates on competition related to landfill operations, which dispose of waste that is either collected directly or delivered from transfer stations. Additionally, Kamita (2001) suggests that most anticompetitive effects in the industry are expected to arise from "final disposal" including the disposal in landfill sites. Although this claim is based on past mergers in an industry that underwent considerable consolidation in the 1990's, the DOJ reached a similar conclusion in its assessment of the merger of Republic Services and Allied Waste in 2008.[12]

In a press release from December 2008 the DOJ announced that it would require the divestiture of several commercial waste collection and waste disposal assets belonging to both firms, if the merger were to be permitted.[13] The two firms were required to sell 87 commercial waste collection routes, 9 landfill disposal sites, 10 transfer stations, as well as access to disposal capacity of landfills in three instances. The DOJ claimed that without these divestitures, the merger would lead to price increases for municipal solid waste collection and waste disposal in 15 regions in the United States. These areas were states and cities where Allied Waste and Republic Services dominated the market and would effectively lessen competition as a result of their merger. As reported in Republic Services' 2008 Annual Report, the firms complied with the DOJ's demands and merged. Through the use of merger simulation, this paper aims to provide

[12] See "Justice Department Requires Divestitures in Republic's Acquisition of Allied Waste" from December 3, 2008.
[13] See "Justice Department Requires Divestitures in Republic's Acquisition of Allied Waste" from December 3, 2008.

quantitative evidence to evaluate the DOJ's claim that the merger would have resulted in a price increase absent the required divestitures.

iii. Modeling Competition

Modeling the 2008 national solid waste disposal market in the U.S. poses somewhat of a challenge, because the three largest firms, despite their combined market share of only 43.4%, had more effective market power than any other firm in the industry. Due to limited availability of data, and the fact that this paper models a merger that occurred on a national level, the firms other than Waste Management, Allied Waste, and Republic Services are grouped into a competitive fringe that has a market share of 56.6%. It seems logical to model the competition among the three major firms differently from the competition between them and the fringe.

The merger simulations in this paper use a Cournot model of competition for the interactions among the three large firms. Cournot competition assumes that firms compete by independently and simultaneously choosing their most profitable levels of output, given their competitors' best-response strategies. This form of competition is often used to model markets with homogenous products where consumer tastes and preferences play less of a role than the firms' production costs and capacities. The solid waste disposal market provides a fairly homogenous service: the management and disposal of garbage. The tipping fees charged for landfilling are based mainly on volume, capacity, and location. Although in practice firms are likely to manipulate their tipping fees instead of selecting specific quantities of output, the Cournot model is likely to provide a good description of competition in this industry.

The Cournot competition model is applied in merger simulations less frequently, than for example, a Bertrand competition model where firms compete in prices.[14] Werden (1997) claims that merger simulations work best in cases where there is product differentiation and firms can charge very different prices based on consumer preferences. Although there is a certain degree of differentiation in the waste disposal market, mainly arising from geography and location, Cournot competition seems more plausible for the purpose of modeling the industry on a national level, because the firms do not compete on the basis of product attributes.

As mentioned previously, the fringe is a group of many small firms, and is unlikely to compete in the same way as the three large Cournot competitors. Therefore, the simulations presented in this paper consider several alternatives for describing the fringe's behavior. For modeling purposes, the fringe is treated as one collective unit, which is not necessarily realistic. However, this assumption may be able to capture the effects of the merger in some local markets, where it is realistic to assume that the fringe acts as a single unit. Additionally, this assumption has an advantage, in that it allows for the potential entry or exit of smaller firms, since there is no specification for the exact number of firms contained in the fringe.

The first simulation shown in this paper assumes that there is a competitive fringe that produces the residual output, which is not supplied by Waste Management, Allied Waste, and Republic Services. The fringe's output is modeled using a supply function, which is estimated with data from the state of California in Section III. This modeling choice enables an analysis of how the fringe's price elasticity of supply, which dictates the fringe's ability to expand its post-merger output, impacts the simulation results. The three large firms interact according to Cournot competition, and compete for the output that is not supplied by the fringe. These firms' best-

[14] If there are capacity constraints, Bertrand and Cournot competition become the same. See Kreps and Scheinkman (1983).

response outputs account for the fact that they know the fringe's supply function, and therewith know the respective output that the fringe will produce post-merger for a given industry price.

The second merger simulation presented in this paper considers a specific case of the first simulation model. In the second simulation model, the fringe's supply function is perfectly inelastic with respect to price. This effectively means that a capacity constraint is imposed on the fringe at its pre-merger level of output. The three large firms once again act as Cournot competitors, and compete for the residual output. In this case though, they know that the fringe's output will not change post-merger.

The third model in this paper assumes that the "big three" are the only firms in the market and act as Cournot competitors. The firms' market shares are scaled up such that they sum to 100%. While this scenario is not realistic for modeling the national market, it may provide insight into how the merger will affect local markets where only the "big three" firms compete.

A major problem with all of the models above is that competition may vary greatly in different areas and states across the country. For example, there may be local markets where only one or two of the large firms are represented, which the simulations in this paper are not able to capture. However, the different models of competition may be useful for describing the national U.S. solid waste disposal market on a broad level, allowing an analysis of the likely effects of the 2008 merger of Allied Waste and Republic Services.

iv. Information Needed for Simulations

There are several pieces of information required for simulating the Allied/Republic merger. Some key data, namely the total industry sales of $52 billion, as well as the firms' market shares are shown in Table 1. Another input needed is an average pre-merger price for the market. One can calculate a value for this input using the datasets presented in Section III. However, for the purpose of simulating the merger, this paper assumes an average price of $41 per ton for 2006, as reported by the University of Michigan Center for Sustainable Systems. Although this price does not correspond to the year 2007, which is the year that the market share and sales information is from, this 2006 price should be closer to the true price than any average tipping fee from 2001 or earlier.

Throughout this thesis, the marginal costs of the three large Cournot competitors are assumed to be constant such that they do not depend on the level of output. Ideally, one would want to know a value for the merged firm's new marginal cost or a percentage of marginal cost savings. Since this data is not available to the public, the simulations use a cost-savings rate, which makes it such that the merger is profitable at the margin in each of the three models. The merged firm experiences the minimum amount of cost reduction that is necessary for its profit to equal the two firms' combined pre-merger profit. In addition, the analysis considers what rate of cost savings would be hypothetically necessary, in order to prevent the merger from having an effect on price and consumer welfare.

The last two parameters needed for the merger simulations are an estimate of the industry price elasticity of demand needed for the demand curve in each simulation, and the fringe's price elasticity of supply used in Model 1. These parameters are estimated econometrically in Section III using empirical data for landfill disposal in California and the United States as a whole. As mentioned previously, the use of two datasets, one for the national market and one for the California market, makes it possible to analyze how the predicted effects of the merger might differ in regional markets. However, the interpretation of the results, particularly in relation to the DOJ's policy regarding the merger, focuses on the national market with a demand elasticity estimate from the National dataset.

III. Estimating Demand and Supply

i. Models for Demand and Supply

Every merger simulation is based on a particular demand function. The simulations in this paper assume isoelastic demand curves, where the industry price elasticity of demand is constant. The choice of a particular demand form is one of the main determinants of the size of the predicted changes for the post-merger market, as shown by Crooke et al. (1999). Since only one form of demand is used in this paper, the results do not allow a comparison of how different demand models would change the implied effects of the merger. In general, the predicted price increase with a constant-elasticity demand form will be larger than with a linear demand curve, all other things equal (Crooke et al., 1999). This section presents econometric estimates of both the demand elasticity parameter needed to calibrate the respective demand functions in the simulations, and the fringe's supply elasticity.

The data in this paper are for landfill disposal of municipal solid waste, an area that has continuously raised competitive concerns in the industry. For the purpose of estimating demand, the demand curve is assumed to be of the form:

$$\ln(\text{Q}) = \phi + \varepsilon \ln(\text{Price}) + \beta \text{X} + u$$

where Q is output, ε is the industry price elasticity of demand, X are other non-price determinants of demand, u is a random error term, and ϕ is a constant. In order to avoid correlation between the price data and other unobserved determinants of demand, this paper uses an Instrumental Variables approach, instrumenting for ln(Price) and controlling for other variables that are likely to affect the level of demand. Two landfill disposal datasets are used, one with data from California and one with national U.S. state-level data. Because each dataset contains slightly different variables, this section presents two different models for carrying out the demand estimation.

Demand Model – National Dataset

The structural equation used for the National data includes the natural logarithm of price, state GDP, state population, and the amount of toxic chemicals released as explanatory variables:

$$\ln(\mathrm{Q}) = \phi + \varepsilon \ln(\mathrm{Price}) + \beta_1 \mathrm{GDP} + \beta_2 \mathrm{Population} + \beta_3 \mathrm{Toxic\ Chemical\ Release} + u$$

On a state level, it is likely that a particular state's GDP, population size, and release of toxic chemicals will have an effect on the amount of landfill disposal demanded in that state. The estimations consider two instruments for ln(Price), population density and the amount of toxic chemicals released relative to state GDP. Although population is a direct determinant of national landfill demand, a state's population density is able to capture the geographical concentration of its population, which is likely to affect the level of supply in terms of transportation costs and the proportion of the state's land area available for landfilling. The demand model shown above also assumes that the absolute level of toxic chemicals released in a state is likely to affect the quantity of landfill disposal demand, since states with higher releases are likely to produce more solid waste overall. However, the level of toxic chemicals released relative to state GDP is used as an instrument for ln(Price) since it is an indicator of each state's relative "environmental friendliness", which may affect its willingness to supply landfill disposal. The demand model is estimated using Two-Stage Least Squares (2SLS) to obtain an estimate of ε, the price elasticity of demand for landfill disposal in the United States.

Demand Model – California Dataset

The demand model for the California dataset includes income per capita, land surface area, and the natural logarithm of price as explanatory variables:

$$\ln(\text{Q}) = \phi + \varepsilon \ln(\text{Price}) + \beta_1 \text{Income per Capita} + \beta_2 \text{Land Surface Area} + u$$

Income per Capita is likely to affect the quantity of landfill disposal demanded in a given county, since counties with a higher income level would be expected to pay a premium for their waste to be disposed of elsewhere. A county's land surface area is likely to affect landfill demand, since in smaller counties, landfill demand may be lower, because the waste they generate may be disposed of elsewhere. Population is excluded from the set of explanatory variables, because on a county level, population itself does not necessarily affect the county's demand for landfill disposal. Waste that is produced in a highly populated county will not always be disposed of in that same county.

