

Beyond Horizontal and Vertical: Simulating the Welfare Effects of Complex Integration^{*}

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Abstract

We study the simulation of mergers that have both horizontal and vertical aspects. Our model features logit Bertrand competition downstream and Nash Bargaining upstream. We apply the model to the Republic/Santek merger as a real-world example.

Keywords: bargaining models; merger simulation; vertical markets; vertical mergers

JEL classification: L13; L40; L41; L42

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1 Introduction

Given the many different ways a firm may be organized, it is rare that any particular merger can be neatly categorized as purely horizontal or purely vertical. This is particularly true for the mergers involving large firms that usually attract the most scrutiny. However, for both historical and practical reasons, antitrust research and practice has generally maintained this dichotomy. Horizontal mergers are cast in terms of whether they create significant upward pricing pressure (UPP), whereas the focus for vertical mergers is on assessing the net effects of the elimination of double marginalization (EDM) versus raising rivals' costs (RRC). As a result, the antitrust community has done little research into "complex" mergers, which here we define as mergers that possess both horizontal and vertical aspects.

The horizontal versus vertical distinction had been enshrined in U.S. Department of Justice (DOJ) and Federal Trade Commission (FTC) Horizontal Merger Guidelines and their companion document, the Vertical Merger Guidelines.¹ Given these policy documents, it is not surprising that the agencies have historically framed most mergers as either horizontal or vertical. Similarly, most antitrust research maintains this separate categorization, leaving us with little guidance for how our merger simulations and related tools apply to complex mergers. However, in recognition of these issues, the DOJ and FTC revised their Merger Guidelines in 2023, releasing a single document that discusses both horizontal and vertical aspects of competition. As part of the revision effort, these agencies requested comments on whether any "modern market realities may be lost by focusing on [horizontal and vertical] relationships categorically."² In this paper, we address this question by exploring the implications that a typical merger simulation model has for the welfare effects of complex

¹The most recent Horizontal Merger Guidelines is from 2010, while the most recent Vertical Merger Guidelines is from 2020. They have both been recently superseded by a joint document.

²The full question is l.g. in the "Request for Information on Merger Enforcement," dated January 18, 2022. The text of the question reads: "Should the guidelines' traditional distinctions between horizontal and vertical mergers be revisited in light of recent economic trends in the modern economy? What aspects of modern market realities may be lost by focusing on these relationships categorically? Should the guidelines address all mergers in a common framework that covers all market relationships relevant to competition? If so, how?"

mergers.

Our model is drawn from Sheu and Taragin (2021), and features a Bertrand logit downstream setup alongside a Nash Bargaining wholesale negotiation upstream. We use this model to investigate the 2021 merger of two vertically integrated solid waste management firms, Republic Services and Santek Waste Services, in one geographic market, Chattanooga, Tennessee. The supply chain of this industry involves collection haulers at the downstream level that bring trash to disposal facilities at the upstream level. Both Republic and Santek operated upstream and downstream in Chattanooga, as did one of their largest rivals, Waste Connections. In this market, the DOJ negotiated a settlement package meant to address harms in downstream collection and in upstream disposal. Using a small set of public data inputs, our merger simulation model is able to produce rich results for the changes in horizontal and vertical competition, including RRC and EDM effects. We estimate that without divestitures, consumers would have faced approximately \$16 million in annual harm in the Chattanooga market. Furthermore, we show that modeling the merger as a purely horizontal upstream or downstream transaction would miss key vertical impacts.

There are a few caveats to our analysis. First, products in our merger simulations do not experience any changes in their qualities or costs, other than movements in their wholesale prices due to shifts in bargaining leverage. Therefore, we rule out merger efficiencies as they are conceptualized in, for example, Werden (1996), and we instead focus on EDM as the main channel through which mergers may benefit consumers. Second, we model upstream bargaining as being over linear fees, rather than over two-part tariffs or other compensation schedules. Although this assumption means bargaining is inefficient, linear input prices are widely observed in some industries, perhaps because of difficulties with implementing or monitoring more complicated contracts.³ Third, our model assumes that upstream and downstream prices are set treating all other prices as fixed. Although we make

³One example of an industry with linear wholesale pricing that has been featured in several vertical merger proceedings is cable programming distribution, as detailed in Rogerson (2014).

this assumption in part for simplicity, it also may be appropriate for industries where prices take time to adjust.⁴ Fourth, we rely on the logit for our demand function, which limits the ways in which consumers substitute between products. We also provide additional results using the nested logit.

Our paper is related to the large literature on competition and vertical integration that grew out of a number of theory articles in the 1980s and 1990s. Riordan (2008) has an excellent summary. This research explores how incentives to disadvantage rivals could arise alongside the efficiencies (such as EDM) associated with vertical integration. Some of these incentives result in RRC effects (e.g. Salop and Scheffman (1983) or Riordan (1998)) or in the foreclosure of competitors from input markets (e.g. Salinger (1988) or Ordover, Saloner, and Salop (1990)). Unlike in our paper, most of these models are not framed explicitly as bargaining problems, instead assuming firms making take-it-or-leave-it offers. However, many of the incentives towards RRC, which usually involve trading off profits from input sales against those from downstream sales, are similar to those that appear in our model. These theory papers tend to focus on pure vertical mergers rather than complex mergers, in order to maintain mathematical tractability.

Meanwhile, the structural empirical industrial organization literature has also studied the competitive effects of vertical integration as part of a greater exploration of the impacts of bargaining power in vertical supply chains. Many of these papers are based on the model developed in Horn and Wolinsky (1988) modified to allow for empirical estimation, as seen in, for example, Draganska, Klapper, and Villas-Boas (2010). These models have been applied to several sectors that are the frequent target of vertical integration, such as healthcare (e.g. Ho and Lee (2017)) and video programming distribution (e.g. Crawford, Lee, Whinston, and Yurukoglu (2018)). These structural empirical papers explore the welfare effects of various

⁴Examples include situations where products are sold under long-term contracts. In contrast, Bonnet, Bouamra-Mechemache, and Molina (2023) allow downstream firms to treat their own prices as adjustable during upstream negotiations. The authors argue that this setup is useful for settings like grocery stores, where menu costs are low.

competitive interactions, including complex mergers, in certain industries.⁵ Our framework is similar to the models appearing in these papers, but it has been simplified for use with limited data, with the goal of being more accessible to practitioners and policymakers.

Our work is also related to the literature on methods for measuring the welfare impacts of mergers, particularly papers about vertical mergers. The closest merger simulation article is our previous research in Sheu and Taragin (2021), which uses the same model we feature here but assumes that no firm is vertically integrated pre-merger, ruling out complex mergers. That paper in turn takes the setup from Werden and Froeb (1994) to characterize downstream competition, and pairs it with a Nash Bargaining model for the upstream market. Das Varma and De Stefano (2020) and Domnenko and Sibley (2022) provide additional vertical merger frameworks that make alternative assumptions about demand and pricing. Moresi and Salop (2013), Rogerson (2020), and De Stefano and Salinger (2024) develop UPP-style tools for assessing the impact of vertical mergers. However, these papers do not focus on complex mergers.

The paper proceeds as follows. In Section 2, we introduce the theoretical framework and explain how we model mergers. Our application to Republic/Santek appears in Section 3. Section 4 concludes. Additional simulation results and information on the data used in the application appear in the Appendix.

2 Theory

We begin by describing our basic framework, based on Sheu and Taragin (2021), which uses a downstream Bertrand model embedded in an upstream Nash Bargaining setup. We extend this framework allows to study a variety of complex merger configurations.

⁵There is a companion empirical literature that relies more on regression analysis that identified changes in market outcomes due to vertical integration (e.g. Chipty (2001) on video programming distribution).

2.1 Downstream and Upstream Competition

Assume there is a set of consumers who each choose to buy a single product sold by a retailer. Retailers are indexed by r , and the wholesalers that supply these retailers are indexed by w . Prior to any mergers taking place, each wholesaler offers only one product, although each retailer may purchase from multiple wholesalers. Therefore, unique products (meaning a wholesale product offered at a given retail outlet) are denoted by pairs of the retailer and wholesaler indices, rw . We denote the set of all retailers by $\mathcal{R} = \{1, \dots, |\mathcal{R}|\}$ and the set of all wholesalers by $\mathcal{W} = \{1, \dots, |\mathcal{W}|\}$. We divide the set \mathcal{W} into potentially overlapping subsets, each labeled \mathcal{W}^r , to indicate which wholesalers' products are carried by which retailers. Similarly, we divide the set of retailers \mathcal{R} into potentially overlapping subsets, each labeled \mathcal{R}^w , to indicate the retailers that carry the product sold by each wholesaler. Note that throughout we take as given the set of retailer-wholesaler combinations being offered in the market. We do not model the process of firm entry and exit or the way in which retailers choose which wholesale products to offer.

Let the share of consumers that choose product w sold by retailer r be denoted by s_{rw} . This share is a function of the vector of retail prices P offered across all available products.⁶ In our simulations we model the share using both logit and nested logit functions. The random coefficients logit is another commonly used option. The profit for retailer r is given by $\pi^r = \sum_{x \in \mathcal{W}^r} [p_{rx} - p_{rx}^W - c_{rx}^R] s_{rx} M$, where p_{rx}^W is the unit fee charged by wholesaler x to retailer r , c_{rx}^R captures any additional marginal costs borne by the retailer, and M is the market size. Downstream prices are set in Bertrand equilibrium according to

$$\sum_{x \in \mathcal{W}^r} [p_{rx} - p_{rx}^W - c_{rx}^R] \frac{\partial s_{rx}}{\partial p_{rw}} + s_{rw} = 0, \quad (1)$$

which is the first order condition for product w sold by retailer r .

Wholesale prices are set via bilateral Nash Bargaining between retailers and wholesalers.

⁶We omit the retail price argument for $s_{rw}(P)$ in what follows for brevity's sake.

We assume that the negotiation for a given input price treats other input prices and all downstream prices as given.⁷ Profits for wholesaler w are given by $\pi^w = \sum_{x \in \mathcal{R}^w} [p_{xw}^W - c_{xw}^W] s_{xw} M$, where c_{xw}^W is the wholesale marginal cost when dealing with retailer x . The first order condition for the negotiation between retailer r and wholesaler w is

$$\begin{aligned} & \overbrace{[p_{rw}^W - c_{rw}^W] s_{rw} - \sum_{x \in \mathcal{R}^w \setminus \{r\}} [p_{xw}^W - c_{xw}^W] \Delta s_{xw}(\mathcal{W}^r \setminus \{w\})}^{\text{wholesaler GFT}} = \\ & \frac{1 - \lambda}{\lambda} \left(\underbrace{[p_{rw} - p_{rw}^W - c_{rw}^R] s_{rw} - \sum_{x \in \mathcal{W}^r \setminus \{w\}} [p_{rx} - p_{rx}^W - c_{rx}^R] \Delta s_{rx}(\mathcal{W}^r \setminus \{w\})}_{\text{retailer GFT}} \right), \end{aligned} \quad (2)$$

where $\lambda \in [0, 1]$ captures the bargaining power of the retailer relative to the wholesaler. The $\Delta s_{xy}(\mathcal{W}^r \setminus \{w\}) \equiv s_{xy}(\mathcal{W}^r \setminus \{w\}) - s_{xy}$ is the difference in the share of good y sold by retailer x when good w is not offered by retailer r versus when good w is offered by retailer r . Thus, the wholesale price p_{rw} is set such that the payoff to wholesaler w when it sells to retailer r less the payoff when it does not (that is, the gains from trade or “GFT”), divided by the payoff to retailer r when it buys from wholesaler w less the payoff when it does not, equals the ratio of wholesaler to retailer bargaining power.

Together the series of downstream and upstream first order conditions determine market equilibrium. After assuming a functional form for shares, the model can be solved and calibrated along the lines described in Sheu and Taragin (2021).

2.2 Mergers

Here we describe the manner in which complex mergers are modeled in this framework. Throughout we assume that all marginal costs, c_{rw}^R and c_{rw}^W , and any non-price product

⁷As explained in Sheu and Taragin (2021), this assumption is equivalent to a situation where all negotiations and choices for downstream prices happen simultaneously.

characteristics remain unchanged after the merger, which rules out merger efficiencies. We begin by describing vertical mergers, as all cases we examine have some vertical aspects. Suppose that retailer t and wholesaler v were to merge. Then the first order condition for profit maximization for the joint firm when setting the downstream price for product tv is given by

$$\begin{aligned} & \sum_{x \in \mathcal{W}^t \setminus \{v\}} [p_{tx} - p_{tx}^W - c_{tx}^R] \frac{\partial s_{tx}}{\partial p_{tv}} + s_{tv} + \overbrace{[p_{tv} - c_{tv}^W - c_{tv}^R] \frac{\partial s_{tv}}{\partial p_{tv}}}^{\text{EDM effect}} \\ & + \underbrace{\sum_{x \in \mathcal{R}^v \setminus \{t\}} [p_{xv}^W - c_{xv}^W] \frac{\partial s_{xv}}{\partial p_{tv}}}_{\text{upstream UPP effect}} = 0. \end{aligned} \quad (3)$$

The pricing problem balances two effects. On the one hand, the term labeled “EDM effect” captures the impact of retailer t being able to access product v at marginal cost. This force would tend to lower the resulting price.⁸ On the other hand, the term labeled “upstream UPP effect” captures the incentive to raise prices for retailer t in order to divert sales to wholesaler v . This force would tend to raise the resulting consumer price.

Turning to input prices, when wholesaler v bargains with unaffiliated retailer j , the first order condition becomes

$$\begin{aligned} & [p_{jv}^W - c_{jv}^W] s_{jv} - \sum_{x \in \mathcal{R}^v \setminus \{t, j\}} [p_{xv}^W - c_{xv}^W] \Delta s_{xv}(\mathcal{W}^j \setminus \{v\}) \\ & \quad \overbrace{\quad \quad \quad}^{\text{RRC effect}} \\ & - \overbrace{[p_{tv} - c_{tv}^W - c_{tv}^R] \Delta s_{tv}(\mathcal{W}^j \setminus \{v\})}^{\text{indirect EDM effect}} - \sum_{x \in \mathcal{W}^t \setminus \{v\}} [p_{tx} - p_{tx}^W - c_{tx}^R] \Delta s_{tx}(\mathcal{W}^j \setminus \{v\}) = \quad (4) \\ & \frac{1 - \lambda}{\lambda} \left([p_{jv} - p_{jv}^W - c_{jv}^R] s_{jv} - \sum_{x \in \mathcal{W}^j \setminus \{v\}} [p_{jx} - p_{jx}^W - c_{jx}^R] \Delta s_{jx}(\mathcal{W}^j \setminus \{v\}) \right). \end{aligned}$$

⁸However, this lower marginal cost raises the potential for a larger margin, which could also cause a multi-product retailer to raise prices on its other goods $x \in \mathcal{W}^t \setminus \{v\}$, in order to divert sales to product tv . This is the Edgeworth-Salinger effect as in Salinger (1991).

which reflects the change in the disagreement payoff coming from the merger with retailer t . Now when the wholesaler considers the possible loss of sales upon ceasing to trade with retailer j , these losses are softened due to a potential for diversion to retailer t , which we label the “RRC effect.”⁹ Furthermore, the margin on product v sold by retailer t is potentially higher due to EDM than the wholesale margin v would have earned, as shown through the expression labeled “indirect EDM effect,” which can further compensate the firm. These impacts tend to raise the resulting input price to retailer j .

When the merged firm is bargaining with the unaffiliated wholesaler k over what input price to pay, the bargaining first order condition becomes

$$\begin{aligned}
& [p_{tk}^W - c_{tk}^W]s_{tk} - \sum_{x \in \mathcal{R}^k \setminus \{t\}} [p_{xk}^W - c_{xk}^W] \Delta s_{xk}(\mathcal{W}^t \setminus \{k\}) = \\
& \frac{1-\lambda}{\lambda} \left([p_{tk} - p_{tk}^W - c_{tk}^R]s_{tk} - \sum_{x \in \mathcal{W}^t \setminus \{v,k\}} [p_{tx} - p_{tx}^W - c_{tx}^R] \Delta s_{tx}(\mathcal{W}^t \setminus \{k\}) \right. \\
& \quad \left. - \underbrace{[p_{tv} - c_{tv}^W - c_{tv}^R] \Delta s_{tv}(\mathcal{W}^t \setminus \{k\})}_{\text{EDM recapture effect}} - \underbrace{\sum_{x \in \mathcal{R}^v \setminus \{t\}} [p_{xv}^W - c_{xv}^W] \Delta s_{xv}(\mathcal{W}^t \setminus \{k\})}_{\text{wholesale recapture leverage effect}} \right). \tag{5}
\end{aligned}$$

In this case, the merged firm has two channels for potential additional profits should it cease to trade with wholesaler k . First, if retail sales are diverted to product v sold by retailer t , those sales will earn a higher margin due to lower marginal costs stemming from what we call the “EDM recapture effect.” Second, the loss of product k carried by retailer t could increase sales by wholesaler v through other retailers, which we call the “wholesale recapture leverage effect.” Both of these effects would tend to lower the resulting input price.

⁹The assumption of simultaneous downstream price setting rules out RRC effects in the style of Salop and Scheffman (1983), in that here the wholesaler does not have an incentive to raise prices in order to directly impact the pricing strategies of rival retailers. Rather, our model has the RRC effect seen in Crawford, Lee, Whinston, and Yurukoglu (2018) (Section 6.2.2, p. 934), where the wholesaler has an incentive to raise prices to rival retailers due to the possibility of increased sales volume for their merged downstream retail partner.

Next consider a merger between an integrated retailer/wholesaler tv and a standalone retailer s . Such a combination has a vertical component and a horizontal component. The first order condition for setting the downstream price p_{tv} becomes

$$\begin{aligned}
& \sum_{x \in \mathcal{W}^t \setminus \{v\}} [p_{tx} - p_{tx}^W - c_{tx}^R] \frac{\partial s_{tx}}{\partial p_{tv}} + s_{tv} + \overbrace{[p_{tv} - c_{tv}^W - c_{tv}^R] \frac{\partial s_{tv}}{\partial p_{tv}}}^{\text{direct EDM effect}} + \underbrace{\sum_{x \in \mathcal{R}^v \setminus \{t,s\}} [p_{xv}^W - c_{xv}^W] \frac{\partial s_{xv}}{\partial p_{tv}}}_{\text{upstream UPP effect}} \\
& + \underbrace{[p_{sv} - c_{sv}^W - c_{sv}^R] \frac{\partial s_{sv}}{\partial p_{tv}}}_{\text{indirect EDM Effect}} + \underbrace{\sum_{x \in \mathcal{W}^s \setminus \{v\}} [p_{sx} - p_{sx}^W - c_{sx}^R] \frac{\partial s_{sx}}{\partial p_{tv}}}_{\text{downstream UPP effect}} = 0.
\end{aligned} \tag{6}$$

Now there is the possibility for what we call the “downstream UPP effect” in the retail market, as the merged firm can recapture sales that are diverted to retailer s when t raises its prices. EDM between v and s can actually increase this UPP impact, because when sales are diverted to product v sold by retailer s , those units may earn a larger margin. This impact, which comes through the interaction of EDM with UPP, follows the logic of Salinger (1991), where EDM on one product can cause a firm to raise prices on other products in order to drive sales to the lower cost good. We label this effect the “indirect EDM effect.”