The variables Population Density and Disposal Site Capacity are used to instrument for ln(Price) using 2SLS to get an estimate of ε, the price elasticity of demand for landfill disposal in the state of California. Population Density captures the average geographical dispersion of each county's population, which affects the cost of landfilling and the level of supply in terms of transportation costs and available space for landfill disposal. While the capacity of each landfill site is unlikely to determine the demand for landfilling, it is a factor that may well determine supply.

Fringe Supply Model – California Dataset

The supply of the competitive fringe is the total industry supply less the output supplied by Waste Management, Allied Waste, and Republic Services. Due to limited data about landfill ownership, this paper only estimates the fringe's supply function for the state of California. The main goal here is to find some empirical indication of the value of the fringe's supply elasticity. The fringe's supply function is given by:

$$\ln(Q_F) = \theta + \mu \ln(\text{Price}) + \gamma Z + v$$

where Q_F is the fringe's output, μ is the fringe's price elasticity of supply, Z are other non-price determinants of the fringe's supply, v is a random error term, and θ is a constant.

The structural supply equation includes Population Density and Landfill Capacity as control variables:

$$\ln(Q_F) = \theta + \mu \ln(\text{Price}) + \gamma_1 \text{Population Density} + \gamma_2 \text{Landfill Capacity} + v$$

The supply function is once again estimated using 2SLS, using the variables Income per Capita and Land Surface Area to instrument for ln(Price). It may be observed that these are the two variables that appear on the right-hand-side of the demand model for the California dataset introduced previously. Since these variables are thought to determine demand, they should be reasonable instruments for estimating landfill supply. The exogenous explanatory variables in this supply model are the supply determinants that were used as instruments for ln(Price) in the demand model.

ii. National Dataset

The Data

The National dataset includes observations for volumes and average prices for municipal solid waste processed in landfills in each U.S. state for the years 2000 and 2001. The data were obtained from Chartwell Information, a division of the Environmental Business Journal. For both years, there are no missing values for the variables provided, except for the District of Columbia, for which no values are reported. Disposal volumes are measured in millions of tons per day and average prices in U.S. dollars per ton.

In addition, this dataset includes information on state GDP, measured as an all industry total in millions of current dollars, for the years 2000 and 2001 from the Bureau of Economic Analysis (BEA). Annual population estimates for the respective states in 2000 and 2001 were obtained from the U.S. Census Bureau. The population estimates correspond to July 1st of each year. In addition, the dataset includes a variable that is meant to capture the degree of environmental regulation across all states. The variable used for this purpose is the amount of toxic chemicals released by each state in 2000 and 2001, as reported in the U.S. Census Bureau's Statistical Abstract for 2003.[15] The toxic chemical release is measured in millions of pounds. From this data for the toxic chemical release and the data for state GDP, this paper creates a new variable, measuring the toxic chemical release relative to GDP. Finally, a population density

[15] The toxic chemical release values reported in the 2003 Statistical Abstract were compiled by the U.S. Environmental Protection Agency in the annual Toxics Release Inventory. The amount of core chemicals released excludes delisted chemicals, chemicals added in 1990,1994, and 1995, and aluminum oxide, ammonia, hydrochloric acid, PBT chemicals, sulfuric acid, vanadium, and vanadium compounds.

variable is created, using the land surface area of each state, as published in the U.S. Census Bureau's Statistical Abstract for 2003.

Table 2 provides an overview of the variables in the dataset along with some summary statistics. The only missing values are for the District of Columbia. Therefore, some variables have 100 observations instead of 102. The standard deviations are very large overall, which may be attributed to the rather small sample size. The average industry price is $34.46 per ton of solid waste landfilled. Overall, the small sample size may limit the amount of insight that these data are able to provide in estimating industry demand.

The fact that this dataset describes the solid waste landfill disposal industry on a very large national scale is restrictive, in that the data cannot capture differences in prices and volumes within the states. However, the dataset does provide a basis for at least roughly estimating industry demand for landfill disposal. The fact that the sample is small and simplifies the regional markets may also be an advantage in terms of the facts that the Allied/Republic merger is simulated on a national level, and that the simulation models used require a single value for both the industry price and the industry price elasticity of demand.

Estimation Results

The results for the estimation of the national landfill demand are shown in Table 3. Three different combinations of instruments for ln(Price) are considered, yielding somewhat different results. The table displays four statistics for testing the identification of the respective model. The first-stage reduced form F-statistic for the instruments, as well as the Cragg-Donald Wald F-statistic may be used to test for weak identification. The Cragg-Donald Wald F-statistic is interpreted using the critical values from Stock and Yogo (2002), where the null hypothesis is that the model is weakly identified. The reduced form F-statistic indicates whether the instruments excluded from the model are significant in the regression of the endogenous right-hand-side variable on all exogenous variables. A significant Anderson canonical correlation LM-statistic leads to a rejection of the null hypothesis of underidentification, while a significant Sargan statistic indicates that the model is overidentified.

In Table 3, regression (1) implies an industry price elasticity of demand of -.752, significant at the 5% level. All diagnostic statistics indicate that the model is identified. Regression (3) results in an elasticity estimate of -.695, again significant at the 5% level, and the diagnostic statistics indicate that the model is identified. Regression (2) gives a positive point-estimate for the industry elasticity, which is not plausible. However, the barely significant F-statistic for the instrument in the first-stage reduced form, and the low Cragg-Donald statistic indicate that the model is weakly identified, which means that the instrument Toxic Chemical Release relative to GDP is not very useful. Population Density, on the other hand, seems to work relatively well as an instrument, and in regression (1) provides an estimate of -.752 for the industry price elasticity of demand. This estimate will serve as an input parameter for the merger simulations. It is evident from the results that there is significant variance in the estimate of this elasticity, depending what instrument is used. Also, considering the confidence interval of one standard deviation for the point estimate -.752, the elasticity is predicted to lie between -.457 and -1.047. Thus, there is some uncertainty about the parameter's precise value.

iii. California Dataset

The Data

In the context of the 2008 merger of Allied Waste and Republic Services, California, in particular Los Angeles and San Francisco, was cited by the DOJ as an area where there would be anticompetitive concerns.[16] California happens to also be one of few states that publish landfill site-specific data about quantities and tipping fees. The California data in this paper for the period from 1997 to 2000 were obtained from the California Integrated Waste Management Board (CIWMB). Quantities are reported in tons of municipal solid waste disposed of in specific California landfills. The price data contains tipping fees reported in a survey of California disposal facilities conducted by CIWMB. Therefore, the data account only for the facilities that reported their tipping fees, and not necessarily all facilities in the state.

The tipping fee data is available in U.S. dollars per ton and U.S. dollars per cubic yard. Since the quantity information is measured in tons, this paper uses the dollar-per-ton data. More specifically, a price variable is created by taking the arithmetic mean of the dollar-per-ton tipping fee for both compacted and non-compacted waste. Three of the 149 landfill sites only reported their prices in dollars per cubic yard. Since there is no quantity or dollar-per-ton price information for these, they are deleted from the dataset.

This leaves a dataset with price and quantity information for 146 landfill disposal sites from 1997 to 2000. The data obtained from the CIWMB also includes the landfill disposal sites' capacities. In addition, the California dataset includes economic data on a county basis, which is linked to individual disposal sites, based on the county where they are located. Population estimates for the California counties for the years 1997 to 2000 were obtained from the

[16] See "Justice Department Requires Divestitures in Republic's Acquisition of Allied Waste" from December 3, 2008.

California Department of Finance. Income per capita data and the land surface area of each county were drawn from the California Statistical Abstract 1999. Using the data for county populations and land surface area, a population density variable was created.

Table 4 provides some summary statistics for the California dataset. There are many missing values for both the tipping fee and the tons of solid waste landfilled, as a result of the fact that many disposal facilities did not report data for each year over the four-year period. The mean of the tipping fee variable implies an average price of $35.33, which is fairly similar to the $34.36 indicated in Table 2 for the national landfill disposal dataset. Overall, the standard deviations reported in Table 4 indicate large variances.

Dummy variables for the “big three” firms and the fringe were used to isolate the individual disposal sites according to their ownership. It must be mentioned that some of the firms placed in the fringe could in fact be owned indirectly by one of the larger firms. With the limited data available to the public, it is very difficult to track the many subsidiary landfills that Waste Management and the other two firms operate. However, the data reported by CIWMB gives a rough picture of how many landfills were owned by Waste Management, Republic Services, or Allied Waste, as illustrated in Table 4. This data is crucial for the estimation of the competitive fringe’s supply function.

The strength of this dataset and its advantage over the National dataset is that it captures price and quantity data on a site-specific level, giving a greater degree of insight into the actual market. Although a demand elasticity estimate for the state of California may not be representative of other markets or the overall national market, it provides a comparison with the estimated national price elasticity of demand, and shows to what extent the simulation results may differ in local markets.

Estimation Results – Demand

The results for the demand estimation with the California dataset are shown in Table 5. Regressions (1), (2), and (3) consider three different instruments for ln(Price). Regression (1) gives an estimate of -6.856 for the industry price elasticity of demand in California, significant at the 1% level. The diagnostic statistics imply that the model is identified. Regression (2) results in a much larger elasticity of -13.815, again significant at the 1% level. However, the diagnostic statistics are smaller than in regression (1), implying that Disposal Site Capacity is a weaker instrument than Population Density. However, the model still passes the identification tests. Regression (3), on the other hand, produces a Cragg-Donald statistic that indicates that the model may be weakly identified. The elasticity estimate of -9.779 from regression (3) lies closer to that of regression (1). Based on these results, Population Density is the strongest instrument. Taking the confidence interval of one standard deviation for the point estimate from regression (1), California's elasticity of demand for landfill disposal should lie between -5.353 and -8.359. Thus, the choice of the model and instrument can lead to great variability in the demand elasticity estimate.

Overall, the California dataset implies a price elasticity of demand for the state of California that is more elastic than the elasticity predicted by the National dataset. Regression (1) in Table 5 suggests a demand elasticity of -6.856, which is much larger than the national demand elasticity of -.752 implied by the National dataset in Table 3. For the purpose of simulating the Allied/Republic merger, the estimate from the National dataset may be more relevant, since the focus is on the merger that occurred on a national scale. However, it is clear that the industry price elasticity of demand may vary greatly from region to region, which must be considered when interpreting the merger simulation results.

Estimation Results – Fringe Supply

For the purpose of estimating the fringe's supply function, the 18 observations in the California dataset that correspond to landfills not owned by the fringe are deleted. Table 6 shows the estimation results for the fringe's supply function, again using three different instruments. The results in regressions (1), (2), and (3) are more consistent than the demand estimations. Regression (1) estimates μ, the price elasticity of supply for the fringe, at 1.853. Regression (2) indicates a value of 1.598, and regression (3) implies an elasticity of 1.725. All three estimates for μ are significant at the 1% level, and all three models pass the diagnostic tests for identification. Based on the F-statistic for the instrument in the first-stage reduced form, regression (2) is the most strongly identified, leading to the conclusion that Land Surface Area is the best instrument.