If instead an integrated retailer/wholesaler tv were to merge with a standalone wholesaler, then the resulting first order condition for product tv would look similar to equation (6) with some changes. The downstream UPP effect would be replaced with an additional upstream UPP effect capturing the value of sales diverted to customers of the new partner wholesaler. The condition would also include an indirect EDM component, reflecting the ability of retailer r to obtain an additional wholesale product at marginal cost, which in turn would raise the value of diverted sales to that product. Whether these additional incentives to raise prices will dominate the direct EDM impact is an empirical question. Furthermore, if we instead considered a merger between two integrated retailer/wholesaler pairs, both upstream and downstream UPP effects would enter.

As for wholesale prices, again consider a merger between an integrated retailer/wholesaler tv and a standalone retailer s . When wholesaler v bargains with an unaffiliated retailer j we have the first order condition given by,

$$\begin{aligned}
& [p_{jv}^W - c_{jv}^W]s_{jv} - \sum_{x \in \mathcal{R}^v \setminus \{t,s,j\}} [p_{xv}^W - c_{xv}^W] \Delta s_{xv}(\mathcal{W}^j \setminus \{v\}) \\
& \quad \text{RRC effect} \\
& - \sum_{x \in \{t,s\}} \left(\overbrace{[p_{xv}^W - c_{xv}^W - c_{xv}^R] \Delta s_{xv}(\mathcal{W}^j \setminus \{v\})}^{\text{indirect EDM effect}} - \sum_{y \in \mathcal{W}^x \setminus \{v\}} [p_{xy} - p_{xy}^W - c_{xy}^R] \Delta s_{xy}(\mathcal{W}^j \setminus \{v\}) \right) = \\
& \frac{1-\lambda}{\lambda} \left([p_{jv} - p_{jv}^W - c_{jv}^R]s_{jv} - \sum_{x \in \mathcal{W}^j \setminus \{v\}} [p_{jx} - p_{jx}^W - c_{jx}^R] \Delta s_{jx}(\mathcal{W}^j \setminus \{v\}) \right).
\end{aligned} \tag{7}$$

The RRC effect is augmented with the profits emanating from the sales of retailer s , in addition to the sales of retailer t , both of which may potentially recapture sales should retailer j lose access to product v . The merged firm has higher bargaining leverage as a result. If instead the integrated retailer/wholesaler tv were to merge with a standalone wholesaler, then the profits earned by firm tv should the negotiation with retailer j fail are augmented with the earnings of the additional wholesaler rather than with the earnings of retailer s . This adds a term similar to the wholesale recapture leverage effect seen in equation (5) to the left-hand side of the bargaining first order condition.¹⁰ In the case of a merger between two integrated retailer/wholesaler firms, all of these effects would appear.

Returning to a merger between an integrated retailer/wholesaler tv and a standalone retailer s , when the merged firm bargains with an unaffiliated wholesaler k to supply retailer

¹⁰For simplicity, we assume that when a retailer fails to reach an agreement with one wholesaler, that retailer's contracts with all other wholesalers remain in place.

t , the first order condition becomes

$$\begin{aligned}
& [p_{tk}^W - c_{tk}^W]s_{tk} - \sum_{x \in \mathcal{R}^k \setminus \{t\}} [p_{xk}^W - c_{xk}^W] \Delta s_{xk}(\mathcal{W}^t \setminus \{k\}) = \\
& \frac{1-\lambda}{\lambda} \left([p_{tk} - p_{tk}^W - c_{tk}^R]s_{tk} - \sum_{x \in \mathcal{W}^t \setminus \{v,k\}} [p_{tx} - p_{tx}^W - c_{tx}^R] \Delta s_{tx}(\mathcal{W}^t \setminus \{k\}) \right. \\
& \quad - \underbrace{\sum_{x \in \{t,s\}} [p_{xv} - c_{xv}^W - c_{xv}^R] \Delta s_{xv}(\mathcal{W}^t \setminus \{k\})}_{\text{EDM recapture effect}} - \underbrace{\sum_{x \in \mathcal{W}^s \setminus \{v\}} [p_{sx} - p_{sx}^W - c_{sx}^R] \Delta s_{sx}(\mathcal{W}^t \setminus \{k\})}_{\text{retail recapture leverage effect}} \\
& \quad \left. - \underbrace{\sum_{x \in \mathcal{R}^v \setminus \{t,s\}} [p_{xv}^W - c_{xv}^W] \Delta s_{xv}(\mathcal{W}^t \setminus \{k\})}_{\text{wholesale recapture leverage effect}} \right). \tag{8}
\end{aligned}$$

Compared to equation (5), now the EDM recapture effect applies to sales of product v at both affiliated retailers t and s . Furthermore, there is also the possibility that sales will be diverted to retailer s should retailer t lose access to product k , which creates an additional “retail recapture leverage effect” alongside the wholesale recapture leverage effect. All of these additional terms tend to increase the bargaining leverage of the merged firm. If we instead examined a merger between retailer/wholesaler tv and an unaffiliated wholesaler, that would augment the EDM recapture effect with sales of retailer t for two merged wholesalers, rather than sales for wholesaler v through two merged retailers. Similarly, the retail recapture leverage effect would be replaced with an additional wholesale recapture leverage effect for the newly merged wholesaler. For a merger between two integrated retailer/wholesaler firms, all of these effects would enter.

3 Empirical Application: the Chattanooga Waste Industry

The U.S. waste and recycling industry generates approximately \$80 billion in annual revenues.¹¹ In recent years the industry has experienced significant merger activity, including several acquisitions between vertically integrated, nationally active competitors. Furthermore, there are a variety of vertical supply chain configurations across local markets, making the industry an excellent application to study the welfare impacts of mergers that have both horizontal and vertical aspects.

Republic Services, the second largest waste management company in the U.S., acquired Santek Environmental in 2021.¹² The DOJ filed a complaint and negotiated a settlement in the case, alleging horizontal anti-competitive effects for four small-container commercial waste (SCCW) collection markets and two municipal solid waste (MSW) disposal markets. In addition, vertical anti-competitive effects were alleged to arise from the combination of Republic and Santek integrated assets in the Chattanooga region.¹³ In this section, we begin by applying our model to simulate the effects of the Republic/Santek merger in Chattanooga. We then compare these results to those of counterfactual merger simulations in which we examine how competition might have been affected by the combination of other market competitors that exhibit different vertical supply chain arrangements.¹⁴ By focusing on one market at a single point in time, we are better able to interrogate the welfare implications of these structural differences.

¹¹See Waste Dive, <https://www.wastedive.com/news/public-companies-increased-control-of-74b-us-waste-industry-in-2018/556079/>.

¹²See Competitive Impact Statement: U.S. and State of Alabama v. Republic Services, Inc. and Santek Waste Services, LLC, <https://www.justice.gov/atr/case-document/file/1382626/download>.

¹³See U.S. and State of Alabama v. Republic Services, Inc. and Santek Waste Services, LLC, <https://www.justice.gov/atr/case-document/file/1382031/download>.

¹⁴The `antitrust` R package contains the computer code needed to run the merger simulations described here.

3.1 Market Background

The vertical supply chain in the solid waste industry is primarily comprised of waste collection operations or “haulers” and waste disposal facilities. Haulers collect MSW from businesses and residences and must dispose of it at a lawful disposal site, usually a landfill. Waste disposal (upstream) is a required input into waste collection services (downstream). Some haulers are vertically integrated and operate their own disposal facilities. Vertically-integrated haulers typically prefer to dispose of waste at their own disposal facilities and may also sell a portion of their disposal capacity. Disposal customers include private waste haulers without their own disposal assets as well as local governments that collect their citizens’ waste themselves. Due to strict laws and regulations that govern the disposal of MSW, there are no reasonable substitutes for MSW disposal.

The Competitive Impact Statement (CIS) filed by the DOJ in association with the Republic/Santek merger describes the alleged lost competition in the “Chattanooga, Tennessee and North Georgia area,” subsequently referred to as the Chattanooga Area, due to lost horizontal competition in MSW disposal and SCCW collection as well as due to RRC in the SCCW collection market by raising the MSW disposal costs of independent haulers. The CIS notes that pre-merger, Republic and Santek combined served approximately 73 percent of the SCCW collection market with three other significant competitors. In MSW disposal, the CIS identifies only one other significant competitor pre-merger and Republic and Santek combined as serving approximately 82 percent of the market, disposed of either directly in the merging parties’ landfills within the area or passing through their transfer stations before ultimately being disposed of in the parties’ landfills elsewhere. Thus, pre-merger both parties were large, vertically integrated competitors in the Chattanooga Area.

In addition, another large, vertically integrated company, Waste Connections, existed in the market at the time of the merger and was the parties’ sole competitor in MSW disposal. National firms Waste Management and ADS owned collection assets in the area but were

not vertically integrated in this market, as demonstrated by MSW disposal data discussed in Appendix A.¹⁵ We treat Waste Management and ADS as a single entity (henceforth “WM-ADS”) because they merged with one another in 2020, and that transaction was completed before the filing of the CIS for Republic/Santek. The final significant participant in the SCCW collection market was a major regional firm that is not identified by name in the CIS. (We label this firm “Regional” in what follows.)