Based on the standard deviations of the point estimate from regression (2) the fringe's elasticity of supply lies roughly between 0.9 and 2.5. For the purpose of the merger simulations in this paper, this estimate of 1.598 is used as the best estimate. Although the results in Table 6 are not necessarily representative of the fringe's supply elasticity on a national level in 2008, they still provide an approximate picture of some plausible values for μ. However, one might expect the fringe's supply to be less elastic on a national level. Due to this uncertainty about the parameter, any merger simulation using this fringe supply function must be accompanied by a sensitivity analysis.

A comparison of the results from the two demand estimations shows that the industry demand is predicted to be more elastic in California than for the overall national U.S. industry. This seems plausible since California landfills should face more competition than the country as a whole. According to the estimations, the demand on the national level is predicted to be inelastic, implying that the quantity demanded for landfill disposal is not very sensitive to changes in price. However, the somewhat ambiguous results of these demand estimations highlight the importance of testing the robustness of any merger simulation with respect to its input parameters.

As a point of reference, Kamita (2001) estimated a landfill own-price elasticity parameter of -3.65 for the state of Illinois, using a discrete random choice model of demand, where waste haulers choose a disposal site based on tipping fees and transportation costs. Kamita's (2001) estimate lies in between those from the National dataset and those from the California dataset in this paper. Other past estimates of landfill price-elasticities of demand resulted in more inelastic values, such as -.11 by Strathman et al. (1995) for the state of Oregon. In summary, there is great uncertainty in the demand and supply estimates for the waste disposal industry. The estimates presented in this paper serve the purpose of providing empirical insight into the possible ranges of values that need to be considered when evaluating the merger simulation results.

IV. Merger Simulations

i. Merger Simulation Models

Assuming Cournot competition among the three large firms in the solid waste disposal industry, this section describes three models that differ in how they account for the behavior of the other firms in the industry, which for the purpose of this analysis are grouped into a fringe. While treating many small firms as one collective unit may be a very restrictive assumption, as mentioned previously, it does have the advantage that it allows for entry and exit of smaller firms in the industry. Since there is no restriction on how many firms can be included in the fringe, these models will allow for potential new firm entry or exit.

Model 1: Competitive Fringe's Supply Function

A constant-elasticity (or isoelastic) demand curve is assumed:

$$\ln(P) = a + b\ln(Q)$$

where Q is the quantity demanded in the industry, measured in tons. The price P is an average price per ton for landfill disposal. The coefficient b in the equation above is the inverse of the industry elasticity of demand, which is estimated in Section III.

$$b = \frac{1}{\varepsilon}$$

The constant *a* includes all non-price determinants of demand, which are held constant in this analysis.[17] Using pre-merger values for P, Q and *b*, one can solve for the constant *a*. The demand curve can be rearranged as:

$$Q = e^{-\frac{a}{b}} P^{\frac{1}{b}}$$

This model describes the competitive fringe's behavior by isolating and estimating its supply function. The competitive fringe's marginal cost, which depends on its level of output Q_F, will equal the industry price, so that the fringe earns zero marginal profit.

$$c_F(Q_F) = P$$

The fringe's supply function can be written as:

[17] The constants *a* and *α* are not calculated from the econometric estimates from Section III because these values are based on data from 1997-2001. In order to model the Republic/Allied merger, this paper uses market share and sales data for 2007 and an average landfill price for 2006, which are the closest data to 2008 that are currently available to the public. Because the analysis in this paper uses an average price from 2006, market data from 2007, and elasticity estimates from 2001 or earlier, the constants *a* and *α* can be "backed-out" from the demand and supply functions, so that the two sides of each equation are equal in the pre-merger equilibrium.

$$Q_F = \alpha\, P^{\mu} \quad \Rightarrow \quad P = \left(\frac{Q_F}{\alpha}\right)^{\frac{1}{\mu}}$$

where α is a constant that accounts for non-price determinants of supply and μ is the fringe's price elasticity of supply. The estimation of the parameter μ based on data for California was presented earlier. Using this estimate, one can solve for the constant α that is consistent with the observed pre-merger equilibrium price and quantities. The supply function implies that the competitive fringe is a price-taking group of firms, which itself is not able to influence the industry price.

The fringe's marginal cost may be written as an expression in terms of Q_F.

$$c_F = \left(\frac{Q_F}{\alpha}\right)^{\frac{1}{\mu}}$$

Since the fringe's marginal cost varies with its level of output, the post-merger value of c_F will change if Q_F changes.

The industry demand Q can be written in terms of the three large firms' outputs and that of the competitive fringe.

$$\begin{aligned}
& Q = q_1 + q_2 + q_3 + Q_F = e^{-\frac{a}{b}}\, P^{\frac{1}{b}} \\
\Rightarrow\ & q_1 + q_2 + q_3 = e^{-\frac{a}{b}}\, P^{\frac{1}{b}} - \alpha P^{\mu} \\
\Rightarrow\ & \frac{\delta P}{\delta q_1} = \frac{\delta P}{\delta q_2} = \frac{\delta P}{\delta q_3} = \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1}\right)^{-1}
\end{aligned}$$

The partial derivative of price with respect to each Cournot competitor's output is an expression depending on the price P, the demand parameters a and b, and the supply parameters μ and α. Each of the three large firm's first-order condition for profit-maximization is found by setting marginal revenue equal to marginal cost.

$$P + q_1 \frac{\delta P}{\delta q_1} = c_1 \quad \text{(FOC for firm 1)} \quad \Rightarrow \quad c_1 = P + q_1 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1} \right)^{-1}$$

$$P + q_2 \frac{\delta P}{\delta q_2} = c_2 \quad \text{(FOC for firm 2)} \quad \Rightarrow \quad c_2 = P + q_2 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1} \right)^{-1}$$

$$P + q_3 \frac{\delta P}{\delta q_3} = c_3 \quad \text{(FOC for firm 3)} \quad \Rightarrow \quad c_3 = P + q_3 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1} \right)^{-1}$$

The fringe's marginal cost is assumed to equal the pre-merger price; that is c_F is equal to P. This gives a complete set of parameters for the pre-merger equilibrium.

A merger between firms 1 and 2 results in a new firm 1 with a new marginal cost C. Model 1 accounts for the change in the fringe's best response using the supply function, which is the output the fringe will produce at any given industry price. Therefore, the post-merger output is given by:

$$Q = e^{-\frac{a}{b}} P^{\frac{1}{b}} = q_1 + q_3 + \alpha P^{\mu}$$

$$\Rightarrow \quad \frac{\delta P}{\delta q_1} = \frac{\delta P}{\delta q_3} = \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1} \right)^{-1}$$

Both firms 1 and 3 again produce at a level where marginal revenue equals marginal cost.

$$P + q_1 \frac{\delta P}{\delta q_1} = C \quad \text{(FOC for firm 1)} \quad \Rightarrow \quad C = P + q_1 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1} \right)^{-1}$$

$$P + q_3 \frac{\delta P}{\delta q_3} = c_3 \quad \text{(FOC for firm 3)} \quad \Rightarrow \quad c_3 = P + q_3 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1} \right)^{-1}$$

These first-order conditions can be solved for the two firms' best responses.

$$q_1 = (C - P)\left(\frac{e^{-\frac{a}{b}}}{b}P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1}\right)$$

$$q_3 = (c_3 - P)\left(\frac{e^{-\frac{a}{b}}}{b}P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1}\right)$$

Substituting these best response outputs into the demand equation above results in an expression for post-merger demand in terms of the post-merger price.

$$\left[(C - P) + (c_3 - P)\right]\left(\frac{e^{-\frac{a}{b}}}{b}P^{\frac{1}{b}-1} - \mu\alpha P^{\mu-1}\right) - e^{-\frac{a}{b}}P^{\frac{1}{b}} + \alpha P^{\mu} = 0$$

This expression can be solved for the post-merger price, and this value is then used to calculate the best responses q_1 and q_3, as well as the fringe's output given by $Q_F = \alpha P^{\mu}$.[18] The fringe's marginal cost is assumed to adjust so that it is equal to price, $c_F = P$, leading to zero marginal profit.

In this model, different estimates for the price elasticity of supply of the fringe may have varying effects on the predicted post-merger market. Therefore, a sensitivity analysis with respect to the supply parameter μ is presented in section iv.

Model 2: Capacity Constraint on Fringe

This model makes the same assumptions as Model 1, that the three large firms are Cournot competitors and a competitive fringe of many smaller firms produces the residual output. However, this model considers the particular case in which the fringe's price elasticity of supply is perfectly inelastic. This means that, at its pre-merger level of output, the fringe cannot expand its output after the merger and is thus subject to a capacity constraint. The fringe's pre-

[18] The results shown in this paper use the Microsoft Excel's GoalSeek function to solve this equation for P.

merger marginal cost will equal the pre-merger price. The large firms know that the fringe is constrained in capacity, and compete for the output $Q - Q_F$, since they know that the quantity Q_F will be supplied by the fringe.

A constant-elasticity (or isoelastic) demand curve is assumed:

$$\ln(\mathrm{P}) = a + b\ln(\mathrm{Q})$$

Q is the quantity demanded in the industry, measured in tons. The price P is an average industry price for landfill disposal in dollars per ton. The coefficient b in the equation above is the inverse of the industry elasticity of demand.

$$b = \frac{1}{\varepsilon}$$

Using pre-merger values for P, Q and b, one can solve for the constant a. The demand curve can be rearranged as:

$$\mathrm{Q} = e^{-\frac{a}{b}}\,\mathrm{P}^{\frac{1}{b}}$$

The capacity constraint on the fringe holds its post-merger quantity constant at the pre-merger value. The total industry demand Q can be written as:

$$\mathrm{Q} = \mathrm{q}_1 + \mathrm{q}_2 + \mathrm{q}_3 + \mathrm{Q}_\mathrm{F}$$

$$\Rightarrow \ \mathrm{Q}_{\mathrm{Cournot}} = \mathrm{Q} - \mathrm{Q}_\mathrm{F} = e^{-\frac{a}{b}}\,\mathrm{P}^{\frac{1}{b}} - \mathrm{Q}_\mathrm{F} = \mathrm{q}_1 + \mathrm{q}_2 + \mathrm{q}_3$$

Since the fringe's output will be the same post-merger as pre-merger, it does not make a difference whether or not one substitutes a supply function for Q_F. Using a supply function as in Model 1, $Q_F = \alpha P^{\mu}$, the fringe's supply elasticity μ would have to equal zero in this case, so that Q_F is equal to a constant α. Although the fringe's output remains constant, the model allows for the possibility that there may be firm entry or exit, such that the individual firms in the fringe pre-merger are not the same as those contained in the fringe post-merger. The only restriction is that the group of firms cannot increase its combined output after the merger occurs.