Using data described in Appendix A, the supply relationships between the upstream disposal market participants (Republic, Santek, and Waste Connections) and downstream collection market participants (Republic, Santek, Waste Connections, WM-ADS, and Regional) can be inferred under the assumption that vertically-integrated haulers first dispose of waste at their own disposal facilities and then sell any residual disposal capacity to rival haulers. Santek and Waste Connections exhibit excess disposal capacity. However, Republic’s collection volumes are estimated to exceed their ability to self-supply disposal in the Chattanooga market. As a result, Republic needs to purchase additional disposal from Santek and Waste Connections, presumably at a higher marginal cost. We assume that this disposal is purchased from both Santek and Waste connections according to their shares of available excess MSW disposal capacity of 63.8% and 36.2%, respectively. We further assume that WM-ADS and Regional purchase disposal capacity from both Santek and Republic according to these shares. The resulting relationships between the upstream and downstream market participants are captured in Figure 1.

Our final input data set is presented in Table 1. As discussed above and in Appendix A, we need to make several simplifying assumptions in order to transform the available information into the data required for our model. We expect that the DOJ would have had access to more accurate confidential information during their investigation. Therefore, we

¹⁵Firms that are national competitors and vertically integrated in other markets are known to enter into contracts with each other to dispose of waste on advantageous terms that may make them effectively vertically integrated. Ignoring these contracting relationships may underestimate the number of effectively vertically integrated competitors in the market.

view our results as only illustrative of the types of analysis and results that could have been produced for this case. Note that, other than imposing that Republic only offers disposal to itself, we do not structurally incorporate capacity constraints into the simulation model. We assume that the changes in volume that would be caused by the merger would not be large enough to shift which constraints would be binding.¹⁶

3.2 Republic/Santek Merger Simulation Results

Overall, the merger between Republic and Santek is estimated to lower upstream prices by 2.8% and increase downstream prices by 12%, resulting in \$16.6 million of annual harm to consumers and total annual producer benefits of approximately \$14 million. Thus, on net the model predicts the merger would be harmful despite the presence of significant EDM that reduces prices upstream.¹⁷ These effects are illustrated in more detail in Figure 2.

Disposal prices for pre-merger integrated pairs are unchanged post-merger. However, MSW disposal prices increase to all rival haulers post-merger (i.e., all unintegrated pairs). The merged firms' disposal prices to downstream rivals are estimated to increase over 91% post-merger, and Waste Connections' prices to its downstream rivals are estimated to increase 24%. These large price increases are offset by the large decrease in the disposal price for the integrating pair post-merger due to EDM, as the cost to Republic for volume disposed with Santek decreases by approximately 61%.

Turning to the downstream market, all collection prices increase post-merger. The merging parties' post-merger collection prices increase by approximately 20%, and their share decreases by about 8 percentage points overall. The Republic/Republic product's price increases 21%, and the Santek/Santek product's price increases by 23%. The newly integrated

¹⁶We also assume that the Waste Connections-Republic product remains on the market, which may only be true in the short run.

¹⁷Our calibrated bargaining parameters for retailers against Santek ($\lambda = 1$) and Republic ($\lambda = 0.7$) give a substantial edge to downstream firms, which, based on our analysis of the previous section, suggests consumers are likely to be harmed. High bargaining power parameters are needed to explain the high collection margin compared to the disposal margin. (See Table 1.)

Santek/Republic product’s price is estimated to increase by 9%, demonstrating that EDM is not fully passed-through to consumers. The integrated rival, Waste Connections, increases its collection price by approximately 6%, and its share increases by 6 percentage points. The unintegrated rivals’ collection prices each increase by about 9%, which again demonstrates incomplete pass-through of the change in upstream costs, and their shares increase slightly.

In Figure 3 we compare the full vertical model results, which compute both post-merger downstream and upstream price effects, to two other models that hold the prices of one level fixed.¹⁸ The “downstream-only” model computes collection price effects holding disposal prices fixed at pre-merger levels, and the “upstream-only” model computes disposal price effects holding collection prices fixed at pre-merger levels.

Ignoring these vertical relationships in the downstream-only model results in an estimated 11% increase in collection prices with a greater than 16% increase in the merging parties’ price, consumer harm of \$10 million annually, and net harm of approximately \$2 million. Estimated consumer harm is 60% higher in the full vertical model and is offset by markedly larger producer benefits. The downstream-only model misses the substantial RRC effect experienced by the Santek/WM-ADS and Santek/Regional products. In the vertical model, the downstream prices for these products rise more dramatically due to this RRC, and other prices increase alongside them. This causes more harm to consumers.

In the upstream-only model, downstream prices and therefore shares are fixed at their pre-merger levels. Upstream prices are still set to marginal cost for integrated products. Overall disposal prices increase by 8.2% post-merger, and the merger effect is a pure transfer between firms. Thus, both consumer and net harm are estimated to be zero. The main impact of the merger is in changing the bargaining leverage for Santek, now that it is combined with Republic. This effect causes Santek to raise its upstream disposal prices to both WM-ADS and Regional. The price increase is even larger in the upstream-only model compared to the full model. The lack of downstream price adjustments means that WM-ADS and Regional

¹⁸This approach uses the same calibrated demand and costs parameters across all three models.

cannot shift their sales towards their cheaper supplier, Waste Connections, in equilibrium, which makes having access to Santek’s disposal facilities relatively more valuable than in the full model, driving up Santek’s price. In this sense, the upstream-only model overstates the increase in leverage that Santek receives from the merger.

The Republic/Santek merger was ultimately settled with the DOJ through a divestiture. According to the Final Judgment, in the Chattanooga Area the parties were required to divest Santek’s SCCW collection assets as well as two landfills and a transfer station.¹⁹ Our results suggest that a divestiture in the collection market alone likely would not have sufficiently remedied the anti-competitive effects of the merger.

3.3 Counterfactual Merger Simulations

In addition to applying our model to estimate the effects of the Republic/Santek merger on the Chattanooga market, in this section we simulate the effects of the hypothetical mergers of three other pairs (Santek/Waste Connections, Santek/WM-ADS, and WM-ADS/Regional) that would have resulted in companies with different vertical supply configurations combining. The estimated aggregate welfare effects of these counterfactual mergers are illustrated alongside those of the Republic/Santek merger in Figure 4.

The pre-merger Herfindahl-Hirschman Index (HHI) for the Chattanooga disposal market is xxxx and collection market is yyyy. The merger of WM-ADS with the Regional collection firm is a straightforward “horizontal” merger between two relatively small downstream competitors. This merger results in a post-merger change in the collection market HHI of zzz. Unsurprisingly, the resulting estimated welfare effects are small and consumer harm and producer benefits approximately cancel each other out. The more detailed results reported in Figure 5 show only minimal changes in prices or collection shares post-merger.

¹⁹See Final Judgment: U.S. and Plaintiff States v. Republic Services, Inc. and Santek, LLC, <https://www.justice.gov/atr/case-document/file/1408616/download>.

Turning to the Santek/WM-ADS merger simulation, we consider the effects of a small downstream rival combining with a vertically integrated firm. Here the merger results in a post-merger change in the collection market HHI of **aaa**, but consumer harm from increased collection prices of **x%** is significantly dampened by price decreases in collection of **y%** from EDM. This results in net harm of approximately **\$z million**.

Finally, we examine the potential merger of Santek and Waste Connections. While this merger is similar to that of Santek and Republic in that it is a merger between vertically integrated rivals, Santek/WasteConn differs in its effects on the Chattanooga market because both parties exclusively self-supplied for their disposal input pre-merger. This diminishes the possibility for EDM effects. In addition, while Santek/WasteConn significantly raise disposal prices to their downstream rivals, the presence of the larger, vertically integrated (even if capacity constrained) Republic limits the merged firm's ability to pass this through to the collection market. Thus, net harm to the Chattanooga market remains relatively small at **\$d million**. This is in spite of post-merger changes in the HHIs of the disposal market of **xxxx** and collection market of **yyyy**.

3.4 Robustness

The robustness of our simulation results depends critically on a few key parameter values. One of these is the assumption of the bargaining power parameter, λ . Sheu and Taragin (2021) shows that mergers tend to benefit consumers when wholesalers have relatively more power, and harm consumers when retailers have relatively more power. Larger wholesaler bargaining power offers more possibilities for EDM, as premerger input prices are likely to be high. This channel becomes less relevant as retailers gain more power. Figure 6 illustrates his relationship between consumer welfare and the value of the bargaining power parameter for the Republic/Santek merger simulation. Harm increases rapidly as bargaining power increases to 0.4 and then becomes nearly constant for values above 0.5. Thus, assuming an

equal split between collection and disposal would yield an estimate of a near upper bound on consumer harm for this merger.

In addition to specification of the bargaining power parameter, our results are highly sensitive to assumptions about the market elasticity which is specified through the share of consumers choosing to purchase goods outside the market (the outside good share). Our baseline results assume that the outside share is zero because there are essentially no reasonable substitutes for SCCW collection or MSW disposal.²⁰ However, this assumption leads to the largest possible consumer harm in our model as shown in Figure 7. Often when the size of the outside share is unknown a market elasticity of 1.0 is assumed. For the Republic/Santek merger example, this would lead to consumer harm approximately 10 percentage points smaller.

4 Conclusion

This paper relaxes an assumption made in much of the merger simulation literature: that mergers occur in vertical supply chains where in the pre-merger state, no firms are vertically integrated. Removing this limitation is important as competition authorities are routinely called upon to investigate complex mergers where one or both of the merging parties are vertically integrated. Using a series of numerical simulations and the model of Sheu and Taragin (2021), we find that most mergers involving one or more firms that are already vertically integrated harm consumers. The exceptions occur when wholesalers have more bargaining power compared to retailers, which are instances where the benefits from EDM would tend to be larger. We also show that having integrated non-merging rivals limits the range of welfare outcomes and tends to make mergers somewhat more beneficial to consumers, although these firms' presence is not a panacea for consumer harm. We apply our model

²⁰See Competitive Impact Statement: U.S and Plaintiff States v. Republic Services, Inc. and Santek, LLC, <https://www.justice.gov/atr/case-document/file/1382626/d1?inline>

to the Republic/Santek merger, where we find that ignoring existing vertical relationships gives an incomplete picture of the merger’s welfare impacts.