Based on the demand expression above, the three Cournot competitors' partial derivatives of price with respect to quantity are determined.

$$\frac{\delta P}{\delta q_1} = \frac{\delta P}{\delta q_2} = \frac{\delta P}{\delta q_3} = \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

Next, these partial derivatives can be substituted into the first-order conditions for profit maximization listed below.

$$P + q_1 \frac{\delta P}{\delta q_1} = c_1 \quad \text{(FOC for firm 1)} \qquad \Rightarrow \qquad c_1 = P + q_1 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

$$P + q_2 \frac{\delta P}{\delta q_2} = c_2 \quad \text{(FOC for firm 2)} \qquad \Rightarrow \qquad c_2 = P + q_2 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

$$P + q_3 \frac{\delta P}{\delta q_3} = c_3 \quad \text{(FOC for firm 3)} \qquad \Rightarrow \qquad c_3 = P + q_3 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

The left-hand sides of the equations are the marginal revenue functions, derived from total revenues, and the right-hand sides are the three firms' constant marginal costs. Based on empirical observations of all the left-hand side parameters, the three firms' marginal costs can be calculated.

With this full set of parameters for the pre-merger equilibrium, one can examine what will happen if firms 1 and 2 decide to merge to become a new firm 1 with a new marginal cost C. The industry demand Q may now be written as:

$$Q = e^{-\frac{a}{b}} P^{\frac{1}{b}} = q_1 + q_3 + Q_F$$

$$\Rightarrow \quad \frac{\delta P}{\delta q_1} = \frac{\delta P}{\delta q_3} = \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

Both firms 1 and 3 will again produce at a level where marginal revenue equals marginal cost.

$$P + q_1 \frac{\delta P}{\delta q_1} = C \quad \text{(FOC for firm 1)} \quad \Rightarrow \quad C = P + q_1 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

$$P + q_3 \frac{\delta P}{\delta q_3} = c_3 \quad \text{(FOC for firm 3)} \quad \Rightarrow \quad c_3 = P + q_3 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

The first-order conditions above may be solved for the two firms' best responses.

$$q_1 = (C - P) \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)$$

$$q_3 = (c_3 - P) \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)$$

Substituting these best response outputs into the demand equation above, results in an expression for post-merger demand in terms of the post-merger price.

$$\left[(C - P) + (c_3 - P) \right] \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right) - e^{-\frac{a}{b}} P^{\frac{1}{b}} + Q_F = 0$$

This expression is then solved for the post-merger price, with which the best responses q_1 and q_3 can be calculated.[19] The fringe's marginal cost remains at its pre-merger value, since its output has not changed. However, since the price-taking fringe can charge a higher price post-merger, it will earn positive marginal profit.

Model 3: Three Cournot Competitors

While the previous two models include a fringe which operates with less effective market power than the three large Cournot competitors, it may also be of interest to consider what the outcome of the merger would be if the three large firms supplied the entire industry alone. This model assumes there are only three firms in the market, which choose their levels of output

[19] The results shown in this paper use the Microsoft Excel's GoalSeek function to solve this equation for P.

according to Cournot competition. The market shares of the three large firms in Models 1 and 2 are now scaled up so that they serve the $52 billion total market revenue. Although it does not seem logical to eliminate the fringe from the analysis and consider only the three Cournot competitors, this variation may offer some insight into potential anticompetitive effects in local markets, where competition may actually be limited to these three firms.

The constant-elasticity demand curve is:

$$\ln(\mathrm{P}) = a + b\ln(\mathrm{Q})$$

Again, Q is the quantity demanded in the industry, measured in tons. The price P again is an average price for landfill disposal in dollars per ton. The coefficient *b* in the equation above is the inverse of the industry elasticity of demand.

$$b = \frac{1}{\varepsilon}$$

Using pre-merger values for P, Q and *b*, one can solve for the constant *a*, and the demand curve can be rewritten as:

$$\mathrm{Q} = e^{-\frac{a}{b}}\,\mathrm{P}^{\frac{1}{b}}$$

$$\Rightarrow \quad \frac{\delta \mathrm{P}}{\delta \mathrm{q}_1} = \frac{\delta \mathrm{P}}{\delta \mathrm{q}_2} = \frac{\delta \mathrm{P}}{\delta \mathrm{q}_3} = \left(\frac{e^{-\frac{a}{b}}}{b} \mathrm{P}^{\frac{1}{b}-1} \right)^{-1}$$

The first-order conditions (FOC’s) that maximize the profit of each firm at the margin are found by setting their marginal revenues equal to their marginal costs.

$$P + q_1 \frac{\delta P}{\delta q_1} = c_1 \quad \text{(FOC for firm 1)} \quad \Rightarrow \quad c_1 = P + q_1 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

$$P + q_2 \frac{\delta P}{\delta q_2} = c_2 \quad \text{(FOC for firm 2)} \quad \Rightarrow \quad c_2 = P + q_2 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

$$P + q_3 \frac{\delta P}{\delta q_3} = c_3 \quad \text{(FOC for firm 3)} \quad \Rightarrow \quad c_3 = P + q_3 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

With this full set of parameters for the pre-merger equilibrium, one can examine what will happen if firms 1 and 2 decide to merge to become a new firm 1 with a new marginal cost C. The industry demand Q may now be written as:

$$Q = e^{-\frac{a}{b}} P^{\frac{1}{b}} = q_1 + q_3$$

$$\Rightarrow \frac{\delta P}{\delta q_1} = \frac{\delta P}{\delta q_3} = \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

Both firms 1 and 3 will again produce at a level where marginal revenue equals marginal cost.

$$P + q_1 \frac{\delta P}{\delta q_1} = C \quad \text{(FOC for firm 1)} \quad \Rightarrow \quad C = P + q_1 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

$$P + q_3 \frac{\delta P}{\delta q_3} = c_3 \quad \text{(FOC for firm 3)} \quad \Rightarrow \quad c_3 = P + q_3 \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)^{-1}$$

These first-order conditions may be solved for the two firms' best responses.

$$q_1 = (C - P) \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)$$

$$q_3 = (c_3 - P) \left(\frac{e^{-\frac{a}{b}}}{b} P^{\frac{1}{b}-1} \right)$$

Substituting these best response outputs into the demand equation above gives an expression for post-merger demand in terms of the post-merger price.

$$\left[(C-P)+(c_3-P)\right]\left(\frac{e^{-\frac{a}{b}}}{b}P^{\frac{1}{b}-1}\right)-e^{-\frac{a}{b}}P^{\frac{1}{b}}=0$$

This expression is solved for the post-merger price, and this value can then be used to determine the best responses q_1 and q_3.[20]

The three merger simulations presented in this paper generate predictions of a merger's unilateral effects. Based on the predicted change in output, one can draw conclusions about what is likely to happen to price, profits, consumer welfare, and total welfare.

ii. Simulation Results

This section presents the simulation results for the Allied/Republic merger using the three models described above. The pre-merger mean industry price is assumed to be $41 per ton. As noted earlier, this price was reported for the year 2006, rather than 2007 or 2008. Although the actual average price may be somewhat higher, the simulation results do not vary much in percentage effects when a slightly higher or lower price is assumed.

The simulations use the estimate of -0.752 from Table 3 as the demand elasticity input. This value represents an estimate for the industry price elasticity of demand for the national U.S. market, which is the market of interest. Although Model 3 seems more appropriate for describing local markets, where demand may be more elastic, the same demand elasticity of -0.752 is assumed for all three scenarios, so that one can compare each model's implied effects. Section iv

[20] The results shown in this paper use the Microsoft Excel's GoalSeek function to solve this equation for P.

provides a sensitivity analysis of this demand elasticity parameter and shows how the results differ for a large spectrum of values, including the more elastic estimates from the California dataset.

The cost-savings rate of the merged firm is assumed to be 0.666% in the results for Model 1 presented in Table 7, because this is the smallest cost reduction that ensures that the merger is profitable for the merging parties. Because this minimum cost savings for the merger to be profitable is largest in Model 1, the 0.666% reduction is also assumed for Model 2 and Model 3 when comparing the simulation results in Tables 11 and 13, as well as in Figure 4. This means that the merged firm produces at a marginal cost, which is 0.666% smaller than the share-weighted average of the two firms' pre-merger marginal costs. Since the exact amount of the reduction in marginal cost due to the merger is not known, 0.666% may be treated as a rough guess. In section iii, it is shown how a sufficiently low marginal cost for the merged firm may actually lead to decreases in price and increases in consumer surplus.

In Model 1, the fringe's supply elasticity with respect to price is assumed to equal 1.598, which is one of the three point estimates presented in Table 6. A sensitivity analysis of this parameter is conducted in section iv. All three cases assume the total pre-merger market sales of $52 billion and the market shares shown in Table 1. The key results from the simulations with these inputs are shown in Tables 7 through 11.

Table 7 shows the results of the merger simulation using Model 1, where the competitive fringe's output is determined using its supply function. These results assume that the merged firm experiences a cost savings of 0.666% as result of the merger, such that its post-merger marginal cost is $38.32. Waste Management's marginal cost remains unchanged, while the fringe's marginal cost increases, because it is a function of its output, which increases due to the merger. These results may be considered a “worst-case scenario” for the demand and supply elasticities assumed, since any cost savings below 0.666% would make the merger unprofitable and unlikely to occur, while any cost savings above 0.666% will lead to a lower price effect, which eventually becomes a price decrease. The demand curve assumed in this simulation is

$$\ln(P) = 4.030 - 1.330\ln(Q)$$

where P is the price and Q is the quantity demanded. The merger is predicted to raise the price by about 1.46%, and decrease both consumer surplus and total surplus.[21]

Table 8 shows a set of results for Model 2, where the fringe is subject to a capacity constraint at its pre-merger level of output. This translates into an unchanged marginal cost, since the merger affects the fringe only through the price. After the merger, the fringe continues operating at the same output and marginal cost as before. The pre-merger marginal costs for the three large firms are lower than those shown in Table 7. The predictions in Table 8 differ from those in Table 7, in that the fringe’s supply elasticity was reduced from 1.598 to 0, and the cost-savings rate for the merged firm was decreased from 0.666% to 0.190%. Under these conditions, the merger is predicted to result in no change in profit for the merged firm. In this case, the price is predicted to rise by 5.17% and consumer surplus as well as total surplus decreases.