Our results suggest that mergers that have horizontal aspects remain harmful for consumers in many instances, even when these mergers also have vertical aspects. This appears to be especially true when retailers have relatively more bargaining power, which in our model occurs when retailer margins are relatively large compared to wholesaler margins. Antitrust agencies may have reason to be especially cautious when reviewing mergers in these situations.

However, we of course have the caveat that our results are specific to our modeling framework. Certain alternative structures are likely to give different welfare results. Indeed, we found in Sheu and Taragin (2021) that using a second score auction to model downstream competition, as opposed to assuming Bertrand pricing, could meaningfully impact the estimated consumer harm from mergers, although results were similar between these models for vertical mergers. This paper is an attempt to provide some information about possible welfare effects from complex mergers within a framework that is used by practitioners. Exploring other commonly used frameworks would be a natural extension in future research.

References

- Bonnet, C., Z. Bouamra-Mechemache, and H. Molina (2023). An Empirical Model of Bargaining with Equilibrium of Fear: Application to Retail Mergers in the French Soft Drink Industry. Available at SSRN: <https://ssrn.com/abstract=3938971>.
- Chipty, T. (2001). Vertical integration, market foreclosure, and consumer welfare in the cable television industry. *American Economic Review* 91(3), 428–453.
- Crawford, G. S., R. S. Lee, M. D. Whinston, and A. Yurukoglu (2018). The Welfare Effects of Vertical Integration in Multichannel Television Markets. *Econometrica* 86(3), 891–954.
- Das Varma, G. and M. De Stefano (2020). Equilibrium Analysis of Vertical Mergers. *Antitrust Bulletin* 65(3), 445–458.
- De Stefano, M. and M. A. Salinger (2024). The Complicated Simple Economics of Vertical Mergers. forthcoming in *Journal of Law and Economics*.
- Domnenko, G. and D. S. Sibley (2022). Simulating Vertical Mergers and the Vertical GUPPI Approach. Working Paper, available at SSRN: <https://ssrn.com/abstract=3606641>.
- Draganska, M., D. Klapper, and S. B. Villas-Boas (2010). A Larger Slice or a Larger Pie? An Empirical Investigation of Bargaining Power in the Distribution Channel. *Marketing Science* 29(1), 57–74.
- Ho, K. and R. S. Lee (2017). Insurer Competition in Health Care Markets. *Econometrica* 85(2), 379–417.
- Horn, H. and A. Wolinsky (1988). Bilateral Monopolies and Incentives for Merger. *RAND Journal of Economics* 19(3), 408–419.
- Moresi, S. and S. C. Salop (2013). vGUPPI: Scoring Unilateral Pricing Incentives in Vertical Mergers. *Antitrust Law Journal* 79(1), 185–214.

- Ordover, J. A., G. Saloner, and S. C. Salop (1990). Equilibrium Vertical Foreclosure. *American Economic Review* 80(1), 127–142.
- Riordan, M. H. (1998). Anticompetitive Vertical Integration by a Dominant Firm. *American Economic Review* 88(5), 1232–1248.
- Riordan, M. H. (2008). Competitive Effects of Vertical Integration. In P. Buccirossi (Ed.), *Handbook of Antitrust Economics*, pp. 145–182. Cambridge: MIT Press.
- Rogerson, W. P. (2014). A Vertical Merger in the video Programming and Distribution Industry: Comcast-NBCU. In J. John E. Kwoka and L. J. White (Eds.), *The Antitrust Revolution, 6th Edition*, pp. 543–575. Cambridge: Oxford University Press.
- Rogerson, W. P. (2020). Modelling and Predicting the Competitive Effects of Vertical Mergers: The Bargaining Leverage over Rivals Effect. *Canadian Journal of Economics* 53(2), 407–436.
- Salinger, M. A. (1988). Vertical Mergers and Market Foreclosure. *Quarterly Journal of Economics* 103(2), 345–356.
- Salinger, M. A. (1991). Vertical Mergers in Multi-Product Industries and Edgeworth’s Paradox of Taxation. *Journal of Industrial Economics* 39(5), 545–556.
- Salop, S. C. and D. T. Scheffman (1983). Raising Rivals’ Cost. *American Economic Review Papers and Proceedings* 73(2), 267–271.
- Sheu, G. and C. Taragin (2021). Simulating mergers in a vertical supply chain with bargaining. *The RAND Journal of Economics* 52(3), 596–632.
- Werden, G. J. (1996). A Robust Test for Consumer Welfare Enhancing Mergers Among Sellers of Differentiated Products. *Journal of Industrial Economics* 44(4), 409–413.
- Werden, G. J. and L. M. Froeb (1994). The Effects of Mergers in Differentiated Products Industries: Logit Demand and Merger Policy. *Journal of Law, Economics, and Organization* 10(2), 407–426.

Table 1: Republic/Santek Merger Simulation Inputs

Table 2: Republic/Santek Merger Simulation Inputs. Volume is reported in thousands of pounds, while prices and margins are reported in dollars.

Disposal Firm	Collection Firm	Volume	Disposal Price	Disposal Margin	Collection Margin	Collection Price
Republic	Republic	165	42	0	44	179
Santek	Republic	34	36	20		173
	Santek	218	16	0		134
	WM-ADS	30	36	20		221
	Regional	30	36	20		221
WasteConn	Republic	19	25	14		162
	WasteConn	48	11	0		110
	WM-ADS	17	25	14		210
	Regional	17	25	14		210

Notes: “WasteConn” stands for Waste Connections. Volume is reported in thousands of tons, whereas prices and margins are reported in dollars per ton.

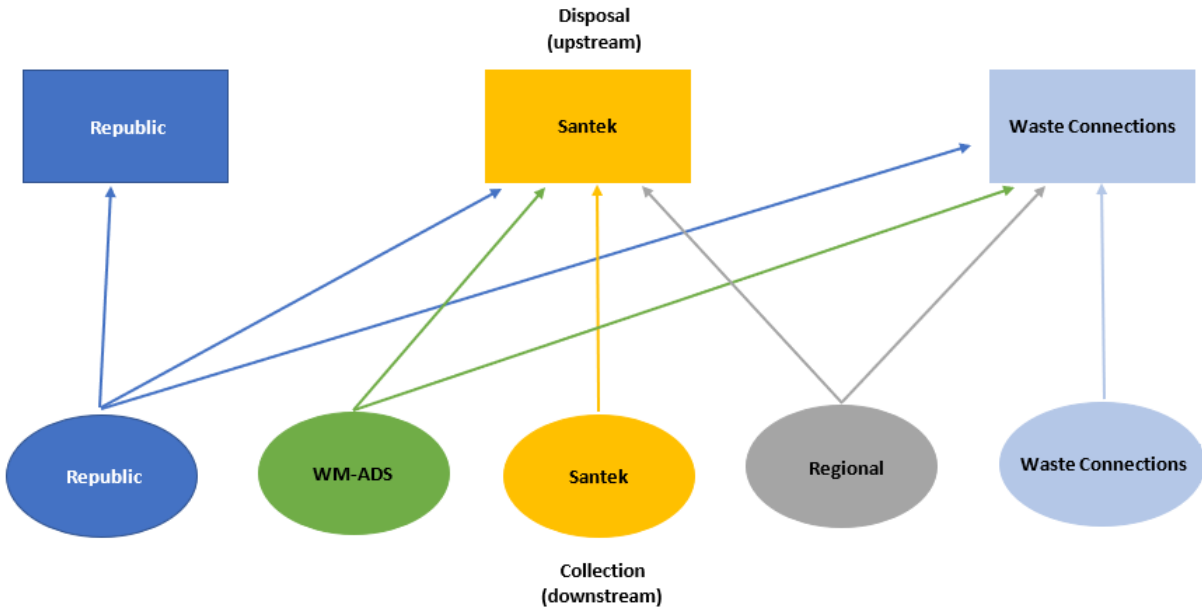
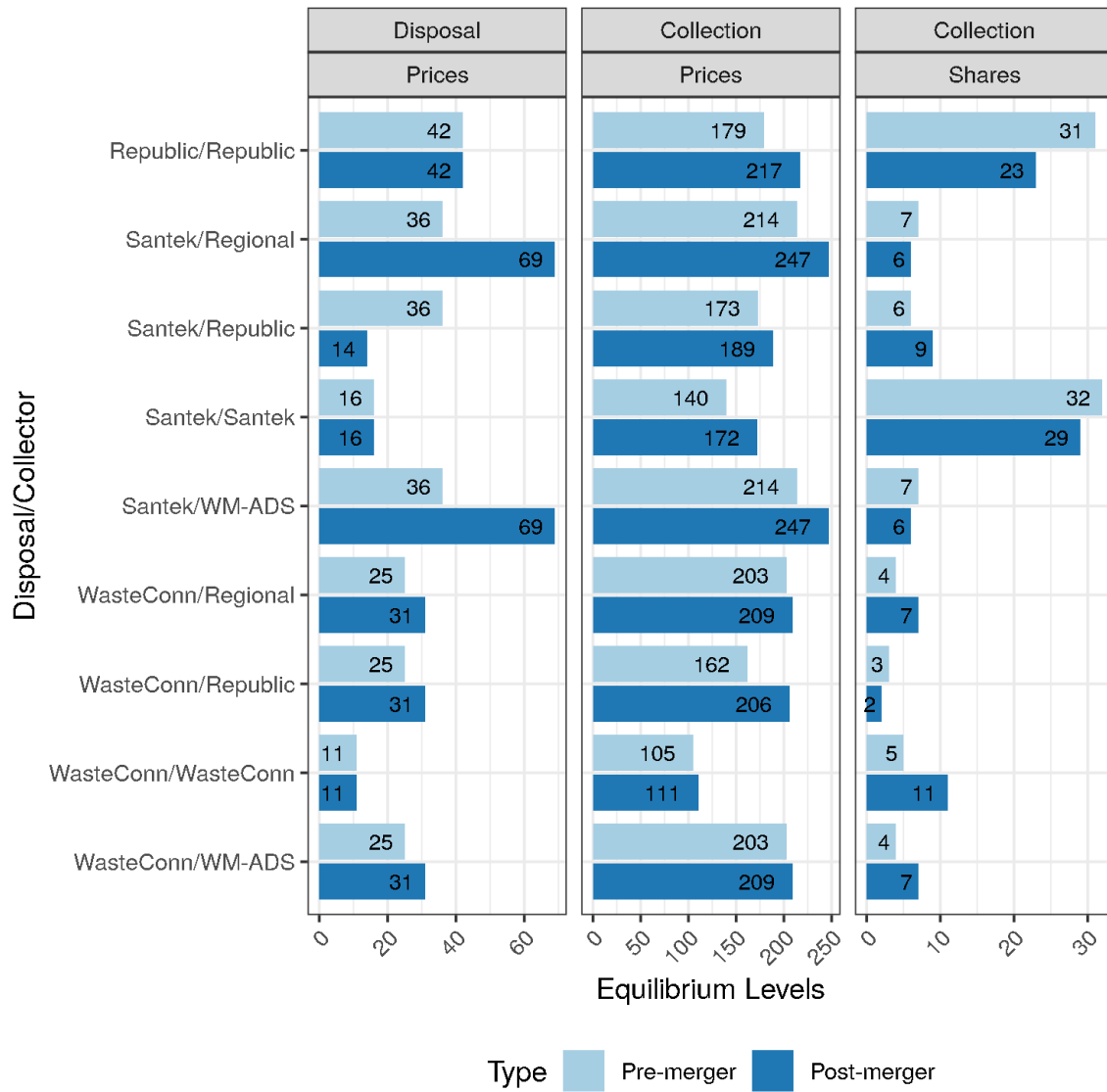


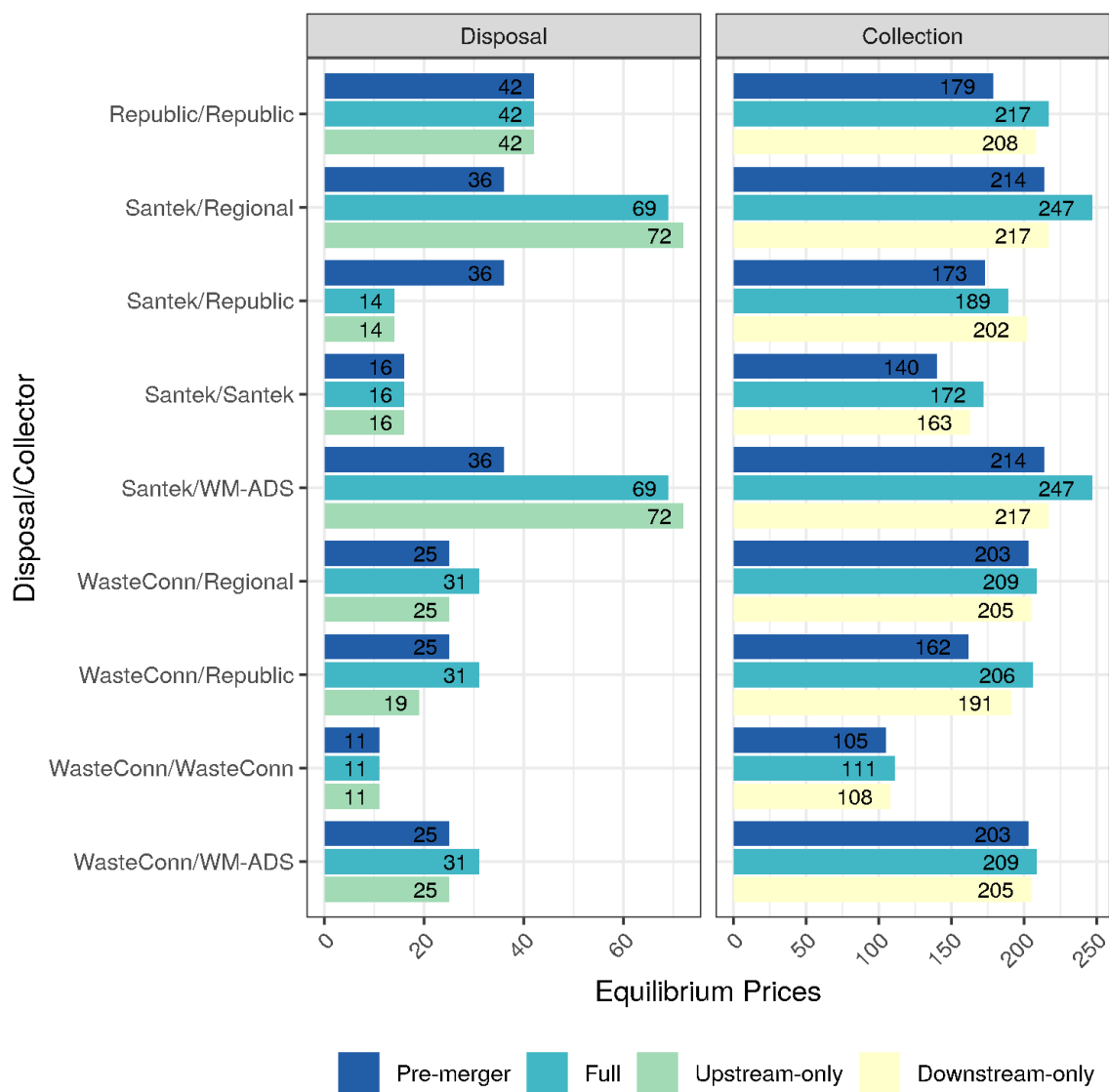
Figure 1 Structure of the Chattanooga Area Disposal and Collection Market

Figure 2 Republic/Santek Simulation Results



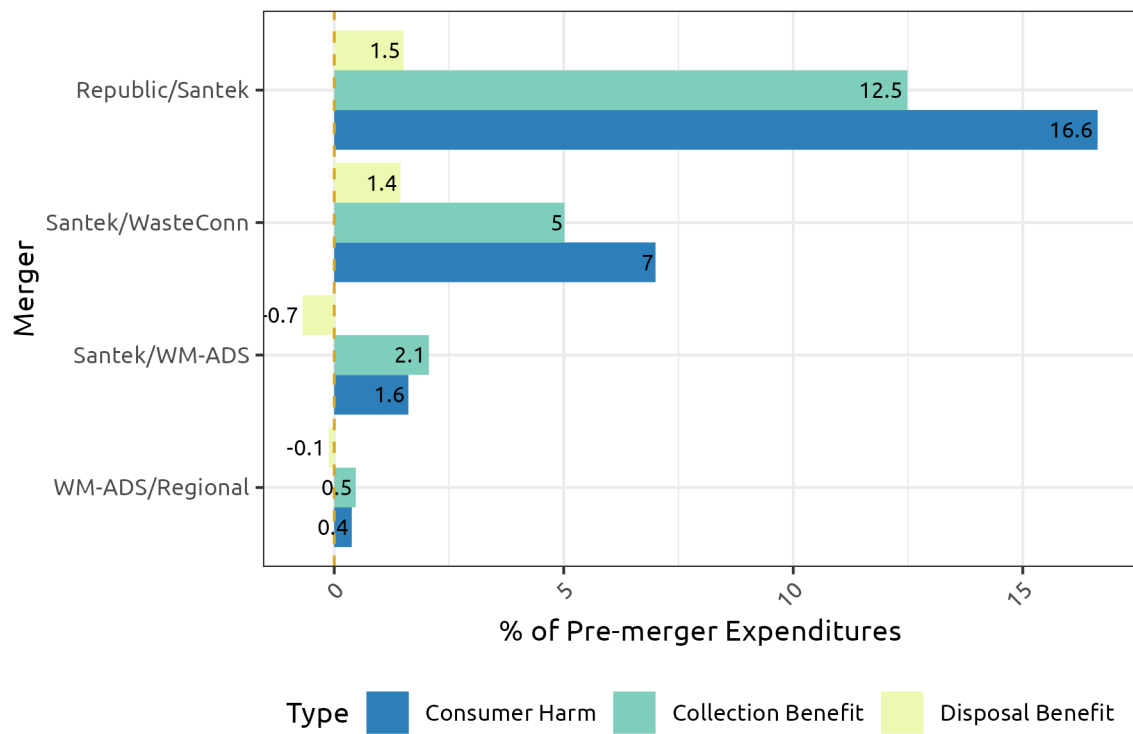
Notes: “WasteConn” stands for Waste Connections.

Figure 3 Republic/Santek Simulations: Full vs. Partial Models



Notes: “WasteConn” stands for Waste Connections.

Figure 4 Simulated Welfare Effects from Mergers between Republic/Santek, Santek/WasteConn, Santek/WM-ADS, and WM-ADS/Regional



Notes: "WasteConn" stands for Waste Connections.