Table 9 shows the results for Model 3, which assumes that the three large firms are the only firms in the market. As mentioned earlier, this may not be a realistic assumption for modeling the merger on a national scale, but it may provide some insight into how strongly the simulation outcomes could differ in regional markets where only these three firms operate.

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[21] For all results shown, Consumer Surplus = $[e^{-a/b} P_{max}^{(1/b + 1)}] / (1/b + 1) - [e^{-a/b} P_{market}^{(1/b + 1)}] / (1/b + 1)$, where P_{market} is the current market price and P_{max} is an imposed maximum price, set to \$100 throughout this paper. This price limit is imposed because $\lim_{Q \to 0} (P) = \infty$, which causes price to rise faster and faster as Q moves towards zero. If one calculated the change in consumer surplus between the pre-merger price and the post-merger price, one would not obtain an implied percentage change for the measure, which is useful in comparing the results from different models.

Assuming zero cost savings, the marginal costs implied by this model are significantly lower than in the other models. The industry price is predicted to increase by 36.69% and the negative consumer and total surplus effects are larger in magnitude than in the other models. It seems though, that the merger is still profitable, even in the absence of any cost savings. In Table 10, it is shown that if the demand elasticity is decreased to -39, the merger will lead to an unchanged profit for the merged firm, which means that there is a very large incentive for the merger to occur based on Model 3's assumptions.

Table 11 contains a comparison of some key predicted effects based on Models 1 to 3, using the estimates for the demand and cost savings parameter. Models 1 and 2 predict that the merger will increase the industry price by 1.5 to 5 percent, depending on the fringe's supply elasticity. Each of the three models consistently predicts an increase in price, a decrease in quantity, a reduction in consumer and total welfare, and profits greater or equal to those before the merger. It is evident from this table that the magnitudes of the predictions are somewhat sensitive to the value that is assumed for the fringe's supply elasticity.

Overall, the conclusion drawn from the simulation results is that the Allied/Republic merger will unambiguously lead to a price increase and reduce consumer and total surplus. These particular results in Table 11 with a cost-savings rate of only 0.666% for the merged firm are consistent with the DOJ's claim that the merger would result in anticompetitive effects. However, the implications of the simulation results may vary significantly when the values of the input parameters are varied.

iii. The Impact of Cost Savings

One of the key questions that merger simulations address is how large the cost savings of the merged firm need to be in order to prevent a loss in consumer welfare. Figure 1 shows the predicted price effects from all three models for a large range of cost-savings rates for the merged firm. As mentioned before, in the absence of a marginal cost reduction greater than 0.666%, all models predict the industry price to rise as result of the merger. However, as the percentage of cost savings is increased, there is a point in each model, at which the predicted price effect turns negative, leading to an increase in consumer surplus.

The vertical lines in Figure 1 indicate the specific cost-savings rate required by each model for the predicted price effect to be zero. Model 1 requires the smallest cost savings of 5.179%, while Model 2 requires the merged firm's marginal cost to fall by 12.28%. Model 3 requires cost savings of 35.12%. These values are summarized in Table 12. The predicted price effect and therewith the consumer surplus effect vary greatly for cost-savings rates between roughly 5% and 12.3%. However, it must be noted that the sensitivity of this parameter may also depend largely on the assumed demand and supply elasticities. It may be concluded that the post-merger price is predicted rather robustly when there is confidence that the merged firm's cost savings will be about 5% or less. When larger reductions in marginal cost are considered, the results are very sensitive to the assumed cost-savings rate. If the fringe's elasticity of supply were to be decreased to 0 in Model 1, the results would be identical to those from Model 2. For values between 0 and 1.598, a cost savings between 5% and 12.3% is needed to offset the merger's price-increasing effect.

iv. Sensitivity of Results to Demand and Supply Parameters

Demand Parameter

In order to analyze the simulation results' sensitivity with respect to the demand elasticity parameter, Figures 2 and 3 present the predicted price effects of each model for different elasticity values. The results for elasticities between -0.5 and -3 are graphed in Figure 2. The results for elasticity values greater than -3 are shown in Figure 3. Only the predicted price effects are displayed, because they summarize the general variability of the other results, such as consumer surplus, with respect to the demand elasticity. The effects on output and consumer welfare follow a consistent trend with the price effect.

As seen earlier in Table 11, the price effects vary in magnitude across the models when a demand elasticity of -0.752 is assumed. Figure 2 shows that Model 3 results in far greater price increases than Models 1 and 2, when the value of the demand elasticity is assumed to lie between -0.5 and -3. As the value of the parameter is increased above -3, the differences in the price effects become smaller, as shown in Figure 3. Since the demand elasticity for the national market is assumed to be -0.752, and Models 1 and 2 make the more realistic assumptions for this merger on a national scale, there is a certain degree of uncertainty about the magnitude of the post-merger increase in price. For larger values for the demand elasticity, as estimated from the California dataset, the predicted price effects lie between -0.04% and 1.11%, which is very close to zero. The predicted price effects for the point estimates from the National and California datasets are shown in Table 13. Overall, the predictions of the post-merger market seem to be fairly robust with respect to the estimates of the industry elasticity of demand, especially when demand is more inelastic, which is a reasonable assumption, based on the estimation of the national demand for the United States presented earlier. However, if demand is considered to be more elastic, as in Figure 3, there will be some variation in the predicted values, since the price effect changes signs at a demand elasticity of about -10.

Supply Parameter

Figure 4 graphs Model 1's predictions for the percentage changes in price, output, consumer surplus, and total surplus for different values of the fringe's supply elasticity. All four effects are robust with respect to the elasticity parameter. The three vertical lines in Figure 4 indicate the three point estimates from the supply estimation with the California dataset. Below the graph, it is shown that the simulation's predictions do not vary much for these estimates. For supply elasticities ranging from 0 to about 7 or 8, the predictions are consistent in their signs but vary in magnitude. Setting the fringe's supply elasticity equal to zero gives the special case of Model 2, where the fringe is constrained in capacity.

Overall, the results of the merger simulations vary quite substantially depending on the demand elasticities. However, the predictions for the post-merger market are rather robust with respect to different supply elasticities for the competitive fringe. Thus, the quality of the prediction of the merger's effect on price and consumer surplus is highly dependent on the precision of the estimated value for the elasticity parameters. This observation was made previously by Walker (2005), among others. Additionally, the uncertainty about the merged firm's marginal cost makes it difficult to make conclusions about the merger's effects for cost-savings rates above about 5%. Due to the considerable uncertainty about the exact value of the demand and cost parameters, the merger simulations in this paper may not be very accurate. However, the simulations do show the factors that cause variability in the predictions of the post-merger market, and enable an analysis of how robust the predictions are with respect to changes in each of these factors.

VI. Conclusion

Horizontal merger analysis tries to predict how a market will change in terms of competition and welfare after a merger. In reviewing the potential effects of proposed mergers, antitrust enforcement agencies such as the FTC or the DOJ increasingly use methods, which combine the estimation of various pre-merger market parameters and the use of formal economic models for imperfect competition, in order to simulate the post-merger market. To evaluate the usefulness of simulation techniques in a specific case, and to assess the effectiveness of simulation techniques in general, this thesis examines the 2008 merger of Allied Waste and Republic Services, previously two of the three major competitors in the U.S. waste disposal industry.

This thesis uses merger simulations in which 1) the three largest firms in the market are treated as Cournot competitors, who take the output of a large fringe group as given when choosing their profit-maximizing levels of output, 2) demand and supply parameters are estimated with two different datasets, one National dataset, and one for the State of California, and 3) three slightly different sets of modeling assumptions are used.

The simulation results indicate that the merger is very likely to be profitable in all three of the simulation models if the merged firm's cost savings are at least 0.666%. However, this cost-savings rate is not sufficient for consumer surplus and total surplus to increase. Only for cost savings above 12.3% do Models 1 and 2 consistently predict price to decrease and consumer surplus to increase. Although the actual cost-savings rate is not publicly available, the DOJ claimed that the merger would result in anticompetitive effects without certain divestitures. Since the merging parties' divestitures provide a force that counteracts a price increase caused by the merger, the results in this paper indicate that the actual cost savings were most likely less than 12%, since the divestitures would have been unnecessary otherwise. Although the results do suggest significant potential for the merger to harm consumer welfare, the evidence supports the DOJ's decision to permit the merger, provided that the divestitures were sufficient to offset any price-increasing effect of the merger.

The results highlight some strengths and weaknesses of merger simulation. One key advantage is the ability to compare a range of scenarios based on slightly different assumptions about costs and market behavior. In addition, merger simulations can identify exactly which parameters and which behavioral assumptions generate the predictions.

However, simulation results depend heavily on the quality of the econometric estimates of key input parameters. There may be a great amount of uncertainty about the exact value of demand or supply parameters, which leads to different predictions for the post-merger market. In order for merger simulations to be useful, adequate data and a high level of confidence about the specific parameter values used are necessary. In addition, different choices of competition models may also lead to significantly different outcomes.

Another weakness of most merger simulations is that they generally do not allow for the entry of new firms, which could at least partially offset a merger's price-increasing effect. Two of the three simulation models in this paper do allow for the entry and exit of smaller firms contained in the fringe, although this will not change the simulations' outcomes, as a result of the restrictive assumption that the firms in the fringe behave as a single price-taking group.

Nevertheless, while there are limitations to the insight that merger simulations can provide, and despite a large range of possible outcomes, based on the results in this paper, simulation techniques can be used to quantitatively identify the causes of different outcomes, and to determine approximate upper and lower bounds of a merger's effects. If merger simulations consistently predict an increase or decrease in welfare, they can add more confidence about the appropriate course of action for a merger case. Based on the findings described above, it is reasonable to assume that merger simulation will increasingly play a key role as a useful tool in antitrust analysis.

Tables & Figures

Table 1: Pre-Merger Data (for year ended December 31st, 2007)

Firm	2007 Revenue	Market Share (of Revenue)	# Landfills operated or owned	% of Revenue from landfills
Waste Management	$13.31 bn	25.6% [1]	277	22.9%
Allied Waste	$6.10 bn	11.7% [1]	161	13.1%
Republic Services	$3.18 bn	6.1% [1]	58	18.3% [2]
Fringe	$29.41 bn	56.6% [1]	1258 [3]	n/a

Note: All data in the table above was collected from the 2007 Annual Reports of Waste Management, Allied Waste and Republic Services. Republic Services and Allied Waste estimate the annual total sales of the industry at $52 billion. [1] Based on percentage of $52 billion industry sales. [2] Also includes revenue from transfer services in addition to landfill disposal. [3] Based on total of 1754 landfills in the United States, as reported by the EPA in *Municipal Solid Waste in the United States: 2007 Facts and Figures.*

Table 2: Summary Statistics for National Landfill Dataset

Variable	Observations	Mean	Standard Deviation
Average tipping fee for landfill disposal in $/ton (Price)	100	34.36	13.60
Millions of tons processed in landfills per day (Q)	100	6.39	7.60
Population Density (population/ sq. mile surface area)	102	364.21	1310.91
Toxic Chemical Release relative to GDP	100	2.22e-04	3.02e-04
Population	102	5561827	6196353
GDP	102	194189	231906
Toxic Chemical Release (millions of pounds)	100	30.64	32.93
ln(Price)	100	3.46	0.38
ln(Q)	100	1.28	1.17

Note: Data is for all U.S. states for the years 2000 and 2001. The observations have been pooled because there was no significant time trend in the data.