Figure 5 Simulation Results from mergers between SanteK/WasteConn, SanteK/WM-ADS, and WM-ADS/Regional

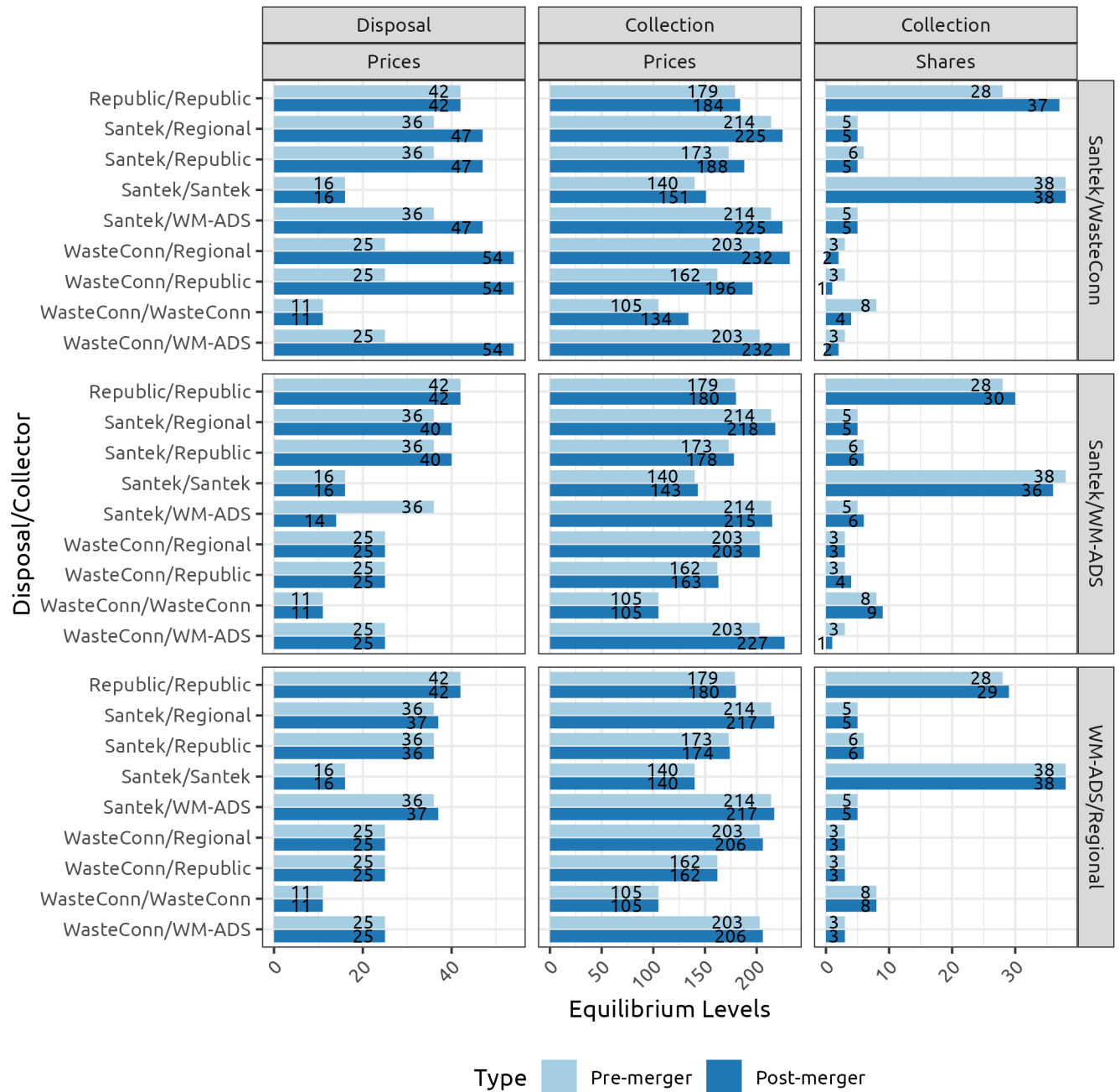
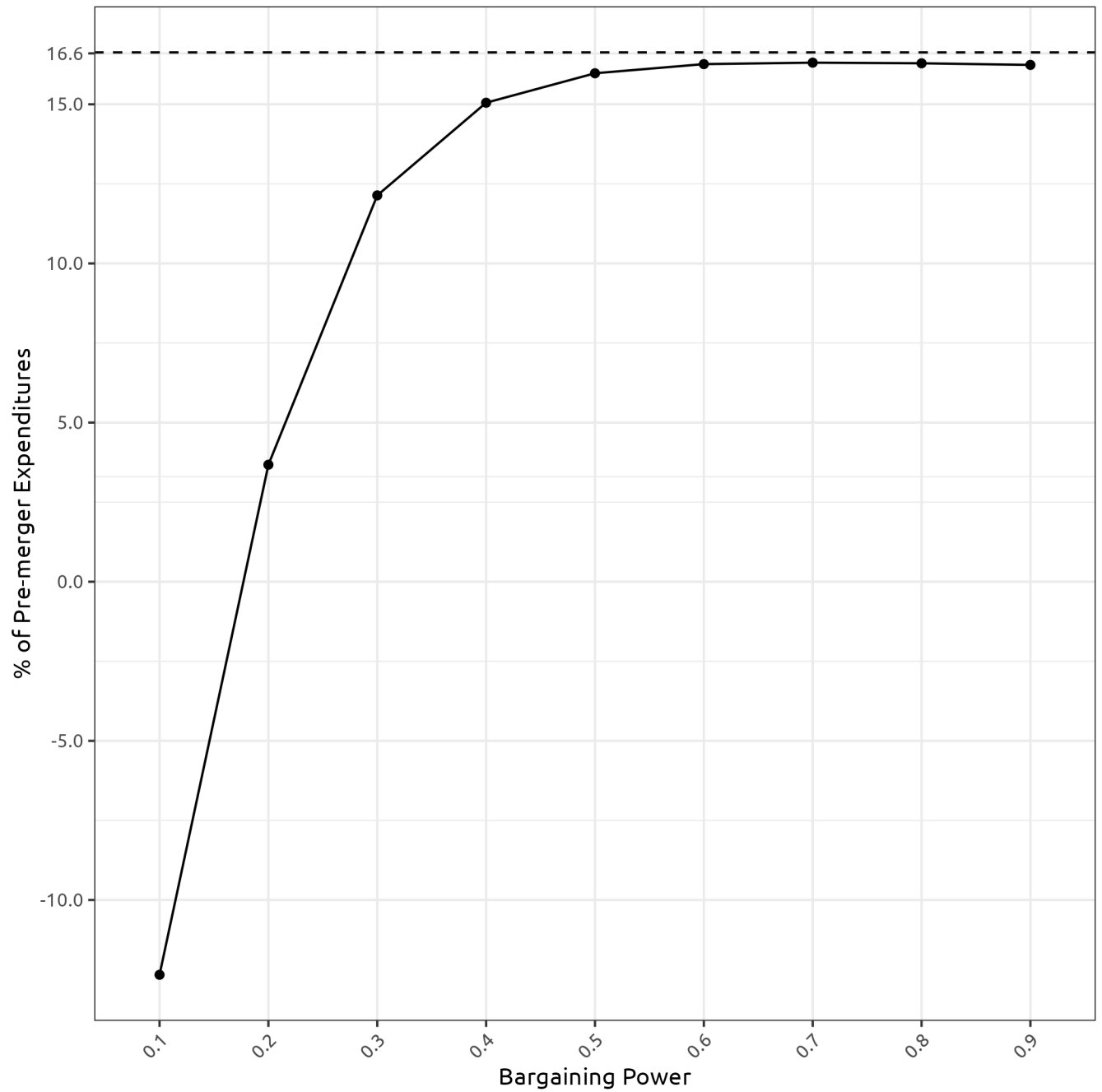
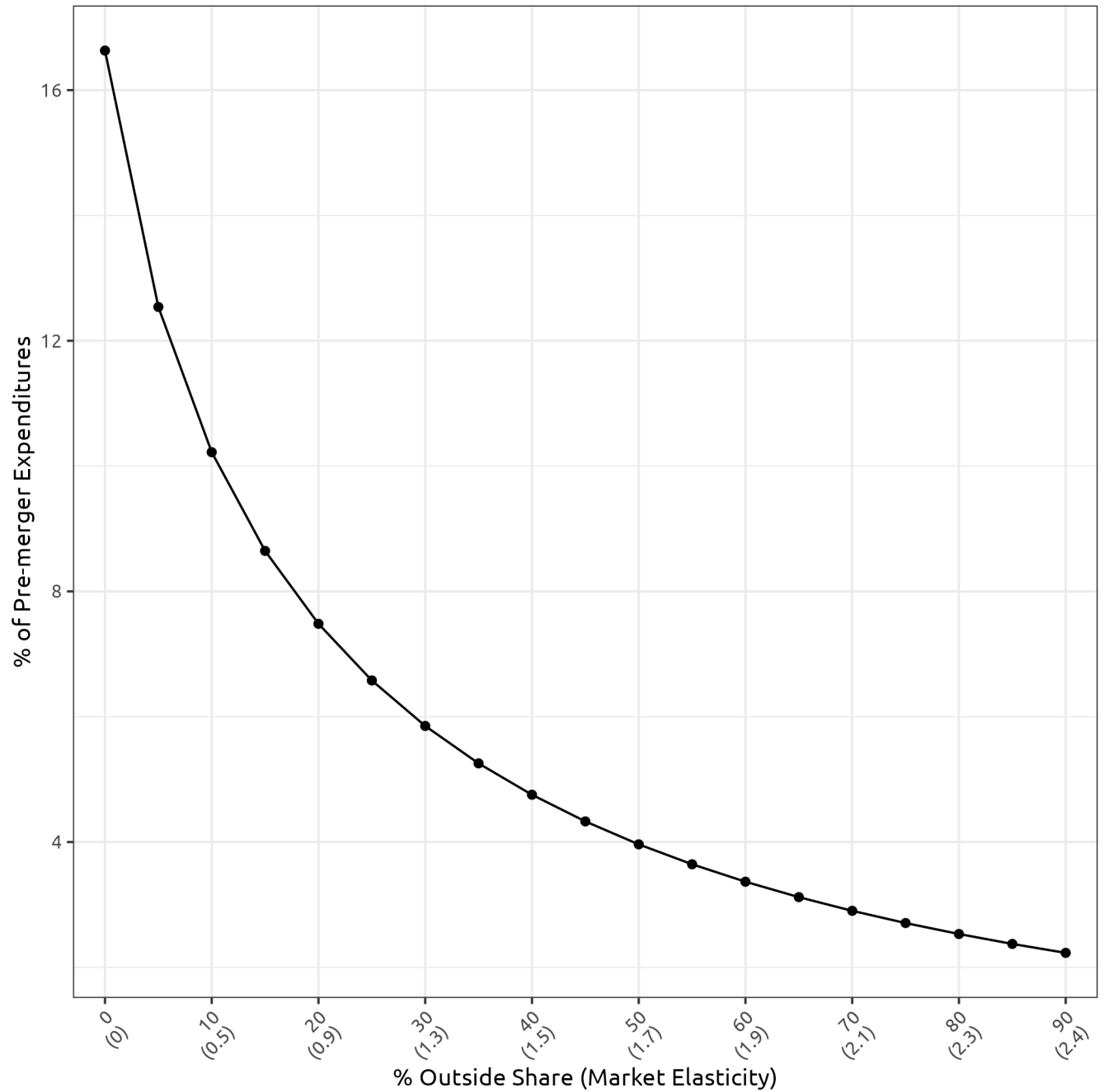