Table 3: Demand Estimation using 2SLS – National Dataset

Dependent variable is ln(Q)

Instrument for ln(Price)	Population Density	Toxic Chemical Release relative to GDP	Population Density, Toxic Chemical Release relative to GDP
	(1)	(2)	(3)
ln(Price)	-.752 *	.281	-.695 *
(Demand Elasticity)	(.295)	(1.009)	(.291)
GDP	-6.84e-06	-.0000105 *	-7.04e-06 **
	(2.71e-06)	(4.53e-06)	(2.70e-06)
Population	3.69e-07 *	.4.93e-07 **	3.76e-07 **
	(1.03e-07)	(1.63e-07)	(1.03e-07)
Toxic Chemicals Release	.009 **	.011 **	.009 **
	(.003)	(.003)	(1.019)
Constant	2.854 **	-.750	2.656 **
	(1.035)	(3.523)	(1.019)
Centered R-squared	.699	.619	.699
Observations	100	100	100
Diagnostic Statistics			
Cragg-Donald Wald F-statistic	41.44 *	15.29 [1]	33.87 *
Anderson canon. corr. LM-stat	30.37 **	13.87 **	41.88 **
Sargan statistic	0	0	1.33
F-stat for IV in reduced form	57.16 **	4.03 *	29.58 **

Note: 2SLS regression. Standard errors are shown in parentheses. Significance of the Cragg-Donald Wald F-statistic indicates that the null hypothesis of weak identification is rejected. The critical values used to interpret the Cragg-Donald statistic were drawn from Stock and Yogo (2002). Significance of the Anderson canonical correlation LM-statistic implies that null hypothesis of underidentification is rejected. A Sargan statistic (for testing overidentification of all instruments) of 0 means that the model is exactly identified and an insignificant Sargan statistic implies that one cannot reject the null hypothesis that all instruments are uncorrelated with the error term.
[1] Cragg-Donald Wald F-statistic is insignificant at the 5% level using the critical value for 10% maximal IV size. Similarly the instrument is barely significant in the reduced form at the 5% level. Therefore there is evidence that this model is weakly identified. ** indicates significance at 1% level. * indicates significance at 5% level.

Table 4: Summary Statistics for California Landfill Dataset

Variable	Observations	Mean	Standard Deviation
Tipping Fee in $/ton (Price)	386	35.33	12.44
Tons of solid waste landfilled (Q)	495	272726	496628
County Population	584	1613278	2617837
Income per Capita	584	25551.12	7960.63
Land Surface Area (sq. miles)	584	4870.22	5058.75
Population Density (population/ sq. mile)	584	546.07	830.69
Disposal Site Capacity (tons/day)	516	2046.65	2654.05
ln(Price)	386	3.50	0.39
ln(Q)	495	11.09	2.20
Ownership of California Landfills			
Waste Management	9 facilities		
Allied Waste	7 facilities		
Republic Services	2 facilities		
Fringe	128 facilities		

Note: Tipping fees are calculated as the arithmetic mean of $/ton tipping fee for compacted waste and $/ton tipping fee for non-compacted waste. Data is for the years 1997-2000. The observations have been pooled because there was no significant time trend in the data.

Table 5: Demand Estimation using 2SLS - California Dataset

Dependent variable is ln(Q)

Instrument for ln(Price)	Population Density	Disposal Site Capacity	Population Density, Disposal Site Capacity
	(1)	(2)	(3)
ln(Price)	-6.856 **	-13.815 **	-9.779 **
(Demand Elasticity)	(1.503)	(3.234)	(1.940)
Income per Capita	1.224e-04 **	1.829e-04 **	1.484e-04 **
	(.248e-04)	(.492e-04)	(.34e-04)
Land Surface Area	-1.488e-04 **	-2.718e-04 **	-2.011e-04 **
	(.404e-04)	(.822e-04)	(.552e-04)
Constant	33.064 **	56.291 **	42.760 **
	(5.129)	(10.910)	(6.566)
Centered R-squared	-1.364	-6.789	-3.150
Observations	363	335	335
Diagnostic Statistics			
Cragg-Donald Wald F-statistic	26.39 *	18.86 *	14.31 [1]
Anderson canon. corr. LM-stat	24.86 **	18.06 **	26.74 **
Sargan statistic	0	0	.003 **
F-stat for IV in reduced form	25.92 **	19.70 **	14.74 **

Note: 2SLS regression. Standard errors are shown in parentheses. Significance of the Cragg-Donald Wald F-statistic indicates that the null hypothesis of weak identification is rejected. The critical values used to interpret the Cragg-Donald statistic were drawn from Stock and Yogo (2002). Significance of the Anderson canonical correlation LM-statistic implies that the null hypothesis of underidentification is rejected. A Sargan statistic (for testing overidentification of all instruments) of 0 means that the model is exactly identified and an insignificant Sargan statistic implies that one cannot reject the null hypothesis that all instruments are uncorrelated with the error term.
[1] Cragg-Donald Wald F-statistic is insignificant at the 5% level using the critical value for 10% maximal IV size. It is significant at the 5% level using the critical value for 15% maximal IV size. This may be an indication of weak identification of the model. ** indicates significance at 1% level. * indicates significance at 5% level.

Table 6: Fringe Supply Estimation using 2SLS – California Dataset

Dependent variable is $\ln(Q_F)$

Instrument for ln(Price)	Income per Capita	Land Surface Area	Income per Capita, Land Surface Area
	(1)	(2)	(3)
ln(Price) *(Supply Elasticity)*	1.853 ** (.635)	1.598 ** (.615)	1.725 ** (.510)
Population Density	2.345e-04 * (1.159e-04)	2.345e-04 * (1.125e-04)	2.345e-04 * (1.141e-04)
Disposal Site Capacity	5.013e-04 ** (.448e-04)	4.928e-04 ** (.438e-04)	.497e-04 ** (.425e-04)
Constant	3.733 (2.262)	4.643 * (2.191)	4.189 * (1.815)
Centered R-squared	.343	.380	.363
Observations	299	299	299
Diagnostic Statistics			
Cragg-Donald Wald F-statistic	36.55 *	36.76 *	29.32 *
Anderson canon. corr. LM-stat	32.97 **	33.13 **	49.71 **
Sargan statistic	0	0	.13
F-stat for IV in reduced form	38.11 **	38.34 **	30.56 **

Note: 2SLS regression with natural logarithm of tonnage disposed of by fringe as dependent variable. Standard errors are shown in parentheses. Significance of the Cragg-Donald Wald F-statistic indicates that the null hypothesis of weak identification is rejected. The critical values used to interpret the Cragg-Donald statistic were drawn from Stock and Yogo (2002). Significance of the Anderson canonical correlation LM-statistic implies that the null hypothesis of underidentification is rejected. A Sargan statistic (for testing overidentification of all instruments) of 0 means that the model is exactly identified and an insignificant Sargan statistic implies that one cannot reject the null hypothesis that all instruments are uncorrelated with the error term. ** indicates significance at 1% level. * indicates significance at the 5% level.

Table 7: Model 1 - Competitive Fringe's Supply Function (Merger Profitable)

Pre-merger Equilibrium

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Allied Waste	11.7%	$6.08	0.148	$38.10	$2.90	$0.43		
Republic Services	6.1%	$3.18	0.077	$39.49	$1.51	$0.12	$51.89	$54.49
Waste Management	25.6%	$13.31	0.325	$34.66	$6.34	$2.06		
Fringe	56.6%	$29.43	0.718	$41.00	$0.00	$0.00		

Post-merger Equilibrium

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Republic Services/Allied Waste	13.3%	$6.94	0.167	$38.32	$3.28	$0.55		
Waste Management	28.1%	$14.69	0.353	$34.66	$6.94	$2.45	$51.13	$54.13
Fringe	58.6%	$30.56	0.735	$41.60	$0.00	$0.00		

Post-merger Price	$41.60	% Δ Profit Merged Firm	0.01%		
% Δ Price	1.46%	% Δ Consumer Surplus	-1.46%	Demand Curve: ln(P) = *a* + *b* ln(Q)	
% Δ Total Output	-1.09%	% Δ Total Surplus	-0.67%	*a*	4.030
% Δ Total Profit	15.04%			*b*	-1.330

Note: The simulation shown above assumes Cournot competition among Allied Waste, Republic Services, and Waste Management. The competitive fringe produces an output such that its marginal cost (a function of its output) is equal to price. The simulation also assumes an industry price elasticity of demand of -0.752, and a cost-savings rate of 0.666%, above which the merger becomes profitable for the merging parties. The pre-merger market price is $41 and the total pre-merger sales in the market amount to $52 billion. The fringe's elasticity of supply is assumed to be 1.598.

Table 8: Model 2 - Capacity Constraint on Fringe (Merger Profitable)

Pre-merger Equilibrium

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Allied Waste	11.7%	$6.08	0.148	$34.62	$6.38	$0.95	$51.89	$57.63
Republic Services	6.1%	$3.18	0.077	$37.67	$3.33	$0.26		
Waste Management	25.6%	$13.31	0.325	$27.04	$13.96	$4.53		
Fringe	56.6%	$29.43	0.718	$41.00	$0.00	$0.00		

Post-merger Equilibrium

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Republic Services/Allied Waste	13.1%	$6.91	0.160	$35.60	$7.52	$1.20	$49.25	$57.48
Waste Management	28.1%	$14.76	0.342	$27.04	$16.08	$5.50		
Fringe	58.8%	$30.95	0.718	$41.00	$2.12	$1.52		

Post-merger Price	$43.12	% Δ Profit Merged Firm	0.00%		
% Δ Price	5.17%	% Δ Consumer Surplus	-5.09%	Demand Curve: ln(P) = *a* + *b* ln(Q)	
% Δ Total Output	-3.79%	% Δ Total Surplus	-0.25%	*a*	4.030
% Δ Total Profit	43.49%			*b*	-1.330

Note: The simulation shown above assumes Cournot competition among Allied Waste, Republic Services, and Waste Management. The competitive fringe has a capacity constraint at its pre-merger level of output. This means that both its level of output and its marginal cost will not change post-merger. The simulation also assumes an industry price elasticity of demand of -0.752, and a cost-savings rate of 0.190%, above which the merger becomes profitable for the merging parties. The pre-merger market price is $41 and the total pre-merger sales in the market amount to $52 billion.

Table 9: Model 3 - Three Cournot Competitors (No Cost Savings)

Pre-merger Equilibrium — Elasticity of Demand = -0.752

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Allied Waste	27.0%	$14.02	0.342	$26.31	$14.69	$5.02		
Republic Services	14.1%	$7.32	0.179	$33.33	$7.67	$1.37	$51.89	$82.33
Waste Management	59.0%	$30.67	0.748	$8.85	$32.15	$24.05		

Post-merger Equilibrium

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Republic Services/Allied Waste	36.7%	$20.61	0.368	$28.71	$27.33	$10.05	$34.99	$75.00
Waste Management	63.3%	$35.58	0.635	$8.85	$47.20	$29.97		

Post-merger Price	$56.04	% Δ Profit Merged Firm	57.18%
% Δ Price	36.69%	% Δ Consumer Surplus	-32.57%
% Δ Total Output	-20.95%	% Δ Total Surplus	-8.90%
% Δ Total Profit	31.45%		

Demand Curve: ln(P) = $a + b$ ln(Q)	
a	4.030
b	-1.330

Note: The simulation shown above assumes Cournot competition among Allied Waste, Republic Services, and Waste Management. The three firms serve the entire $52 billion market before the merger. The simulation also assumes an industry price elasticity of demand of -0.752, and a cost-savings rate of 0% so that the merged firm's marginal cost is equal to the pre-merger output-weighted average of the two merging firms' marginal costs. The pre-merger market price is $41.

Table 10: Model 3 - Three Cournot Competitors (Merger Profitable)

Pre-merger Equilibrium — Elasticity of Demand = -39

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Allied Waste	27.0%	$14.02	0.342	$40.72	$0.28	$0.10		
Republic Services	14.1%	$7.32	0.179	$40.85	$0.15	$0.03	$1.37	$1.96
Waste Management	59.0%	$30.67	0.748	$40.38	$0.62	$0.46		

Post-merger Equilibrium

	Market Share (%)	Sales ($bn.)	Quantity (bn.)	Marginal Costs	Markup	Profit ($bn.)	CS ($bn.)	TS ($bn.)
Republic Services/Allied Waste	31.8%	$15.11	0.368	$40.76	$0.34	$0.12	$1.25	$1.94
Waste Management	68.2%	$32.36	0.787	$40.38	$0.72	$0.57		

Post-merger Price	$41.10	% Δ Profit Merged Firm	0.00%		
% Δ Price	0.24%	% Δ Consumer Surplus	-8.71%	Demand Curve: ln(P) = *a* + *b* ln(Q)	
% Δ Total Output	-8.93%	% Δ Total Surplus	-0.88%	*a*	3.720
% Δ Total Profit	17.38%			*b*	-0.026

Note: The simulation shown above assumes Cournot competition among Allied Waste, Republic Services, and Waste Management. The three firms serve the entire $52 billion market before the merger. The simulation also assumes an industry price elasticity of demand of -39, which is the value below which the merger is not profitable for the merging parties. The results assume a cost-savings rate of 0% for the merged firm. The pre-merger market price is $41.

Table 11: Comparison of Simulation Results between Models

	Model 1	Model 2	Model 3
% Δ Price	1.46%	5.00%	36.00%
% Δ Quantity	-1.09%	-3.62%	-20.64%
% Δ Consumer Surplus	-1.46%	-4.92%	-32.02%
% Δ Total Surplus	-0.67%	-0.18%	-8.64%
% Δ Total Profit	15.04%	42.65%	31.21%
% Δ Profit of Merged Firm	0.00%	2.94%	57.50%

Note: All simulations assume an industry price elasticity of -0.752 and a cost-savings rate of 0.666% for the merged firm. Model 1 assumes the fringe's price elasticity of supply to equal 1.598. Model 2 assumes a fringe price elasticity of supply equal to 0. Model 3 assumes a market with three Cournot competitors.

Table 12: Required Cost Savings to Prevent Price Increase

Cost-Savings Rate of Merged Firm	Model 1		Model 2		Model 3	
	Price Effect	Consumer Surplus Effect	Price Effect	Consumer Surplus Effect	Price Effect	Consumer Surplus Effect
0.00%	1.68%	-1.67%	5.30%	-5.21%	36.69%	-32.57%
5.179% (Model 1)	**-0.01%**	**0.01%**	3.11%	-3.08%	31.28%	-28.22%
12.28% (Model 2)	-2.35%	2.37%	**-0.05%**	**0.05%**	23.86%	-22.02%
35.12% (Model 3)	-9.99%	10.41%	-10.29%	10.74%	**-0.01%**	**0.01%**

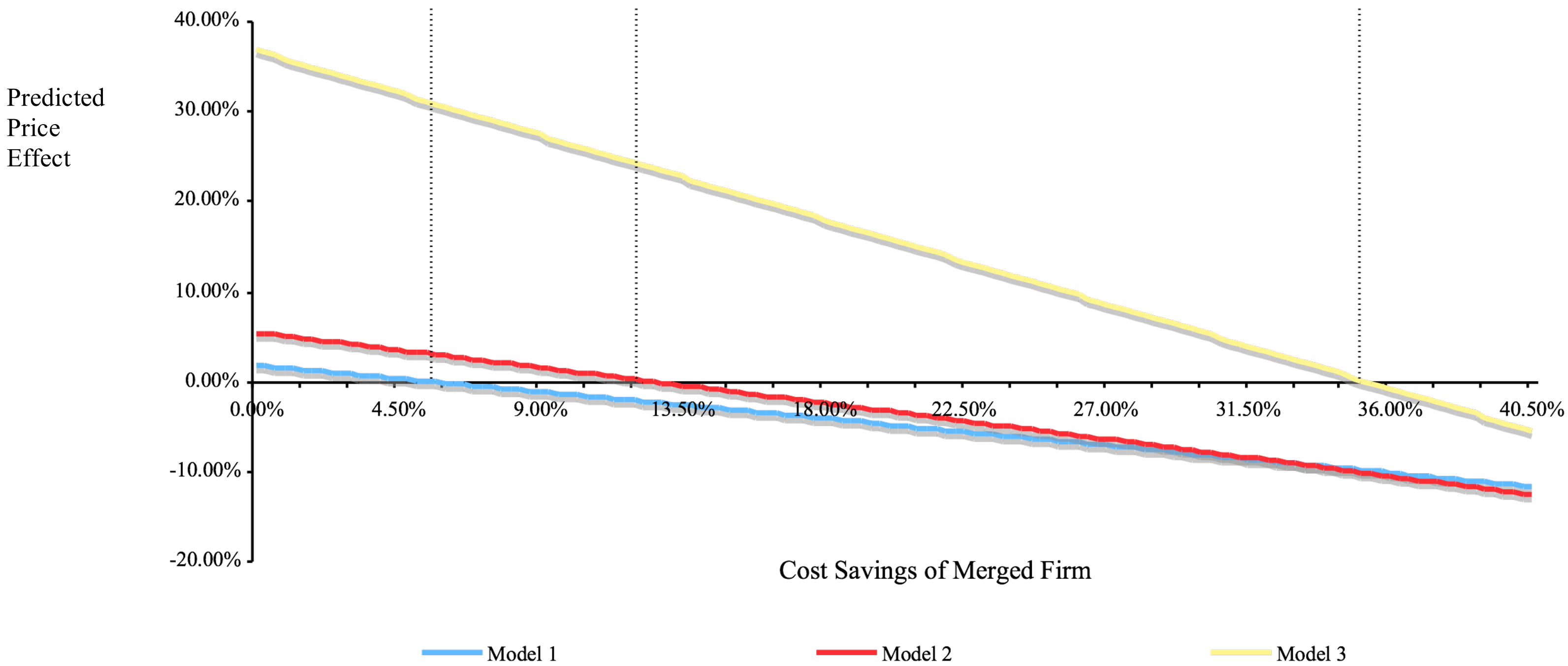
Note: All simulations assume an industry price elasticity of -0.752. Model 1 assumes a supply price elasticity of 1.598 for the fringe.

Table 13: Sensitivity Analysis of Estimated Demand Elasticities

	Predicted Price Effects		
Industry Elasticity of Demand	Model 1	Model 2	Model 3
Estimates from National Dataset			
-0.752	1.46%	4.99%	36.0%
-0.695	1.52%	5.58%	46.62%
Estimates from California Dataset			
-6.856	0.14%	0.21%	1.11%
-9.779	0.04%	0.06%	0.65%
-13.815	-0.04%	-0.03%	0.35%