Figure 6 The sensitivity of consumer welfare in SanteK/Republic merger simulations to changes in the bargaining power parameter.



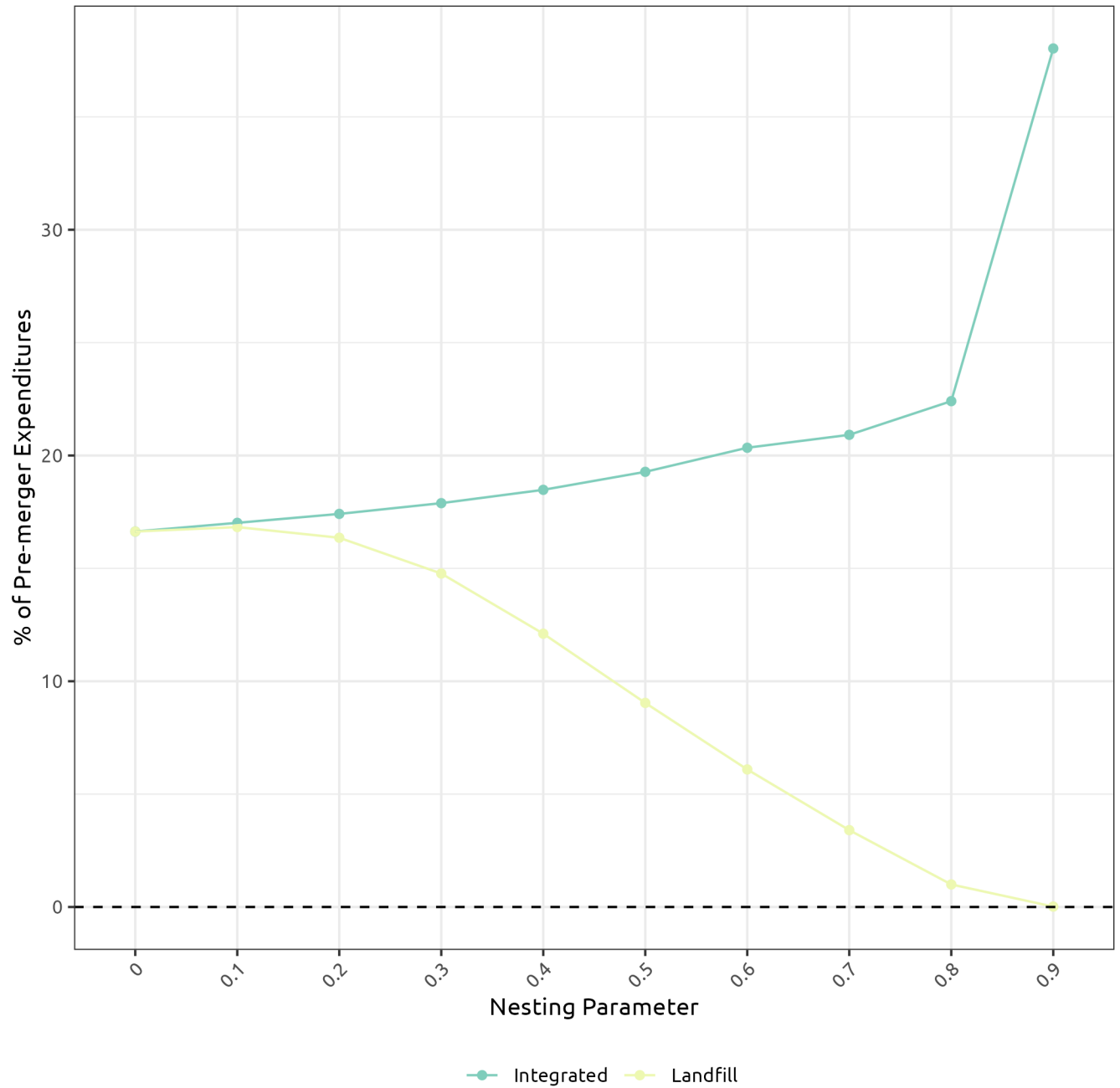
Notes: “WasteConn” stands for Waste Connections.

Figure 7 The sensitivity of consumer welfare in the Republic/Santek simulations to changes in the outside share. The absolute value of the market elasticity corresponding to the change in outside share is in parentheses. Baseline results assume 0 outside share.



Notes: “WasteConn” stands for Waste Connections.

Figure 8 The sensitivity of consumer welfare in the Republic/Santek simulations to changes in the nesting parameter. ‘Integrated’ assumes that all vertically integrated products are in a single nest, while ‘Landfill’ assumes that all collectors that use the same landfill are in a single nest. A nesting parameter of 0 displays baseline results.



Notes: “WasteConn” stands for Waste Connections.

A Appendix: Data for Republic/Santek

Data on MSW disposal come from information collected by the Tennessee Department of Environmental Quality (TDEQ) consisting of Class 1 landfill ownership, Class 1 Solid Waste Origin Reports, and waste disposal by county for 2019. These data identify the origin county and destination landfill, including owner and operator information, for all MSW produced in Tennessee as well as waste volumes passing through transfer stations in Tennessee. The MSW disposal market definition follows that outlined in the DOJ CIS and attributes share to the company owning the final disposal landfill (i.e., ignoring transfer stations that are an intermediate disposal site only). Thus, the total market quantity is defined as all MSW volumes originating in Hamilton County, Tennessee where Chattanooga is located.

Disposal volumes are measured in tons and have been combined across landfills owned by the same firm. The TDEQ data identify landfills owned or operated by Republic, Santek, Waste Connections, and three other market participants (each with less than 0.5% share) receiving MSW volumes originating in Hamilton County.²¹ These three fringe participants have been excluded from the analysis. After re-scaling, the resulting market shares are Republic, 28.4%, Santek, 54%, and Waste Connections, 17.6%.

However, the market shares required for implementation of our model are expressed as upstream-downstream market participant pairs. Following the discussion of supply relationships in Section 3, vertically-integrated pairs without capacity constraints (i.e., Santek disposal and collection, Waste Connection disposal and collection) are assigned their full collection share. Capacity constrained integrated firms (Republic disposal and collection) are assigned their collection share up to their available capacity with the remainder allocated by residual disposal share to pairs with the respective upstream firms (i.e., Santek disposal and Republic collection, Waste Connections disposal and Republic collection). Unintegrated

²¹The City of Chattanooga and Marion County landfills are municipally owned and operated, accounting for less than 1% share combined. Global Envirotech is a privately-owned transfer station that sends its 0.03% share to an out-of-state landfill in Georgia.

firms' collection shares are distributed among the upstream suppliers with available capacity by residual share as well.

MSW disposal prices are collected from the 2019 Waste Business Journal's Directory of Waste Processing & Disposal Sites. The measure of price is the "gate rate," which is the posted price at the landfill, measured in dollars per ton.²² Republic and Santeck both operate multiple landfills in the market with different prices. The price used in the analysis for each is the volume-weighted average for their landfills.

The CIS states that in the Chattanooga Area the post-merger HHI for SCCW collection would be approximately 5,551 post-merger with an increase of 2,660 points and that the combined market share of the merging parties is 73%. Taking these figures as given we can recover the collection market shares under the assumptions that 1) the merging parties are of equal size, and 2) the non-merging parties are of equal size. After re-scaling, this produces downstream market shares for Republic, 37.6%, Santeck, 37.6%, Waste Connections, 8.3%, WM-ADS, 8.3%, and Regional, 8.3%.

Collection and disposal margins are calculated for Republic from data on revenue by line of service and from components of the cost of operations in the company's 2019 annual report. The data are reported at the company level and are not specific to the Chattanooga Area, but revenues are reported by collection segment. Collection costs in dollars per ton are estimated from Republic and Waste Management 2019 10k financial statements. These costs are reported at the company level across all segments. The estimated share of these costs attributable to the Chattanooga market, based on the number of markets in which the companies operate, is divided by the tons disposed for each company. Santeck, Waste Connections, and Regional do not publicly produce comparable financial statements. Instead, we assume that the cost structure is the same for the vertically-integrated companies, taking into account their individual tons disposed, and that WM-ADS and Regional share the same cost structure due to their lack of internal disposal capacity.

²²Disposal prices for large customers may be bilaterally negotiated instead of paying the gate rate.