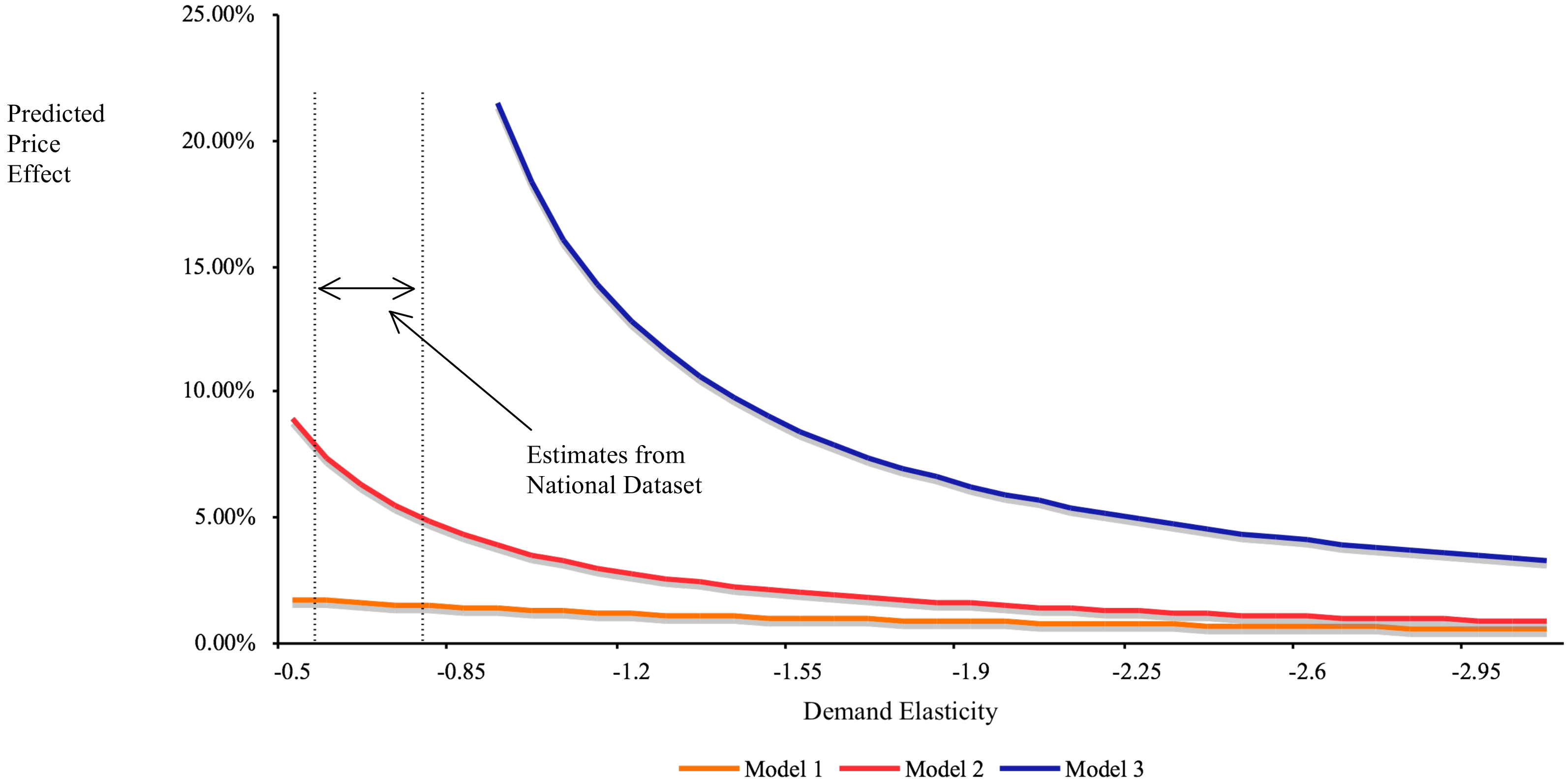
Note: Only the predicted price effects of the simulations are shown. All simulations assume a cost-savings rate of 0.666% for the merged firm. Model 1 assumes the fringe's price elasticity of supply to equal 1.598.

Figure 1: Sensitivity Analysis of Cost-Savings Rate – Predicted Price Effects



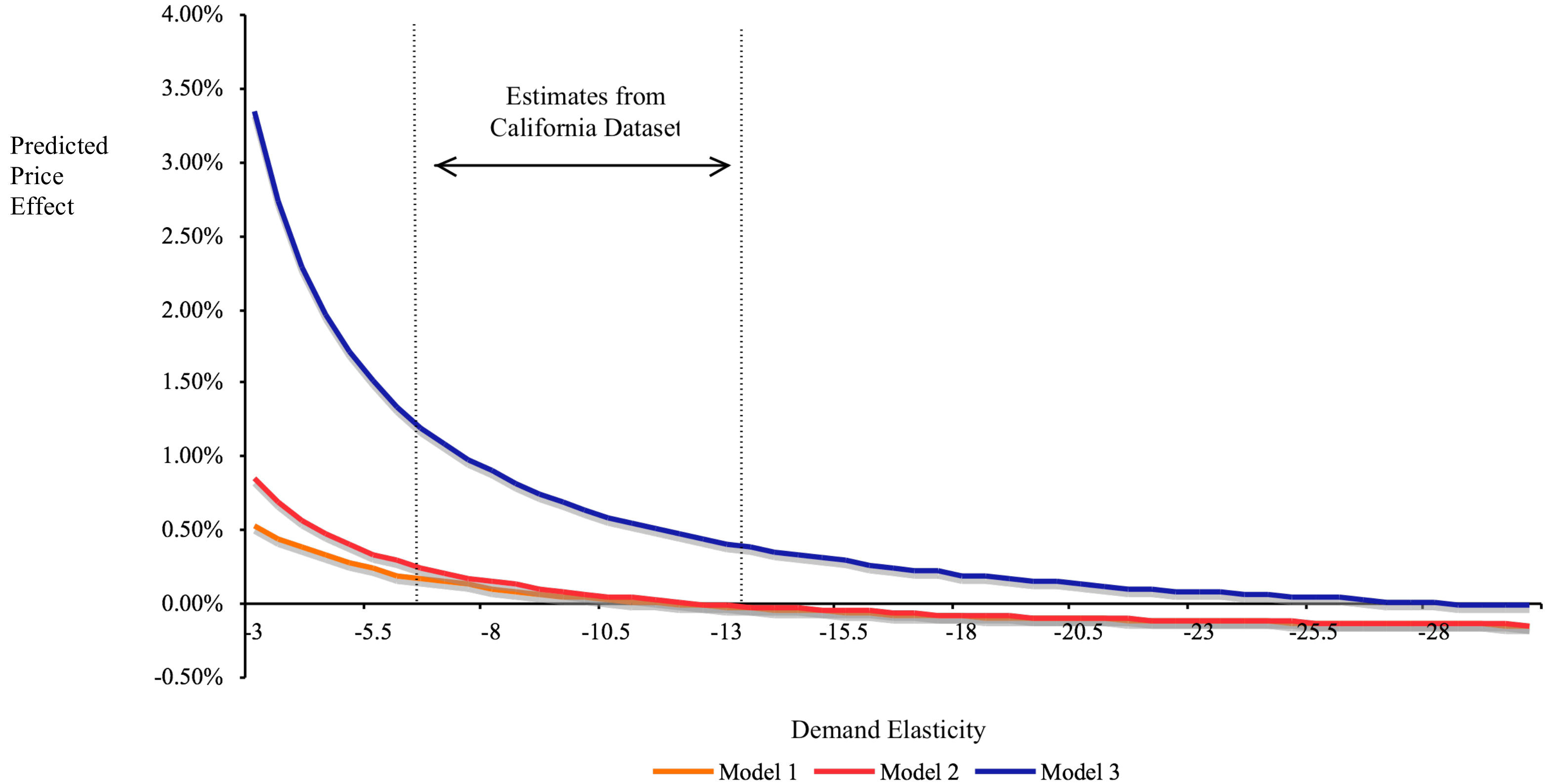
Note: All simulations assume an industry price elasticity of -0.752. Model 1 assumes a supply price elasticity of 1.598 for the fringe.

Figure 2: Sensitivity of Demand Elasticity Parameter – Price Effects (1/2)



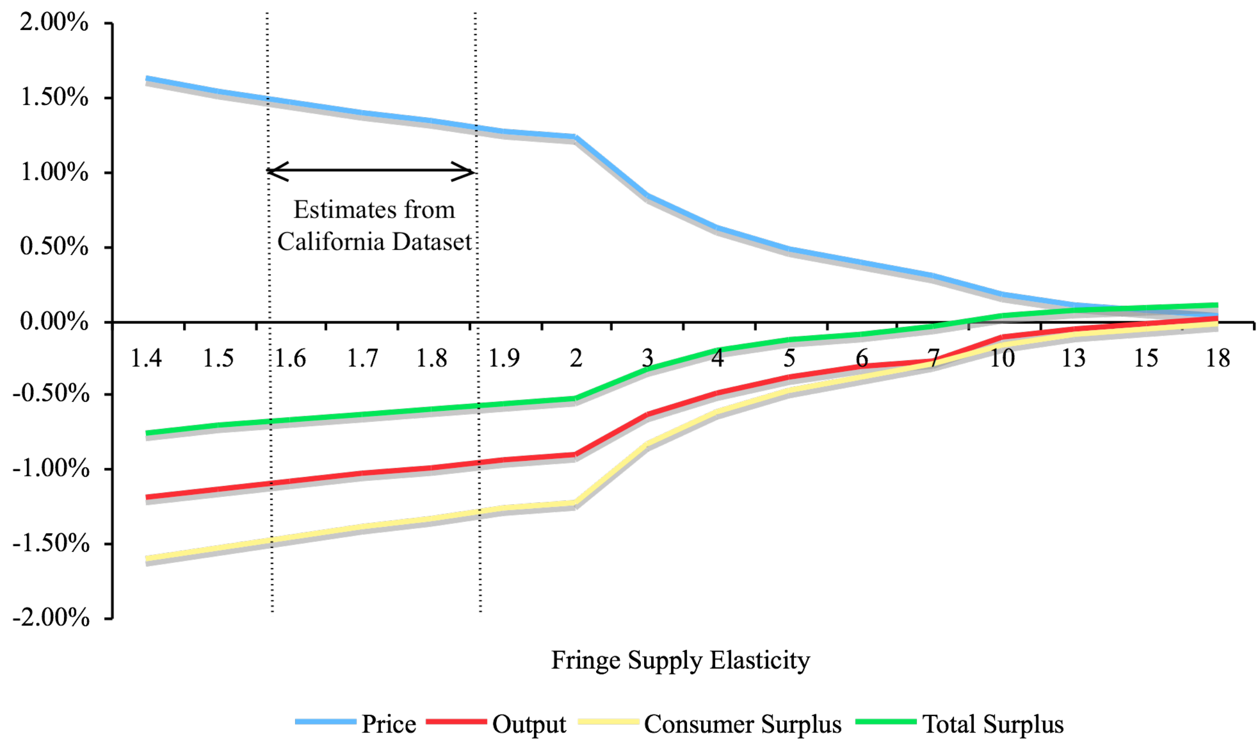
Note: Only the predicted price effects of the simulations are shown. All simulations assume a cost-savings rate of 0.666% for the merged firm. Model 1 assumes the fringe's price elasticity of supply to equal 1.598.

Figure 3: Sensitivity of Demand Elasticity Parameter – Price Effects (2/2)



Note: Only the predicted price effects of the simulations are shown. All simulations assume a cost-savings rate of 0.666% for the merged firm. Model 1 assumes the fringe's price elasticity of supply to equal 1.598.

Figure 4: Sensitivity Analysis of Fringe's Supply Elasticity (Model 1)



Fringe Supply Elasticity Estimate	% Δ Price	% Δ Output	% Δ Consumer Surplus	% Δ Total Surplus
0	5.00%	-3.62%	-4.92%	-2.73%
1.598	1.46%	-1.09%	-1.46%	-0.67%
1.725	1.38%	-1.02%	-1.37%	-0.62%
1.853	1.30%	-0.97%	-1.30%	-0.58%

Note: All simulations assume an industry price elasticity of -0.752 and a cost-savings rate of 0.666% for the merged firm.

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